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SPECIAL FEATURE

THE GRAND PLAN FOR CARBON CAPTURE



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TO THE SMART
HELICOPTER**

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SPACE
**NEW SUPERCONDUCTING
DETECTORS FOR FUTURE
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EDITORIAL

by the editorial team

A MUCH-NEEDED BOOST FOR CCS IN EUROPE

Most people know the Paris Agreement for its noble and ambitious goal: keeping the global temperature rise this century well below 2 degrees. However, whilst this promise was welcomed by a vast majority of scientists, questions are still pending regarding the deployment of some of the technologies required for all signatories to keep it.

‘Carbon capture and sequestration’ (CCS) technologies are among these. Various reports have highlighted the critical role that CCS could play in meeting the climate goals set in the Paris Agreement. More recently, several studies, including one from January 2017 published in the journal *Nature Climate Change*, took a step further. The latter states that ‘the continued lack of large-scale carbon capture and storage threatens 2030 targets and the longer-term Paris ambition of net-zero emissions.’

**‘Continued lack of
large-scale carbon
capture and storage
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term Paris ambition.’**

Whilst the Global CCS Institute tells us that there are as many as 38 large-scale CCS projects across the world, 20 of which are expected to be operational by the end of this year, the organisation also regrets that the current level of CCS deployment ‘does not go anywhere near what is required’ from CCS to meet the Paris climate target.

So what do we do now? Luckily enough, scientists across Europe have been working relentlessly to raise more interest in CCS. Thanks to

funding under FP7 and H2020, new infrastructure, industrial pilots, decision-making tools, technology improvements and brand new CCS systems are all under way. In fact, some of these solutions are so close that seven of them are sharing the spotlight for this new edition of the research*eu Results Magazine.

As usual, the special feature is followed by highlights across nine themes of research: health, society, transport, environment, agriculture and forestry, industry, information and communication technology, space and fundamental research. The magazine closes with a list of upcoming events hosted by or involving EU-funded research projects.

We look forward to receiving your feedback. You can send questions or suggestions to: editorial@cordis.europa.eu



Erratum

In Issue 63 of the research*eu Results Magazine, our focus on the WINESENSE project mentioned Prof. Maria José Concero Alonso as the coordinator of the project. This was an unfortunate mistake on our part, as all credit should go to Prof Maria José Cocero Alonso.



Focus on
Stemming the
blood cancer tide

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SPECIAL FEATURE

THE GRAND PLAN FOR CARBON CAPTURE

PROMOTING EUROPEAN LEADERSHIP IN CCS TECHNOLOGY

A project to establish a distributed world-class lab network will help Europe become a leading light in CCS research, opening up new commercial opportunities and providing a coordinated effort to tackling climate change.

While global demand for 'Carbon capture storage' (CCS) continues to grow, further development is urgently needed if this technology is to become viable and cost-effective.

To this end, the ambitious EU-funded ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure) project aims to establish European leadership in the field by developing world-class distributed lab infrastructure, accessible for industry and research. The project has created partnerships in order to avoid duplication and streamline joint funding for new research facilities across Europe.

Opening up research potential

'As a facilitator of world-class CCS research, ECCSEL will be able to engage with the European research community and other knowledge providers to offer expertise, advanced laboratories and test sites,' explains ECCSEL project director Sverre Quale from the Norwegian University of Science and Technology (NTNU). 'This is not something that would be possible by a single nation working alone.'

ECCSEL has since been transformed into a permanent European legal entity called ERIC (European Research Infrastructure Consortium). There is a main hub with national nodes, with around 50 distributed world-class laboratories and test pilots integrated into the structure. Completed and/or approved common investment plans total nearly EUR 90 million.

The lab infrastructure, which currently connects nine countries, will encourage the development of commercial CCS applications to come out of Europe. For example, engineering companies and technology providers will be able to promote the latest innovations and solutions to prospective partners, while plant owners and industrial partners will find it easier to invest in state-of-the-art CCS technologies.

'ECCSEL ERIC will also ensure that facilities required for conducting research in priority areas are available for the international research community,' adds Quale. 'By doing this, ECCSEL ERIC will contribute to pushing technological development beyond the current state-of-the-art, thereby accelerating the commercialisation and deployment of CCS.'

Environmental leadership

In addition to representing an economic opportunity for European business, CCS is also an emerging technology of geopolitical importance. 'In order to meet the 2 °C scenario of the IEA (International Energy Agency) and the Paris Agreement (1.5 °C), CCS must be developed and deployed within a decade,' says Quale.

In its most recent roadmap, the IEA provides advice on how CCS should be applied in various regions through to 2030 and 2050, while emphasising the importance of employing CCS extensively in power generation and industry sectors.

'In a European context, this means that aggregated CO₂ amounts of 1.8 Gt until 2030 and 12.2 Gt until 2050 need to be captured and stored, taking into account expected

growing demands. According to the IEA, 40% of these emission cuts must take place in European industry. The challenges of climate change and the corresponding need for CCS research, innovation, technology development, testing and verification cannot be met by today's individually based research laboratories alone.'

As a result, the need for upgraded and new CCS research facilities has been widely recognised among stakeholders across Europe. This has been expressed through platforms such as the Zero Emissions Platform (ZEP) and the European Energy Research Alliance on CCS (EERA-CCS), and will now be realised through ECCSEL.

'Ultimately, our hope is that we will fulfil our vision, which is to enable low to zero CO₂ emissions from industry and power generation in Europe, and to contribute strongly in combating climate change,' concludes Quale.

ECCSEL

- ★ Coordinated by NTNU in Norway.
- ★ Funded under H2020-INFRADEV.
- ★ <http://cordis.europa.eu/project/rcn/198279>
- ★ Project website:
<http://www.eccsel.org/>

INTERVIEW

GETTING CCL TECHNOLOGY READY FOR USE AT COAL POWER PLANTS

Among second generation carbon capture technologies stands 'Calcium carbonate looping' (CCL). But even though it is considered less toxic than alternatives and proved to yield low efficiency penalties, the method is still far from being market-ready. SCARLET-enabled breakthroughs are expected to give it a push.

The SCARLET (Scale-up of Calcium Carbonate Looping Technology for Efficient CO₂ Capture from Power and Industrial Plants) project aimed to pick up where previous work from the Technical University of Darmstadt left off: since April 2014, the team has been upgrading an existing 1 MWth pilot plant to bring it as close as possible to meeting industrial setup requirements.

With the resulting experimental data, Dr Jochen Ströhle and his team hope to enable the future construction of a 20 MWth pilot at the Emile Huchet coal power plant in France. The coal industry is indeed the most likely to be attracted to CCL technology over the next few years.

★ What makes CCL superior to competing technologies?

Dr Jochen Ströhle: Just like with other post-combustion technologies, the CO₂ contained in a flue gas is absorbed in one reactor and desorbed in another reactor.

One important advantage of CCL is that the sorbent is a natural mineral, i.e. limestone, which is cheaply available all over the world and has no negative impact on the environment. However, the main advantage of CCL compared to technologies based on liquid sorbents is that the process is operated at a high temperature above 650 °C. This means that the heat required for sorbent regeneration can be utilised in a highly efficient steam cycle to produce electricity. It also leads to rather low efficiency penalties in the range of 6-7 percentage points (incl. CO₂ compression) for

coal-fired power plants, which is significantly lower than competing technologies. Furthermore, the CO₂ avoidance costs are also significantly lower.

★ What were the main results from your field tests on a 1 MWth plant?

One challenge of CCL is the deactivation of the sorbent by sintering and sulphation as well as dilution with ash. Hence, a certain stream of make-up limestone has to be added to the process. However, this deactivation and dilution is a rather slow process, so steady-state conditions in the plant can only be achieved after ~50 hours of continuous operation.

The major achievement of the 1 MWth pilot test was that several such steady-state operating points were achieved for various make-up

rates, fuel types (hard coal and lignite), fuel particle sizes, limestone types, etc. CO₂ capture efficiencies above 90% could be achieved for several steady-state operating points.

★ What are the main difficulties you could face in upscaling to a 20 MWth plant and how would you overcome these?

As the reactors are based on well-known circulating fluidised bed technology, the scale-up of the reactors is rather straightforward. One challenge is to have proper control of the transfer of solids between the reactors. Various concepts have been discussed with experts in fluidised bed technology, and some of these concepts have been successfully tested in a scaled cold flow model. However, the main uncertainty for scale-up of CCL was





© Jochen Ströhle

JOCHEN STRÖHLE

actually the determination of the sorbent performance considering deactivation and dilution effects, as already discussed above. The results from pilot testing were used to validate models for the prediction of the sorbent performance, which could then be used to design the 20 MWth plant.

★ **What would you say are the project achievements you are most proud of?**

I am most proud of the fact that we managed to operate the pilot plant for more than 1 000 hours in CO₂ capture mode, so that it was possible to

generate a comprehensive database that can be used to validate models and reliably evaluate the CCL process.

★ **What has been the feedback from industry so far?**

GE Carbon Capture as the main driver of the CCL technology was deeply involved in the planning and evaluation of the 1 MWth pilot tests. They are very happy with the results, in particular, that we achieved steady-state conditions for various operating points. They now have more confidence in their design methodology of the CCL process.

The end users involved in the project, i.e. power plant utilities and cement manufacturers, were quite happy with the relatively low CO₂ avoidance costs for CCL.

★ **How is the 20 MWth plant coming along?**

The objective of SCARLET was to provide a basic design of the 20 MWth plant. So this plant has not yet been built. However, the layout and estimated costs are according to our expectations.

★ **What are the next steps now that the project is completed?**

The next step could be the construction and operation of a 20 MWth pilot plant for industrial demonstration of CCL technology. However, such a plant requires rather large resources with a high industrial participation.

“CCL is particularly interesting for cement plants, because a large part of their CO₂ emissions result from the calcination of the limestone.”

Unfortunately, the price for CO₂ certificates is rather low, so industrial partners, in particular power plant utilities, currently do not see a business case for CCS in the very near future. Rather high funding rates by authorities would be required to make this happen.

One interesting case could be CCL for cement plants, because cement plants and CCL require more or less the same resources, i.e. limestone. CCL is particularly interesting for cement plants, because a large part of their CO₂ emissions result from the calcination of the limestone, which cannot be omitted by using renewable energy sources. Hence, the erection of a 10-20 MWth CCL pilot plant located on a cement plant could be a feasible option for scale-up of CCL technology.

SCARLET

- ★ Coordinated by the Technical University of Darmstadt in Germany.
- ★ Funded under FP7-ENERGY.
- ★ <http://cordis.europa.eu/project/rcn/186062>
- ★ Project website: <http://www.project-scarlet.eu>

INTERVIEW

WEB-BASED TOOL HELPS SITE OPERATORS CHOOSE THE SAFEST CO₂ STORAGE OPTION

Before they can be licensed by public authorities and welcomed by the public, CO₂ storage plans first need to be perceived as safe and reliable. A key concern in this regard is the prevention of CO₂ leakage. Numerous options and strategies exist, but it's not always easy to identify the most suitable one.

MIRECOL (Remediation and mitigation of CO₂ leakage) performed a full-fledged analysis of both existing and upcoming remediation and mitigation techniques. Focusing on corrective measures inside or close to the storage reservoir, the project has gathered knowledge about the efficacy of these techniques and has made its conclusions available in a dedicated handbook and web-based tool.

Depending on the requirements of the site operator, the tool evaluates each technique according to its longevity, likelihood of success, spatial extent, response time and cost, and even allows for comparisons between different options.

Filip Neele, project leader at TNO and coordinator of MIRECOL, discusses the project's results and expected impact on the development of CCL technology in Europe.

★ **Your project focuses on CO₂ leakage. Would you say that the latter is a barrier to the implementation of CCS technology?**

Filip Neele: The risk of CO₂ leaking from its reservoir is not a barrier to the implementation of CCS. Proper site selection and site design will minimise this risk, while any remaining risk will be managed through monitoring. In the unlikely case where leakage does occur, site operators can

deploy corrective measures. The MIRECOL project has increased the number of options that are open to them.

★ **What were the main findings from the project related to existing and upcoming mitigation techniques?**

The main result from the project is that a storage site operator has many more options for corrective actions than those currently listed in corrective measures plans. The project has provided the starting point for storage site operators to build their corrective measures plan during site development and permit application, as well as the basis for deciding on suitable corrective actions should such a need arise.

★ **Is there a specific technique coming out as the best option?**

There is no single, best technique. In some cases changing the injection strategy will be sufficient, while in other cases a well workover may be required. The feasibility and efficacy of a specific corrective measure depend on the details of the specific storage site and of the irregularity that has occurred, as well as on the conditions at the surface where activities around the well or wells may be limited.

The MIRECOL project studied a large number of corrective measures that, together, cover a wide range of potential undesired events in or near the reservoir. While a real event in a real storage reservoir will always be different from the scenarios covered in the project, the results from the project will be useful to operators when making a first selection amongst the available techniques.

★ **What can you tell us of the results of your field demonstrations?**

There were two pilot sites used by the MIRECOL project: the offshore K12-B gas field in the Netherlands (operated by project partner ENGIE) and the Ketzin site in Germany (operated by project partner GFZ). These sites were used to study the efficacy of back-producing-injected CO₂ as a corrective measure.



© Filip Neele

FILIP NEELE



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At a third site — the Bečej CO₂ field in Serbia — sealant material developed within the project was tested. This injection test was executed by MIRECOL partner NIS (Serbia); the test produced promising results, which form the basis for further, larger-scale testing.

★ **What do you hope will be the impact of MIRECOL on the sector?**

The project has studied a large number of potential corrective measures, each in a large number of realistic scenarios. To make this dataset available to site operators, as well as to regulators, the project team has developed a web-based tool. From the database of results, the tool selects a scenario that best matches the situation defined by the user and shows the performance of relevant corrective measures.

With guidance from operators in the project consortium, the tool was developed so as to enable its use by future storage site operators when building their corrective measures plan, or by operators and regulators to discuss available options in the case of an undesired event in or near the reservoir. All reports produced by the project team are available from the project site: an online corrective measures 'handbook' provides easy access to these reports.

★ **What are your plans now that the project is completed?**

The project team will disseminate project results at conferences and events focusing on CCS. The project website will provide access to the web-based handbook and to the web-based tool which will be maintained and improved thanks to input from users. The actual impact of the MIRECOL project, at least in Europe, is expected when CCS projects are developed and start operating.

MIRECOL

- ★ Coordinated by TNO in the Netherlands.
- ★ Funded under FP7-ENERGY.
- ★ <http://cordis.europa.eu/project/rcn/186071>
- ★ Project website:
<http://www.mirecol-co2.eu>

NOVEL NANOMATERIALS BRING CCS EFFICIENCY TO THE NEXT LEVEL

If the world is to meet the targets set under the Paris Climate Change Agreement, new-generation, highly-efficient carbon capture processes are required. The INTERACT project is rising to this challenge with innovative materials and technologies.

The core objective of INTERACT (INnovaTive Enzymes and poly-ionic-liquids based memBRAnes as CO₂ Capture Technology) was to surpass the energy efficiency and cost-effectiveness of existing capture processes. To this end, the team relied on enzymes to provide extraordinary fast biocatalysts and developed highly efficient nanomaterials called 'polyionic liquids' (PILs). The latter were used to create highly selective membranes for gas separation, which in turn were integrated in innovative technologies.

'Current post-combustion processes, such as chemical scrubbing, face severe economic obstacles due to their high energy consumption,' explains Prof. Dr Andrzej Gorak, coordinator of the project for TU Dortmund. 'INTERACT provides a technological basis for advancing these processes: We notably enhanced the gas scrubbing process thanks to enzyme-catalysed solvent systems and innovative contacting equipment such as membrane contactors. Most importantly, we tried to exploit synergies between the high CO₂ capture affinity of our materials and intensified technologies, whilst analysing performance based on a detailed techno-economic and life cycle assessment.'

INTERACT required extensive experiments and detailed performance models for each technology, not only in the lab, but also at pilot scale. To identify suitable enzyme-solvent systems, for example, the team first performed activity tests with enzyme assays, whilst systems allowing for long-term stability were further investigated in terms of mass transfer improvements in dedicated lab-scale experiments in a wetted-wall column. Then, the most promising enzyme-solvent systems went through technical-scale absorption columns at different locations and with different diameters and packing heights.

'The implementation of effective enzymes allows for the exploitation of solvents with lower absorption heat and higher CO₂ capacity, which finally results in a significant reduction in the energy requirement of the chemical absorption process,' Prof. Dr Gorak points out. The combination of carbonic anhydrase and an aqueous



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MDEA solution with the new enzyme showed an improvement in CO₂ transfer by a factor of up to nine, and such a system can be applied to state-of-the-art scrubbing equipment. In the future, Prof. Dr Gorak is confident that even more improvements are possible.

Untapped potential

The project's gas membranes based on PILs also showed potential for improving the energy efficiency of the CO₂ capture process, although Prof. Dr Gorak says the economics still need to be improved: 'The developed concept of a hybrid membrane contactor, which combines the application of both PILs and enzymes, is an interesting concept that allows for the exploitation of the synergies between these materials, but it needs to be investigated in more detail before a final assessment can be made.'

The most selective, porous and dense PILs proved to be competitive sorbents for use in adsorption processes as well as highly selective and active layers in thin film composite gas membrane processes.

'Interestingly, one of the developed PIL materials, which was commercialised by one of the project partners, has aroused most interest so far in the field of electrochemical energy storage systems as a component of gel/polymer based electrolytes. It might help improve energy storage systems and the use of renewable energy,' says Prof. Dr Gorak.

Prof. Dr Gorak and his team made sure that, for each of the newly developed

technologies, suitable process concepts were made available to exploit potential benefits while taking into account potential restrictions. These concepts were all evaluated under an industrial CO₂ emission scenario. Detailed techno-economic and environmental evaluations showed that INTERACT technologies not only have the potential to significantly reduce the environmental impact of coal-fired power plants and other CO₂ emitting processes, but also outperform state-of-the-art amine scrubbing process.

In the future, Prof. Dr Gorak foresees applications beyond efficient CO₂ capture from power plant flue gas. These include cement flue gas and biogas treatment: 'Applying our technologies to produce "Renewable natural gas" (RNG) would give a push to more sustainable transportation fuels. There is an important potential in this sector where relatively large biogas infrastructures already exist. Moreover, RNG is a "drop in" fuel that can also be used as a diesel replacer for shipping and high-horsepower vehicles where few low carbon alternatives exist.'

One thing is certain: the project's materials will certainly keep getting talked about over the years to come.

INTERACT

- ★ Coordinated by TU Dortmund in Germany.
- ★ Funded under FP7-ENERGY.
- ★ <http://cordis.europa.eu/project/rcn/109973>
- ★ Project website: <http://interact-co2.eu/>

USING NANOSCALE OPHIOLITIC ROCKS TO CAPTURE AND SEQUESTER CO₂

Ophiolitic rocks' high reactivity and abundance make them an ideal candidate for CO₂ capture and storage. Drawing on the world's best-preserved ophiolite complex and a process known as 'ball milling', the CO2NOR project has been building novel nanomaterials to provide a safe, long-term CCS solution that will notably appeal to the building industry.

Remnants of ancient oceanic crust and upper mantle, ophiolites have been uplifted by tectonic activity and thrust onto the edge of continents and/or incorporated into mountain belts. CO2NOR (Carbon dioxide storage in nanomaterials based on ophiolitic rocks and utilization of the end-product carbonates in the building industry) specifically focuses on ophiolitic rocks from Cyprus' Troodos Mountains — the country's largest mountain range.

'The Troodos ophiolite is the most intact worldwide,' says Dr Ioannis Rigopoulos, Postdoctoral fellow at the University of Cyprus. 'It is the closest thing we have to a complete ophiolite sequence which consists, from bottom to top, of a clearly defined sequence including ultramafic, mafic, hypabyssal and extrusive rocks.'

This sequence is typically what makes ophiolitic rocks particularly attractive for CO₂ capture and storage, as Dr Rigopoulos explains: 'The reactions between these rocks and CO₂ create carbonate minerals (mineral carbonation), which are stable over geologic timescales. Hence, sequestration by mineral carbonation eliminates any risk of leakage back to the atmosphere. Additionally, the global abundance and low cost of ophiolitic lithologies are crucial parameters, taking into account that we need these rocks to mitigate the global problem of climate change.'

To do so, CO2NOR converts ultramafic and mafic ophiolitic rocks into nanomaterials using the ball milling process — a grinding technique used to turn a material into ultrafine powder. By applying this technique to reduce the particle size of ophiolitic rocks to the nanoscale, Dr Rigopoulos and his team aimed to hasten the reactions occurring between ultramafic/mafic rocks and CO₂, more specifically the natural process

that controls atmospheric CO₂ concentrations over geologic timescales.

'Our results clearly show that we can substantially increase the carbon sequestration capacity of ultramafic and mafic rocks by reducing their particle size to the nanoscale,' Dr Rigopoulos says. 'The fact that large volumes of ophiolites occur on almost every continent makes us believe that a significant mass of the CO₂ emitted to the atmosphere every year could be sequestered using the proposed CCS method.'

The University of Cyprus also conducted experiments on waste materials from quarries operating in the Troodos ophiolite in order to highlight the sustainability of the process. 'So far, we have performed more than 100 ball milling experiments in a variety of rocks/waste materials, and we have determined the optimum ball milling conditions for each one. The experimental results demonstrated that even ball-milled waste materials from ophiolitic quarries could be used as a feedstock for the *ex situ* mineralisation of CO₂,' Dr Rigopoulos explains.

From next-gen building materials to geoengineering

The nanomaterials resulting from the process were successfully used in the production of environmentally-friendly, nano-modified building materials. These composite materials, lime-based mortars, enriched with nanostructured quarry waste materials, present enhanced engineering properties and a potential capacity to sequester CO₂, which Dr Rigopoulos hopes will appeal to the construction industry — one of the biggest emitters of CO₂. The nanostructured quarry wastes can be used to replace lime binder, the

"Even ball-milled waste materials from ophiolitic quarries could be used as a feedstock for the ex situ mineralisation of CO₂."

SPECIAL FEATURE

production of which is responsible for a substantial part of these emissions.

But Dr Rigopoulos and his team do not plan to stop there. 'Together with our collaborators at the National Centre for Scientific Research — CNRS (France), we designed a number of experiments related to the new field of geoengineering or climate engineering, which is the large-scale human intervention in the Earth's natural systems to counteract climate change. The results of these experiments were very promising.'

Specifically, the team assessed the potential drawdown of CO₂ directly from the atmosphere by the enhanced weathering of nanoscale peridotites and basalts in seawater. The results demonstrated that ball milling can substantially enhance the weathering rate of peridotites in marine environments, promoting the permanent storage of CO₂ as environmentally benign carbonate minerals.

'It is worth mentioning that this enhanced weathering process removes carbon directly from the atmosphere, providing capture and storage in a single step. In this approach, the

CO₂ storage reservoir is the ocean, which covers over 70% of the Earth's surface. In addition, the enhanced weathering of nanoscale peridotites in seawater may also avert ocean acidification, which has drastic consequences for marine ecosystems,' Dr Rigopoulos points out.

In the future, the University of Cyprus hopes to build upon this research and improve its understanding of nanoscale rock materials. This entails further investigation into the efficiency of the proposed CCS approach over the longer term and, for geoengineering, emphasis on its effects on marine life.

CO2NOR

- ★ Coordinated by the University of Cyprus in Cyprus.
- ★ Funded under H2020-MSCA-IF.
- ★ <http://cordis.europa.eu/project/rcn/194929>
- ★ Project website: <http://www.co2nor.ucy.ac.cy>

CLEANER COAL POWER THROUGH COMBINED TECHNOLOGIES

Retrofitting a combination of carbon capture technology to existing coal fired power plants could help facilities reduce their emissions and meet stringent environmental targets, say EU researchers.



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The EU-funded ECO-SCRUB (Enhanced capture with oxygen for scrubbing of CO₂) project investigated — from a technical point of view — whether methods for retrofitting carbon capture technology to existing power plants could achieve environmental and economic efficiencies. 'Carbon capture and storage' (CCS) involves capturing waste 'carbon dioxide' (CO₂) from power plants and transporting it to a storage site, where it will not enter the atmosphere.

'For coal fired plants there are two key possible techniques; oxygen enrichment and post-combustion solvent scrubbing,' explains ECO-SCRUB project coordinator Dorian Matts from RWE Npower in the UK. For example, CO₂ can be removed from post-combustion flue gas using regenerable solvents; the most frequently used for CO₂ capture is 'monoethanolamine' (MEA), an amine solvent. Power plants can also put in place new procedures to increase efficiency.

These options for reducing CO₂ emissions from coal fired plants present significant cost and technical issues. 'The technologies available to greatly reduce or eliminate CO₂ from flue gas are expensive, have a large footprint and have significant energy demands that also impact significantly on the market position for coal fired plants,' explains Matts.

Harmonious solution

In order to address this, the ECO-SCRUB project sought to determine whether it

was technically feasible to combine parts of both of these techniques in order to achieve efficient and more sustainable operations. The project team began by evaluating the impact of enhancing the oxygen content in the air feed and using existing generation carbon capture scrubbing on coal combustion. They also assessed flue gas recirculation, which can help with respect to reducing corrosion and SO₂ emissions.

‘We were able to demonstrate that the concept is credible and has advantages for retrofitting on existing coal fired plants,’ says Matts. ‘We were able to determine what the likely design conditions would be — the amount of oxygen to inject and where; which current amine solution to select; and the amount of flue gas recirculation — to avoid higher NO_x emissions or increased corrosion rates on the plant.’

The ECO-SCRUB project also addressed issues relevant to conventional capture, with results that could have wider applicability to new plant construction and

ongoing carbon capture research. ‘If existing coal fired plants can survive long enough economically for the rest of the carbon capture and storage infrastructure to be put in place, then this appears to be an interesting and credible option for retrofitting,’ says Matts.

‘For example, European manufacturers may be able to develop this technology for retrofitting on newer existing coal fired power facilities globally. This in turn could help other countries, such as India and China, meet their Paris Agreement commitments.’

Going forward

The technology could help fossil fuel plants navigate increasingly treacherous waters. The EU’s Emissions Trading System (EU ETS) and other carbon pricing mechanisms have severely impacted on the relative competitiveness of coal generated power. ‘The requirement to address acid rain pollutants (NO_x and SO_x) has also resulted in significant investment

“We were able to demonstrate that the concept is credible and has advantages for retrofitting on existing coal fired plants.”

in flue gas cleaning technology in coal fired plants,’ adds Matts.

Moving forward, achieving economic efficiency is therefore key to this sector, as is regulatory support. ‘Clear and stable environmental policies are now required to enable investment in CO₂ capture, combined with the development and implementation of the transport and storage parts of the CCS approach,’ says Matts.

ECO-SCRUB

- ★ Coordinated by Npower in the United Kingdom.
- ★ Funded under Research Fund for Coal and Steel.
- ★ <http://cordis.europa.eu/project/rcn/87195>

INTERVIEW

CHEMICAL LOOPING COMBUSTION FOR CO₂-NEUTRAL GAS FACILITIES

A novel gas combustion method removing the need for expensive gas separation has been successfully scaled up. The novel method has gas-to-steam efficiency penalties much lower than alternative CO₂ capture technologies, as well as a CO₂ avoidance cost reduced by 60% compared to amine scrubbing. The consortium is already looking to extend it to biomass combustion.

Although cleaner than crude oil or coal combustion, current methods for combusting natural gas still generate CO₂ as part of a flue gas mixture including nitrogen, water vapour and other substances.

In this form, the CO₂ cannot be stored or recycled. This has pushed researchers funded under the SUCCESS (Industrial steam generation with 100% carbon capture and insignificant efficiency penalty — Scale-Up of Oxygen Carrier for Chemical-looping Combustion using Environmentally Sustainable materials) project to look for a viable, alternative combustion method which they found in ‘Chemical looping combustion’ (CLC).

★ What makes CLC such a high potential solution for carbon capture and storage?

Dr Stefan Penthor: The biggest advantage of the CLC technology is the fact that air and fuel are never mixed, whilst the energy intense gas-gas-separation step (separating CO₂ out of an exhaust gas stream), which is common in other carbon capture technologies, is avoided. This dramatically reduces the energy penalty of CO₂ separation.

★ What was the role played by SUCCESS in its further development?

The SUCCESS project focused on the two most important aspects of the technology: Scaling-up of oxygen carrier production and scaling-up of the reactor system



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STEFAN PENTHOR



design. The main objective of the project consisted in making CLC technology ready for demonstration in the range of 10 MW fuel power input. For that purpose, production processes for oxygen carrier material were scaled up to the multi-tonne scale and a reactor concept suitable for this size was presented.

★ **What were the main difficulties you faced and how did you overcome them?**

The main difficulties lay in the scaling-up of the oxygen carrier material from lab scale to multi-tonne scale. This scaling-up includes two critical aspects: The identification of raw materials available at industrial scale/quantities and the scaling-up of the production process itself.

“The biggest potential for CLC of gaseous fuels, such as natural gas or refinery gas, is in industrial steam production.”

Large-scale production of oxygen carrier material is performed using raw materials which have more impurities than clean chemicals used at lab scale. The challenge is to identify the impacts of these impurities on the final product and to select the most suitable raw material. These problems were solved during the project, and material production was successfully scaled up with the production of 3.5 tons of material.

The approach consisted in the iterative optimisation of large-scale production, i.e. regular feedback during scale-up process from testing in pilot units. However, we still see further potential for optimisation of the production process, leading to better-performing materials.

★ **How did the validation phase go?**

The validation phase went very well. The produced materials have been tested in several pilot units from

10 kW to 1 MW. Operation with these materials was successful in all units. Comparison with benchmark materials shows that the performance of the scaled-up material is similar to that of the benchmark material.

★ **What did you learn regarding the commercial potential of CLC?**

The techno-economic analysis of the technology showed that the biggest potential for CLC of gaseous fuels, such as natural gas or refinery gas, is in industrial steam production. We also saw how critical it is to make the step to move on to the next scale (in the order of 10 MW) to gain operational long-term experience with the CLC technology.

★ **Do you have any follow-up plans?**

Based on the results of the project, we are confident that the technology is ready for demonstration at the next scale. There are, however, no specific follow-up plans for demonstration projects yet.

It would also be of great interest to develop CLC technology for the use of biomass towards below-zero emission energy production. In light of the remaining carbon budget for a below 2 °C increase, Bio Energy CCS (BECCS) is gaining more and more importance. This has also been underlined in the last assessment report of the IPCC. We see a great potential for CLC in this field.

SUCCESS

★ Coordinated by TU Wien in Austria.

★ Funded under FP7-ENERGY.

★ <http://cordis.europa.eu/project/rcn/110098>

HEALTH

FIRST IN-MAN STUDIES DEMONSTRATE HIGH PREVALENCE OF DIABETES AND CARDIOVASCULAR DISEASE IN SHIFT WORKERS

Existing epidemiological studies have shown a correlation between shift working and a higher prevalence of type 2 diabetes and cardiovascular disease. The EURHYTHDIA project has developed predictive biomarkers and prevention strategies that should help identify and protect patients at risk.

The circadian clock, more specifically its so-called clock genes, is basically the programme that tells us when to sleep, wake up or eat. In shift workers, however, this body clock is deeply challenged, to the point where it may lead to diabetes and cardiovascular disease, as well as insulin resistance and disturbances in glucose metabolism.

With no existing study in human subjects, the EURHYTHDIA (Chronotherapeutic lifestyle intervention for diabetes and obesity to reset the circadian rhythm and improve cardiometabolic risk in the European working population) team was left with two questions to answer: What's the causality between inner clock rhythm disturbances and the development of type 2 diabetes? Does the re-setting of the circadian clock through the likes of exercise, diet, light exposure and melatonin intake alter cardiometabolic risk to a clinically relevant degree?

'At the beginning of the project, it remained unclear to what extent shift work may directly influence gene expression of the clock system and whether certain markers may be predictive for the development of diabetes and cardiovascular disease in shift workers,' Prof. Rainer Böger, coordinator of the project and director of UKE Hamburg, recalls.

To close this gap in knowledge, EURHYTHDIA aimed to establish novel predictive markers for the development of diabetes and cardiovascular disease in

shift workers. The team also tested whether interventional strategies such as light therapy, melatonin or physical activity may reset the clock system, and whether similar strategies may have an impact on the conversion from pre-diabetes to diabetes in patients at risk. Tests were run on healthy night shift workers, whilst people with a history of metabolic syndrome or diabetes were excluded.

'Evidence from the cross-sectional study on night shift nurses in Italy identified early metabolism and vascular alterations compared to the control group,' Prof. Böger explains. 'The analysis showed that even after stopping working on the night shifts for a few years, the same defects were found among these nurses, potentially suggesting the maintenance of metabolic memory even post night shift work. Other factors such as epigenetics and other mechanisms are being investigated.'

In a clinical trial, light therapy was demonstrated to have no effect on glucose metabolism among nurses, at least for a short intervention period of three months.

Towards early detection in patients

Pre-clinical studies on mice were more fruitful, as Prof. Böger emphasizes: 'Our team in Lille demonstrated that Rev-erb- α , a regulator of the circadian clock, is also a pharmacological target for restoring circadian rhythms, thereby improving metabolic homeostasis and

reducing inflammation. This may have important clinical implications in diabetes and atherosclerosis.'

In Helsinki, another project team validated zebra fish larvae as a reliable and cost-effective animal model for sleep and circadian studies. This should allow for faster response to specific research questions related, for instance, to the additive effects of lighting conditions, sleep deprivation and nutritional factors on the behaviour and physiological functions of larvae. 'The results can help recognise potentially identical effects in humans. When necessary, the model can also provide recommendations for arranging work shifts, nutrition and light schedules in a way that would induce minimum harmful effects on workers.'

All in all, EURHYTHDIA may lay the foundations for future research and general recommendations for shift workers. It also paves the way for future clinical studies to identify effective strategies to reduce cardiovascular morbidity and mortality in shift workers.

EURHYTHDIA

- ★ Coordinated by UKE Hamburg in Germany.
- ★ Funded under FP7-HEALTH.
- ★ <http://cordis.europa.eu/project/rcn/101286>
- ★ Project website: <http://www.eurhythdia.eu>

NEW DEVICE ALLOWS PEOPLE WITH HEARING LOSS TO HEAR WITH LIGHT PULSES

EU-funded researchers pioneered the development of laser-based implantable technology that has the potential to improve hearing restoration of conventional cochlear implants based on electric stimulation.

Nearly 70 million adults in Europe suffer from hearing loss greatly enough to negatively affect their quality of life, and numbers are expected to reach about 90 million by 2025. Cochlear implants, which are surgically implanted devices, have already proved that they can transform the daily lives of hearing-impaired patients.

Conventional cochlear implants transmit a signal to an array of electrodes placed in the cochlea, which in turn electrically stimulate the cochlear nerve causing it to send signals to the brain. Electrical stimulation is, however, limited in many aspects, mainly because the cochlear shape limits the options of narrowly focusing the electric field in the desired region.

With EU funding, the project ACTION (Active implant for optoacoustic natural sound enhancement) overcame challenges associated with spatial constraints related to cochlear implants based on electric stimulation. Researchers developed an optoacoustic single-channel device that has the potential to free up the outer ear and offer patients a greater degree of freedom.

Listening with light

ACTION built on the discovery that pulsed infrared laser light is capable of triggering auditor activity in hair cells. 'The project relies on the use of laser light to create a sound wave in the fluid of the cochlea,' explains project coordinator Mark Fretz. 'Unlike conventional implants which use electric currents, optoacoustic stimulation relies on functional hair cells to convert sound waves to electric signal.'

Laser light is used to produce a sound wave travelling in the cochlea fluid that moves the tiny hair cells. In response, these generate an electric signal travelling along the auditory nerve to the brain where it is perceived as sound.

The device used as a light source for optical stimulation is a 'Vertical cavity surface emitting laser' (VCSEL) with optimised wall plug efficiency in the infrared part of the spectrum. Given that high-intensity light is more likely to generate an audible sound in the cochlea fluid, project partners designed a new ultra-thin lens made of silicon to collimate the VCSEL light. The VCSEL was hermetically sealed inside a biocompatible sapphire box to protect it from bodily fluids and prevent any toxic materials affecting the body.

ACTION selected sapphire due to it being biostable, biocompatible, and with very low permeation with regard to water vapour as well as the optical transparency necessary for the device.

Project partners also worked on the development of a biocompatible flexible substrate that accommodates the metal lines needed to connect the VCSEL to the power supply. Specially designed antifouling coatings can impede growth of body tissue on the sapphire package. Adhered body tissue absorbs the VCSEL light and thus reduces device efficiency.

Optimising functionality

The newly developed miniaturised device has the size of an average laptop adaptor. The next-generation device will be capable of measuring the optoacoustically generated 'Compound action potentials' (CAPs).

'This is the first time that use of a light source fully inserted into the unmodified cochlea can trigger the generation of a CAP,' explains Mr Fretz. 'Until now, CAPs in the cochlea could only be achieved with external light sources connected to a fibre optic light guide or with optogenetically modified cells.'

Until the implementation of such systems, there are a number of challenges that need to be overcome. These include further miniaturisation of the sapphire package to be inserted further in the cochlea. In addition, the device's power consumption has to be reduced by at least a factor of two to achieve an acceptable operation time before battery recharge.

ACTION's new device requires the presence of the hair cells in the cochlea. Patients who lack functioning hair cells in a certain region may in the future benefit from the use of a conventional cochlear implant and a laser-based one integrated in a single device.

ACTION

- ★ Coordinated by CSEM in Switzerland.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110222>
- ★ Project website:
<http://action-project.eu/>



A LESSON ON PATHOGEN MANIPULATION OF HOST IMMUNITY

Drug-resistant infections kill thousands of people annually and these numbers are expected to rise. There is an overall consensus on the need for novel effective therapeutics.

According to the World Health Organisation, *Klebsiella pneumoniae* is considered a health-threatening microbe and antibiotic-resistant strains pose a serious clinical problem in many hospitals worldwide.

The lack of antimicrobials and antiviral therapies combined with the very few new drugs that have entered the market in the past years emphasise the need for novel targets and compounds.

Delineating the mechanisms employed by human pathogens to evade host immunity will set the grounds for the development of innovative therapies that enhance innate resistance to infection. The EU-funded INBIONET (Infection biology training network: shaping the future of infectious diseases treatments) project embarked on the analysis of bacteria, viruses and enteric parasites to identify cellular pathways important for infection as well as pathogen determinants involved in disease progression. Their work focused mainly on *Klebsiella pneumoniae*, *Helicobacter pylori*, *Streptococcus* species, and *vaccinia* and influenza viruses.

A new strategy for the identification of drug targets

'Interference with pathogen virulence and signalling pathways hijacked by pathogens for their own benefit is thought to apply less selective pressure for the development of resistance than traditional strategies, which kill pathogens or prevent their growth,' explains project coordinator Prof. Bengoechea.

Researchers investigated how innate immune system manipulation could be utilised to tackle infections. They uncovered several hitherto unknown anti-immune strategies employed by human bacterial pathogens.

Scientists observed that although each pathogen employed unique molecular pathways, they all exploited the same mechanisms that our body uses to return to homeostasis upon infection. The most common anti-immune strategy employed by pathogens was interference of their detection. This was exemplified by *Klebsiella pneumoniae*,



which manipulated macrophages to avoid immune control.

A signalling pathway dependent on the production of interferons — currently known to be employed by the host against viruses — was illuminated. Scientists discovered that interferons help defend us against bacterial infections and minimise tissue damage. Using interferons, they were able to fight *Klebsiella pneumoniae* infection and decipher the strategies used by the pathogen to counteract the beneficial effect of interferons.

Innovative technologies

The INBIONET consortium developed several new *ex vivo* models to investigate host-microbe interactions. These included three-dimensional organoids to assess the immune response to *Helicobacter pylori*, the causative agent of gastric cancer as well as an *ex vivo* lung infection model to investigate *Klebsiella pneumoniae*.

Additional cell-based assays were generated for high-throughput screenings, to determine pathogen effects on the activation of immune defence pathways and cell-intrinsic immunity. Furthermore, the consortium developed pre-clinical models to investigate compounds targeting cellular components for the potential to clear infections. These models have important translational impact and have been instrumental to

investigate the health problem of viral-bacterial co-infections.

From a drug discovery perspective, scientists will test now a number of drugs already approved for use in humans against *Klebsiella pneumoniae*. Given the extensive body of evidence available on the pharmacodynamics, lack of toxicity and potential side effects for these drugs, researchers envisage a fast transition to clinical trials.

'A cornerstone of our programme was the truly collaborative nature of our research bridging different fields of research, and providing an unprecedented opportunity to train early stage researchers at the cutting edge of infection biology research,' states Prof. Bengoechea. Raising public awareness on antibiotic resistance and the threat of multidrug resistant pathogens was equally important and was made through a public engagement programme and the project website.

Overall, the INBIONET findings significantly advance our understanding of microbial strategies and will undoubtedly shape the future treatments of infections.

INBIONET

- ★ Coordinated by Queen's University of Belfast in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105108>
- ★ Project website: <http://www.inbionet.eu>

MAJOR ADVANCES IN BIOENGINEERED HEART IMPLANTS

'Tissue engineering' (TE) and 'regenerative medicine' (RM) will be at the core of heart surgery in the future. An EU initiative generated a platform of expertise to supply top-class training for researchers to enable development of bioengineered cardiovascular implants.



Europe has a shortage of trained scientists in the rapidly emerging areas of TE and RM. The EU-funded TECAS (Towards tissue engineering solutions for cardiovascular surgery) project developed a multidisciplinary and intersectorial training programme for 'Early stage researchers' (ESRs).

Repair and replacement for a broken heart

Sotiris Korossis, project coordinator, elaborates: 'The TECAS-ITN structured doctoral training in cardiovascular TE at a European level by creating a cross-European research and training infrastructure, further enhancing European competitiveness in TE and RM.' The Initial Training Network (ITN) team focused on cardiac valve replacement/repair, myocardium (heart muscle tissue) reconstruction and patch graft angioplasty to repair large blood vessels.

Researchers used biological tissues that were treated to remove their cells, with a view to producing acellular non-immunogenic scaffolds so that they would not invoke an immune response on implantation. These scaffolds can then either be implanted directly to the patient, or reseeded with the patient's own cells and trained in the laboratory under physiologically relevant physical stimuli to acquire complete biological and biomechanical functionality prior to implantation.

The success of the project is reflected in the number of developments for commercial exploitation, readily translatable to clinical practice. 'Specifically, the infrastructure has enabled the rapid translation of a semi-automatic pattern recognition method for histopathological assessment of images in the Hannover Medical School practice. Moreover, the developed sterilisation and preservation methodologies for decellularised valvular scaffolds are being used by Corlife oHG in production,' emphasises Korossis.

To appear in the clinic shortly

TECAS-ITN research has generated a number of disruptive technologies destined for significant medical impact. Particularly

notable are flow bioreactors for the functional assessment of valve scaffolds to determine long-term fatigue and calcification as well as scaffolds for cardiovascular patching. 'This,' explains Korossis 'together with a non-destructive method for quality control of seeded TE constructs, is expected to streamline the development and quality production monitoring of the scaffolds for safe clinical use, significantly reducing the need for animal testing.'

The three novel valve prostheses and the living myocardial patch developed in the project are expected to promote tissue remodelling and regeneration, reducing the need for costly revision surgery. Importantly, the calcification bioreactor and the patch enable monitoring of calcification and myocardial infarction respectively and new therapies can be studied *in vitro* for these conditions.

TECAS-ITN research produced five patentable technologies, including an *in vitro* calcification system, anticalcification treatment for scaffolds, a decellularised pericardial percutaneous heart valve, and the pattern recognition method for quality control of tissue-engineering constructs. Emphasising the commercial potential, Korossis points out that 'external companies have expressed interest in the exploitation of all five technologies, which will be commercialised once the relevant patents have been granted.'

Spreading the word on TECAS technology

Wide dissemination includes 19 peer-reviewed papers with another 19 in preparation. In addition, an impressive total of 47 podium and poster presentations were made by the ESRs at major conferences. The ITN researchers have also published six Wiki articles.

The TECAS consortium organised eight cardiovascular TE symposia in major conferences, whereas the ESRs organised and participated in seven science fairs with exhibits, workshops and lectures. Five summer schools were held for secondary school students and teachers, which will continue to run annually. The educational net was extended to primary school workshops and seminars were held to inform patients about new advancements in heart valve TE.

Korossis summarises TECAS' significance. 'Overall, the TECAS-ITN produced a cohort of translatable and enabling technologies that will produce significant and direct scientific, clinical and commercial benefits to a range of different stakeholders, including the wider academic and cardiothoracic surgeon communities, and the medical devices industrial sector. Patients will be the ultimate beneficiaries by receiving safer implants with personalised potential, reducing the need for revision surgery.'

TECAS

- ★ Coordinated by Hannover Medical School in Germany.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105000>

LEPTIN: A BETTER ALTERNATIVE TO INSULIN THERAPY?

Insulin administration constitutes practically the sole intervention for millions of diabetes sufferers worldwide. However, the side-effects of the therapy necessitate novel, safer alternatives.

Type 1 diabetes mellitus' (T1DM) constitutes the insulin-deficient form of diabetes caused by pancreatic β -cell loss. Emerging evidence challenges the dogma that insulin is a pre-requisite for survival as it does not restore normal metabolic homeostasis. Instead, it causes ectopic lipid deposition increasing the risk of heart disease. Furthermore, its capacity to rapidly clear glucose from the bloodstream often leads to hypoglycaemia.

As early as 1995, another hormone, leptin — known for its role in body weight and food intake control — proved to have anti-diabetic properties at least in rodents. In these experiments, systemic leptin administration at low doses ameliorated hyperglycaemia and demonstrated that insulin was dispensable for normal glucose and lipid metabolism. Additional studies indicated that leptin reverses the consequences of insulin deficiency and 'because it doesn't cause hypoglycaemia and lowers circulating lipid levels, it represents an attractive adjuvant therapy for T1DM,' explains project coordinator Dr Coppari.

The precise mechanism of action of leptin remains unknown. Scientists on the EU-funded LEPTINT1DM (Unravelling the mechanism underlying the anti-diabetic action of leptin) project investigated the hypothesis that the anti-diabetic function of leptin was mediated by the hypothalamus. Previous work by the consortium had shown the involvement of the central nervous system in regulating glucose homeostasis in response to leptin. 'In the present study, we wished to further delineate the mechanism and examine if hypothalamic neurons mediated leptin's anti-T1DM action,' states Dr Coppari.

Leptin administration in preclinical models of T1DM

To examine the efficacy of leptin therapy in T1DM, researchers generated mice lacking or expressing leptin receptor only in specific hypothalamic neurons. These hypothalamic 'proopiomelanocortin' (POMC) neurons belong to the central melanocortin system, known for its role in body weight control through regulation of appetite and

energy expenditure. POMC neurons have been shown to control glucose metabolism in insulin-normal animals.

Subsequent destruction of the pancreatic insulin-producing beta-cells rendered these mutant mice diabetic. Following intracranial administration of leptin, scientists monitored the clinical symptoms of T1DM over time. They observed that in mice lacking leptin receptors only in POMC neurons, administration of leptin did not lower hyperglycaemia. The same effect was seen in diabetic mice expressing leptin receptors only in POMC neurons after leptin administration.

Collectively, the findings of the LEPTINT1DM study demonstrated that leptin receptors on POMC neurons were required for mediating only a marginal component of the hyperglycaemia-lowering effect of leptin. POMC neurons played a minor role in leptin's anti-diabetic action suggesting that other neurons are involved. In subsequent experiments, when scientists expressed leptin receptors on both GABAergic and POMC neurons they observed that leptin engagement with these receptors mediated its life-saving and antidiabetic effects in the context of insulin deficiency.

Clinical translation of leptin monotherapy

Insulin therapy bears several limitations and underlies a number of morbidities that threaten the lives of insulin-deficient patients. Although preclinical results of leptin administration seem hopeful, clinical trials have failed to show effectiveness of leptin administration in patients who do not lack leptin.

Comprehensively understanding the neuronal and molecular mechanisms of leptin function in diabetes should aid in identifying new targets to counteract the metabolic dysfunctions caused by insulin deficiency. These targets will serve as the basis for the development of improved anti-T1DM strategies without the risks of hypoglycaemia and cardiovascular disease. In fact, harnessing the hypothalamic neural circuits and their downstream effector components may improve hyperglycaemia in cases of insulin deficiency.

LEPTINT1DM

- ★ Coordinated by the University in Geneva in Switzerland.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105033>



DON'T LET A GOOD CRISIS GO TO WASTE

By examining the impact that large-scale crises have on consumer behaviour and business performance, EU-funded researchers have created a blueprint for responding to — and thriving in — such crises.

In school one is always taught to learn from one's mistakes. And why shouldn't this hold true when that mistake is a business, industry or even a global economic crisis? This is exactly the thinking of EU-funded researchers with the CONCRISIS (Never waste a good crisis. Dealing with the impact of crisis situations on consumer behaviour and firm performance) project, who believe one should never let a good crisis go to waste.

The project examined the impact large-scale crises or turbulence have on both consumer behaviour and business performance. Consisting of two stages, first, researchers looked at consumer reactions to business-specific service-performance crises. This in turn was followed by a second study that looked at the impact business advertising and

pricing actions have on consumer behaviour throughout the year.

'As to this second part, our research was guided by two key questions,' says Project Coordinator Dr Maarten Gijsenberg. 'Do consumers react equally to advertising and price decreases and increases and, based on this, what should firms do given tight budgets? Second, given these reduced spending levels, how can firms communicate the value of innovation in order to make a product more successful?'

The objective of both studies was to identify how businesses can best respond to such crises or turbulence in order to identify opportunities for growth, both in the short and long run.

Long-lasting effects

According to the first study, service crises can have long-lasting detrimental effects on businesses. 'Such crises will lead to clear drops in consumer satisfaction with a business, which will last over time,' says Gijsenberg. 'Equally sized improvements, however, have only a small effect that are not permanent and tend to dissipate over time.'

Knowing this, CONCRISIS recommends that businesses try to be as consistent as possible with their customer service and do their utmost to avoid any major disruptions to their service. Furthermore, when a crisis does hit, a business cannot expect to reach pre-crisis service levels without sustained better performance. 'Just improving once is not enough, and may even backfire, resulting in lower

consumer satisfaction,' says Gijsenberg. 'Instead, what we found is that sustained improvements in service performance result in sustained higher levels of customer satisfaction.'

Ups and downs

The results from the second study showed that consumer reactions to a business' advertising and pricing actions are not constant over the course of a year. Instead, they depend on intra-year cycles characterised by periods of high demand followed by periods of low demand. Although businesses do adjust their advertising and pricing over a year, these adjustments are not usually in-line with changes in consumer demand.

'As consumers are more advertising-sensitive in periods of high demand, brand-focused strategies that

communicate the distinct features and advantages of the product over a competitor's product will be the most effective during such periods,' says Gijsenberg. 'In periods of low demand, consumers tend to care more about price than brand, and a business should adjust their strategies accordingly.'

Practical guidelines

With this insight in hand, businesses now have clear and practical guidelines on how to deal with — and even benefit from — different types of crises by means of investments in marketing and innovation.

'The CONCRISIS findings are and will continue to be highly relevant to businesses in improving their long-term success, health and viability,' concludes Gijsenberg. 'It helps ensure

"Consumer reactions to a business' advertising and pricing actions are not constant over the course of a year."

their role in the creation of value for society and overall welfare through, for example, sustained job creation.'

CONCRISIS

- ★ Coordinated by the University of Groningen in the Netherlands.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106386>

MOBILISING FOR DEMOCRACY — THE POWER OF SOCIAL MOVEMENTS AND CIVIL SOCIETY

EU-funded researchers have provided valuable insights on how social movements and civil society contribute to democratisation processes but also empower political change in already firmly established democracies, looking at several varied case studies from across the world.

The results from the MOBILIZING4DEMOCRACY (Mobilizing for democracy: Democratization processes and the mobilization of civil society) project indicate that popular social movements and civil society organisations play an important role in democratisation processes by intervening in opposition to authoritarian regimes, transition to democracy, democratic consolidation and democratic deepening.

Whilst the underlying reasons behind the political, social and cultural conditions of many popular mobilisations for democratic reform are complex, they often share a single characteristic,

"Progressive social movements, even in an age seemingly dominated by populism, should not be written off just yet."

coordinator Professor Della Porta explains — they were unexpected. Such movements also often centred around one particular public space (for example, Tahrir Square in Cairo

or Maidan Square in Ukraine) that becomes the defining symbol of citizens struggling for democratic change.

'Intense emotions experienced during such protests (or even through a "virtual" participation in them through social media) changes not only the way in which people perceive their environment, or assess their chances of success, but also, more deeply, their motivations, perceptions and interests,' explains Prof. Della Porta. 'Those who remained at home because they feared repression, become instead outraged and feel they "must be there" — because their friends are there, but also because they start to identify with the strangers that they meet.' By keeping the main site

of protest open to all, social movements also put a special emphasis on the inclusivity of the process, aimed towards facilitating real political, economic and social change.

Social movements on both left and right

Social movements and civil society organisations are not just catalysts for change in newly-democratising states. Recent political events in established democracies, such as the UK's vote for Brexit and the election of Donald Trump in the United States, have been interpreted as a lurch towards populism, led by right-wing movements and fuelled by working-class grievances over globalisation.

However, data has shown that wealthy, educated people also voted substantially for Brexit and for Trump. 'Money was injected into media campaigns that spread simple messages, and often lies, appealing to fear and focusing outrage on scapegoats,' says Prof. Della Porta. She notes that research into right-wing popular movements has long singled out a cultural demarcation, with cosmopolitanism on one side and xenophobia on the other, that separates them from the left.

Prof. Della Porta argues though that the research undertaken in MOBILIZING4DEMOCRACY has shown progressive social movements, even in an age seemingly dominated by populism, should not be written off just yet. She points to the fallout from the 2008-2009 financial crisis in Southern Europe that saw the rise of left-wing social movements that have fundamentally challenged and altered established political systems (examples include Podemos in Spain and Syriza in Greece). 'In recent public debate, these progressive movements on the left, however, have been



temporarily outweighed by the success of right-wing parties and movements,' she argues. 'But they're definitely not out of the picture for good!'

Beyond the project

MOBILIZING4DEMOCRACY has been an extremely productive project, churning out 20 books and hundreds of articles and chapters. The quality of the project's research has also been recognised as being theoretically innovative and empirically rich.

Prof. Della Porta is now finalising two books related to the project — one on the debate on citizenship following the Charlie Hebdo attacks in France (studied by the project as an example of democratic responses to incidents they designate as 'critical junctures') and one on social movements and the European refugee crisis, focusing on the 'long summer' of 2015. She is also beginning work on four new

projects, all continuing her work on social movements and building upon MOBILIZING4DEMOCRACY's successes.

However, without a doubt, she says that one of the project's greatest legacies is the setting-up of the Centre on Social Movement Studies (COSMOS) at the European University Institute (EUI), Italy which promises to continue studies into what has become one of the most important and intriguing features of modern democracy.

MOBILIZING4DEMOCRACY

- ★ Coordinated by SNS in Italy.
 - ★ Funded under FP7-IDEAS-ERC.
 - ★ <http://cordis.europa.eu/project/rcn/98917>
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BRINGING A WEALTH OF KNOWLEDGE TO THE FIGHT AGAINST POVERTY

The EU-funded project NOPOOR has been contributing to the fight to eradicate global poverty, by providing a more in-depth empirical understanding of its root causes, and possible solutions.

Millennium Development Goal 1 — to cut the 1990 poverty rate by 50% — was achieved in 2010, five years ahead of schedule. Despite these welcome advances, the global figure remains high and there are concerns about further progress. Chief amongst these is the fact that progress has been

uneven, with most of the global poor lacking education, living in rural areas and working disproportionately in the agricultural sector.

Key to the success of the new Sustainable Development Goal (SDG) 1 (and indeed arguably all the goals) will be a better understanding of this unevenness, to understand patterns of poverty and look for local solutions that may be transferable. This effort requires a supply of absolute and comparative data, enabling evidence based decision-making. The EU-funded

NOPOOR (Enhancing Knowledge for Renewed Policies against Poverty) project has studied the dynamics of poverty, investigating how and why people fall into and escape poverty, by gathering and analysing information that reflects its multidimensional nature.

Getting to the devil in the detail

The NOPOOR team is comprised of research teams from 17 countries, 10 of which are from developing and emerging countries in three regions

(Latin America, sub-Saharan Africa and South Asia). This diversity reflects the various barriers to escaping poverty, as well as different experiences in policies aimed at reducing poverty.

NOPOOR conducted 18 original surveys, analysing qualitative and quantitative data, including modelling future scenarios. Data was collected from more than 10 000 people in Burkina Faso, Ecuador, India, Peru, Madagascar, Mali, Ghana, Niger, South Africa and Vietnam. What is especially valuable about the surveys is their capture of the non-monetary dimensions of poverty such as: segregation and discrimination; violence; absence of rights; accountability of representatives; and inequalities among household members. This richness of information is more instructive than a single aggregate index.

For example, researchers from NOPOOR published results of their work in India, which were recently reported in the Indian e-paper 'Livemint'. The researchers found that real earnings increased at all percentiles between 2004-2005 and 2011-2012, and also that inequality had fallen over the same period. Yet, they also discovered that globalisation had contributed to the existence of two Indias, 'One of educated managers and engineers who have been able to take advantage of the opportunities (...) and the other — a huge mass of undereducated people who are making a living in low-productivity jobs in

the informal sector — the largest of which is still agriculture.' One conclusion they draw is that owing to factors such as climate or global pricing volatility, 'policies designed to foster the employment opportunities and wage growth of unskilled workers outside agriculture are crucial for improving the economic well-being of the rural workforce in India.'

Providing a cornerstone for SDG indicators

Looking at both global and local poverty levels, the project suggests a net positive globalisation effect on employment and wages, informed by factors such as trade, aid, FDI and migration. However, when looking at specific situations, global trends do not impact countries the same way. The work does point to some policies that can tackle the root causes of poverty, such as better access to public goods, quality of education, greater participation and 'voice' for the poor, protecting women against domestic violence, etc. However, it also finds that there are no 'catch-all' universal policies for poverty eradication but only those that work because they are appropriate for the local context.

NOPOOR highlights just how important data is for the pursuit of the new SDGs and its research aligns well with their indicators. Indeed, the project actually provided input to stakeholders developing Goal 16 on Governance, Peace

and Security, for example drawing on its research on African populations' perception of governance. In this way NOPOOR advocates for the ongoing importance of statistical surveys and so it also champions the support of National Institutes of Statistics (NIS). Towards this end NOPOOR has collaborated with, and built capacity within, NIS in particular in Senegal, Mali, Madagascar, Vietnam, Haiti and Peru.

The project data, which has been systematically uploaded to the 'data warehouse' portal, has been actively disseminated to relevant decision-makers and is also intended for public access.

NOPOOR

★ Coordinated by IRD in France.

★ Funded under FP7-SSH.

★ <http://cordis.europa.eu/project/rcn/103688>

★ Project website:
<http://www.nopoor.eu/>

"Looking at both global and local poverty levels, the project suggests a net positive globalisation effect on employment and wages."



SPOTTING BLACK SWANS ON THE HORIZON, WITH NEW MATHEMATICAL MODELLING

The largely unforeseen financial crisis of 2008 made a mockery of much financial modelling. By embracing the dynamism of complex systems, the EU-funded STRIKE project created models built to better cater for the unexpected; from stock market pricing to the true cost of a country joining (and leaving) the EU.

Up until the financial crisis of 2008, financial models were simplified by incorporating assumptions known to be relatively unrealistic. The trade-off was in the generation of models which were easier and faster to use but which contained data, which was approximate rather than wholly accurate. Applying statistical and probability theory to aspects of the financial crisis made it clear that events such as this — considered extreme and therefore unlikely — are actually more common than previous models had assumed.

A consequence is that more recent financial mathematical modelling has increased in computational complexity. Making the most of these models was the key driver for the EU-funded STRIKE (Novel Methods in Computational Finance) project. STRIKE sought to do so through the creation of a specially trained network of young European scientists.

Beyond number crunching

One of the key challenges that STRIKE set out to overcome was that of combining various methodologies and approaches, such that they complimented each other. This curated training incorporated mathematical analysis, sophisticated numerical methods, stochastic simulation methods, financial modelling (with deep qualitative and quantitative financial market data), optimal control techniques and model validation techniques. It also went beyond an understanding of the numbers, towards a better consideration of their potential social impact.

The theoretical framework for the research was the European response to the financial crisis evidencing characteristics described as ‘contagion’ and ‘herding’, beyond standard models (such as Black-Scholes-Merton’s model used as an investment tool, especially for derivatives). To develop a new, more robust non-linear (or non-Gaussian) model relied on meaningful inputs and so data for the project was provided by companies and banks. As the project coordinator Prof. Matthias Ehrhardt illuminates, ‘This allowed us to compare simulation outcomes with real data from history. The data also of course helped us to calibrate models.’

These models were then collated into the STRIKE Computational Finance Toolbox. Prof. Ehrhardt further explains, ‘This enables example runs and documentation with background information, allowing for input changes and then the observation of the resulting impact, caused by these settings. Several implementations also exploited the computational power of graphical parallel processing units (such as those used for computer gaming) to speed-up simulations.’

What can Cxexit learn from quantum theory?

Further elaborating on the utility of the toolkit, Prof. Ehrhardt calls for the understanding of financial systems to follow that of the evolution of physics, which has



successfully moved beyond linear causality assumptions. As he summarises, ‘With STRIKE, outcomes hedging and risk analysis can be better trusted or assumptions adapted in a more, timely manner.’

Adhering to its aim of providing useful decision making tools and a knowledge centred collaborative network, STRIKE has developed models applicable to real situations and problems. Prof. Ehrhardt highlights one example of very timely significance when recollecting that, ‘A special example for our modelling was taking the situation where a country wanted to join the EU, when we were able to properly estimate the temporal evolution of the interest rate.’ He elaborates that, ‘Now a similar technique can be used when a country leaves the EU or decouples its currency from the euro. The later situation fits to “Cxexit”, whereby in April 2017, the Czech Republic decided to decouple the Czech koruna from the euro.’

There are wide-ranging real world applications for the algorithms STRIKE developed, including apps providing customers with stock market advice or energy market pricing information, to help citizens make consumption decisions. For now, as well as maintaining the research consortium, the project will also publish a book of research outcomes and further develop its biennial International Conference on Computational Finance series.

STRIKE

- ★ Coordinated by the University of Wuppertal in Germany.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106526>
- ★ Project website: <http://www.itn-strike.eu/>



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TRANSPORT

ONE STEP CLOSER TO THE SMART HELICOPTER

Active-flow-control systems in rotor blades can adapt their aerodynamic properties to air flow conditions. EU-funded researchers have developed a computational method for implementing such innovative systems, promising higher speed and lower noise.

The COMROTAG (Development and testing of computational methods to simulate helicopter rotors with active gurney flap) project was part of the Clean Sky Joint Undertaking. The team focused on active-Gurney-flap systems in helicopter rotor blades.

The adaptation of these systems in helicopter rotor is a very challenging task, due to geometrical, kinematic (high frequencies of motion) and strength limitations, specific for the rotor-blade typical conditions. Using computer simulations, the project team examined the configuration of these actuators under different flight cases.

‘During flight simulations, the blade pitch controls were adjusted so as to obtain the desired thrust and moments generated by the rotor. The so-called power loading was used for comparisons of different configurations,’ explains Dr Wenczyslaw Stalewski from Instytut Lotnictwa in Poland, leading the research.

Active gurney flaps

Among smart blade concepts under development, the active gurney flap has been selected in the framework of the Clean Sky’s green rotorcraft integrated technology demonstrator.

This choice was based on its potential impact on helicopter performance and its technology readiness level.

Actively deploying gurney flaps in the retreating phase of the rotor-blade motion improves the lift of the rotorcraft as well as its overall performance. This technology is already in an advanced stage of development. However, numerical studies and wind-tunnel testing on rotor blades are necessary for its validation.

‘COMROTAG’s goal was to assess computationally the benefits of active Gurney flaps on rotor blades in real-scale helicopter flights,’ says Dr Stalewski. In addition to taking into account the various aerodynamic forces involved, the project team had to identify combinations of extension levels for the mechanism, air flow direction and speed.

‘Happily, difficulties in reproducing the deep dynamic-stall phenomenon appearing on the retreating blade were overcome, and we also achieved helicopter rotor trimming in this hazardous flight condition. This required significantly more computational effort than dynamic stall-free flight simulations,’ he adds.

‘Computational fluid dynamics’ (CFD) in flight

The ‘virtual rotor’ simulation module under development in Instytut Lotnictwa was modified to accurately model blade

feathering and flapping as well as the cyclic motion of active gurney flaps. This set of user-defined functions was linked to the commercial CFD software Ansys Fluent, commonly used in aeronautical engineering.

'The flap motion was reproduced through local deformations of the surrounding computational mesh. The mesh deformation methodology was developed especially for COMROTAG and proved to be a successful alternative to overlapping grid methods,' notes Dr Stalewski.

The simulation results offer valuable input for researchers working on the implementation of active gurney flaps in rotor blades. Tests on helicopters can be planned to obtain flight conditions where the benefits are more pronounced or to avoid dangerous situations for flight safety.

The new computational methodology is expected to support the development of actuation system solutions that meet both durability and reliability requirements of the aerospace industry. The next generation of smart helicopters will soon be heading to the skies.

COMROTAG

- ★ Coordinated by the Institute of Aviation in Poland.
- ★ Funded under FP7-JTI.
- ★ <http://cordis.europa.eu/project/rcn/192420>
- ★ Project website:
<http://comrotag.ilot.edu.pl/>

NOVEL AIRCRAFT-INTEGRATED VENTILATION CONCEPTS TO REDUCE NOISE IN AIRCRAFT CABINS

An EU initiative has examined ways to reduce aircraft cabin noise by focusing on 'Environmental control systems' (ECSs) and aerodynamic interaction between components.

Aircraft cabin noise is a comfort concern for passengers and an occupational health and safety issue for cabin and maintenance crews. Aircraft ECSs — i.e. cooling and ventilation systems — are a key contributor, yet the fundamental physics of confined-flow turbulence remain poorly understood.

The EU-funded IDEALVENT (Integrated design of optimal ventilation systems for low cabin and ramp noise) project set out to investigate aircraft noise, focusing on modelling the acoustic and aerodynamic interaction between ECS subcomponents.

To provide a deeper understanding of these interaction mechanisms, project partners undertook extensive experimental studies and advanced analytical and numerical developments. They investigated aerodynamic and acoustic installation effects through innovative experimental methods. As such, robust multimodal decomposition techniques based on microphone and loudspeaker arrays were developed.

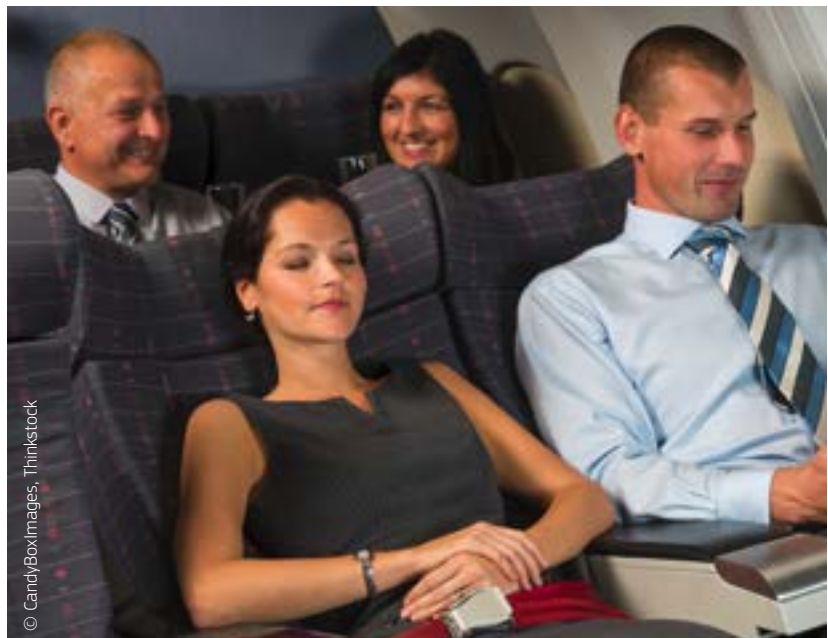
Researchers also explored integrated passive flow and noise control strategies in the laboratory initially, and then on full-scale industrial equipment. Knowledge gained in the experimental and numerical investigations of the installation effects enabled team members to devise optimised noise mitigation strategies with the greatest potential for reducing ECS noise.

IDEALVENT's new concepts for the design of aircraft ventilation systems will lead to reductions in cabin noise of 3-10 decibels. Such improvements should ultimately reduce the adverse health effects of noise. The techniques will also be applicable to other forms of noise reduction. Lastly, the project contributes directly to meeting several air transport objectives of the Advisory Council for Aviation Research and Innovation in Europe (ACARE)'s Strategic Research and Innovation Agenda as well as its FlightPath 2050 vision for aviation.

"IDEALVENT's new concepts for the design of aircraft ventilation systems will lead to reductions in cabin noise of 3-10 decibels."

IDEALVENT

- ★ Coordinated by VKI in Belgium.
- ★ Funded under FP7-TRANSPORT.
- ★ <http://cordis.europa.eu/project/rcn/104301>
- ★ Project website:
<https://www.idealvent.eu/>



ADVANCED DESIGN, MODELLING AND TESTING METHODS TO REDUCE NOISE AND VIBRATION IN ELECTRIC VEHICLES

An EU initiative developed leading-edge modelling and testing tools to address noise and vibration issues related to the electrification of passenger cars.



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Now that the first 'electric vehicle' (EV) prototypes have entered the market, it has become increasingly evident that concerns over noise were greatly underestimated. Only after prototypes were introduced did noise originating from various components become annoying sounds. Closer analysis, assessment and optimisation of electric motors in terms of 'Noise, vibration and harshness' (NVH) during the early development phase are essential.

In an electric driveline, mechanical and electrical components are connected via sensors and actuators with controllers that define overall functions. The design of such EV systems requires simulation and test solutions that are capable of analysing and optimising performance, while considering mechanical, electrical and control subsystem/component interactions. The design and development of each subsystem necessitates increasing integration levels and reliance on models. Depending on the design stage, different model accuracy levels and algorithms are required.

Noise and vibration stand in the way of electric motor integration

The EU-funded DEMOTEST-EV (Design, modelling and testing tools for electrical vehicles powertrain drives) project 'aimed at developing advanced and extended design, modelling and testing tools for improved concept modelling and higher prediction accuracy of noise and vibration generated by EV motors,' says project coordinator Professor Claudia Martis from Romania's Technical University of Cluj-Napoca. 'It responded to two main challenges: NVH issues involving electric driveline integration and new tools to deal with the high EV integration levels.'

DEMOTEST-EV developed and validated analytical coupled electromagnetic-vibroacoustic models for three different types of electric motors for automotive applications. It analysed the influence of different parameters on the motors' magnetic noise, and studied the influence of winding and rotor topologies on such noise. Lastly, a system-level evaluation of noise and vibration levels was undertaken.

Modelling tools and test benches to tackle EV noise and vibration problems

According to Prof. Martis, the most significant achievement of DEMOTEST-EV was the opportunity given to early-stage and experienced researchers from academia and industry to broaden necessary skills and competencies. Collaborative research, secondments, shared state-of-the-art infrastructure, training and dissemination activities enhanced knowledge, know-how and technology transfer. 'Choosing and manipulating different design and modelling parameters, and using advanced tools and techniques at each level of analysis are easier achieved through joint work,' she adds.

Sharing facilities increased the scope of available equipment, improved accessibility of dedicated hardware and software instruments and tools, and generated more understanding of the shared equipment. This helped to stimulate the transfer of knowledge and expertise in designing, modelling and testing the three electric motors.

Another important result was the development of an inter-linked design, modelling and testing environment. It is directly or remotely accessible, both online and offline, by all project partners even beyond the project. Test benches were also designed for use by all team members.

Other notable results include two new research directions. One was a multi-physics and multilevel approach to EV design, modelling and testing. The other was cutting-edge research in the EV electrical machine domain.

'New powertrain designs like the ones for EVs and hybrid vehicles trigger new vibration phenomena which negatively impact NVH performance and ultimately driveline efficiency,' explains Prof. Martis. DEMOTEST-EV provided engineers with greater awareness of such phenomena in order to measure and eliminate the root cause of NVH. 'We are helping them to better understand and predict the noise and vibration levels of EVs,' she concludes. This should help to accelerate the market arrival of EVs in Europe.

DEMOTEST-EV

- ★ Coordinated by the Technical University of Cluj-Napoca in Romania.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106671>
- ★ Project website: <http://www.demotest-ev.com/>

NANOCARBON COATING REDUCES ICE FORMATION AND MAKES AIRCRAFT MORE AERODYNAMIC

A nanocarbon coating developed by EU-funded scientists reduces both surface ice build-up on aircraft and in-flight turbulence from wind drag.

De-icing aircraft in cold weather can be costly in terms of time, labour and materials such as solvents. Now scientists, under the EU-funded SANAD (Synthesis of Advanced top Nano-coatings with improved Aerodynamic and De-icing behavior) project, have developed a top coat for aircraft that repels water, leading to significant maintenance cost savings. The innovative nanocarbon coating at the same time reduces wind drag on the aircraft's surface, reducing fuel consumption and carbon emissions.

'From the beginning we wanted one coating that would combine these attributes,' says project coordinator Dr Stephanos Nitodas, head of the nanotechnology research department at Glonatech in Athens, Greece. 'We started with several coatings with different combinations of nanostructured materials embedded in resins to see how we could combine these effects.'

Among the different coatings formulations prepared at the facilities of partners NSCR Demokritos in Greece and Bionanovate Ltd in the UK, in collaboration with the other partners, three candidate coatings based on metal oxides or nanostructured carbon — carbon nanotubes or graphene oxide

— were identified as the best performing ones after thorough characterisation and according to specifications set by British Airways. Wind tunnel testing and computational fluid dynamics analysis was carried out at Kingston University, UK, before successful testing during in-flight conditions on British Airways' (BA) Airbus A320 aircraft.

'Depending on the particular formulation tested, we found 20% to 40% improvements in water contact angle measurements, and consequently hydrophobicity, compared to the commercially-available coatings used on current aviation fleets that do not contain nanoparticles,' Dr Nitodas says. This represents a considerable saving; de-icing can cost tens of thousands of euros, or even more if the task has to be carried out several times a day in extreme weather.

Using surface nanorestructuring, the project team also tailored the roughness of the coating, aiming at decreasing in-flight turbulence. This reduces build-up of debris on the plane's main structure, the leading edge of the wings and other areas, thus decreasing friction and drag on the surface of the aircraft. In turn, this reduces aircraft fuel consumption and the overall flight

cost, as well as lowering carbon emissions, making aircraft more environment-friendly. In addition, the nanostructured coating is stiffer, more durable and does not need to be replaced as often as currently available commercial coatings, Dr Nitodas says.

The challenge was not only to chemically modify the nanoparticles. 'We tried to identify processes for the surface treatment of the nanoparticles in a way that was not only efficient in terms of the final performance, but could also be easily scaled up for industrial-scale production,' he says.

The developed product, a topcoat, is currently moving towards being patented and the project partners, including academics, nanotechnology companies and BA, are carrying out market analysis for its use not just in the aviation industry, but also in the automotive industry and other commercial fields.

SANAD

- ★ Coordinated by Global Nanotechnologies in Greece.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/106774>



ENVIRONMENT

HOW SENSITIVE IS CLIMATE TO INCREASED CARBON DIOXIDE IN THE LONG TERM?

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Examining the levels of carbon dioxide and climate change in the past could help us predict the extent of global warming well beyond the end of this century, according to EU climate scientists.

Climate scientists involved in the EU-funded PLIO-ESS (Pliocene Constraints on Earth System Sensitivity) project have spent the last five years searching for a number. This is not any old number but rather one which will allow us to more accurately predict just how sensitive the global temperature is to 'carbon dioxide' (CO₂) emissions.

Until now calculations for defining the CO₂ emission stabilisation targets that could limit global warming have looked at how the earth's climate system responds via fast feedbacks such as clouds and sea-ice albedo. This concept is known as short-term or 'Equilibrium climate sensitivity' (ECS).

Slow feedbacks

'But more recently there has been a realisation that there are slower responding components of the Earth system — when you increase the amount of CO₂, sea ice will respond relatively quickly, but there will be a delay until vegetation distribution reacts and ice sheets may only respond over millennia,' says Prof. Alan Haywood, project coordinator and professor of paleoclimate modelling at Leeds University, UK. This new definition of responsiveness, known as long-term or 'Earth system sensitivity' (ESS), emerged in the last decade and provides a different guide to the future of our climate.

The PLIO-ESS team set out to provide a robust estimate of ESS using the last period in earth's history when levels of CO₂ were at modern levels three million years ago in the mid-Pliocene Warm period.

They integrated records of mid-Pliocene vegetation and ice sheets into climate and earth system models. Using geological proxies for the two variables of vegetation distribution and ice cover, 'we ran hundreds of new climate simulations in an attempt to densely sample this period of time,' says Prof. Haywood. With the help of the UK Met Office's Hadley Centre for Climate Prediction and Research and climate modelling groups around the world, they used a wide variety of state-of-the-art models to calculate ESS, thus ensuring their findings were not dependent on one particular model.

One unforeseen benefit of the project is the way it encouraged growth in climate modelling capacity for the Pliocene. In 2008 eight international research groups agreed to run Pliocene climate simulations, in 2016 that number increased to 16.

Greater increase

Five years on, the PLIO-ESS team now has enough evidence to state that ESS is definitely greater than ECS. 'We expect that when the slower feedbacks start to come into play, they will inevitably increase the temperature above and beyond what would be predicted by ECS alone. So, the next question is how much greater?' says Prof. Haywood.

Their findings indicate that ESS is up to twice as large as ECS, according to an article published in 'Climate of the Past' in 2013. 'If you were expecting a 3 °C rise from ECS, in the worst case scenario, it could be up to 6 °C. But our best statistical answer is that ESS is 1.5 times greater than ECS so if you have a climate sensitivity of 3 °C, our best answer is currently 4.5 °C,' says Prof. Haywood.

This result could fundamentally change the debate about how much CO₂ can be put into the atmosphere before a climate red line is crossed. 'So far there has been a strong focus on the earth's response to the end of the twenty-first century,' concludes Prof. Haywood. 'We now know that even if we stabilise the concentration of CO₂ in the atmosphere, there will still be additional warming because of the longer term feedbacks.'

PLIO-ESS

- ★ Hosted by the University of Leeds in the United Kingdom.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/100206>
- ★ Project website:
<http://www.see.leeds.ac.uk/research/essi/palaeoleeds/current-research/plio-ess-pliocene-constraints-on-earth-system-sensitivity/>

RECONNECTING EUROPE'S RIVERS THE SMART WAY

Barriers on Europe's rivers can improve fishing, be a source of energy and reduce the passage of invasive species, but they can also be a flood risk, interfere with migration patterns and fragment habitats. So what's the best approach to reconnecting our rivers? One EU-funded project is providing some answers.

Rivers rank amongst the most threatened ecosystems in the world. We depend on them for hydropower, food production and for drinking water. But in 2015 only half of Europe's surface water met the target of 'good ecological status' as defined by the EU's Water framework Directive. The EU-funded AMBER (Adaptive Management of Barriers in European Rivers) project has presented the results of its case study on the management of the dams on the Nalon-Narcea basin, in Asturias, Spain, and their findings offer interesting insights into both the natural and social science elements that go into sustainable river management.

A two-pronged approach

AMBER researchers, based at the University of Oviedo, worked with local stakeholders and city councils to involve them in the study: public engagement and a familiarity with local priorities on the part of researchers, allied with the resident's understanding of the research aims, is key to successful resource management. In order to achieve those objectives, the project formulated and validated a questionnaire, which they are now disseminating. This will shine a light on the opinions of residents of the Upper Nalon regarding the reserves.

To analyse the biodiversity of the ecosystem in a non-invasive manner, researchers applied molecular tools they developed to create a thorough inventory that avoided the need to disturb biota with electrofishing. 'eDNA' (environmental DNA) from the water samples was extracted, giving a clear picture of local biodiversity and macroinvertebrates, fish and birds should be detectable from these samples. The team hopes also to see traces of mammals visiting the streams.

The project recently published a paper on the identification of salmonids in eDNA from water samples taken from the river Nora, along with other target sites in Asturias. They write, 'Our tool allows for a rapid overview of the *Salmonidae*

community without the use of real-time PCR systems, and in the particular case of Spain it allowed the detection exotic and native salmonids at the same time. As it is, the method is ready to be used in Spanish waters, but it could be easily adapted for application in other regions by checking for any cross-amplification with the local aquatic fauna.'

Dams — challenged ecosystems

The area under study includes the Tanes and Rioseco reservoirs, which are involved in the production of energy. Water is pumped from Rioseco to Tanes during the night and its direction is reversed during the day to produce energy. The uppermost zone is located within the UNESCO Biosphere Reserve and Natural Park of Redes. The ecosystem is dominated by forest and the two reservoirs are rich in amphibians. The basis for the trophic chain of the ecosystem is its diverse group of aquatic invertebrates, at its top are otters. Second in the chain are two native salmonoid fish: brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*). However, the Atlantic salmon cannot reach upstream areas due to the impassable dams, meaning that only natural populations of brown trout occur in the case study zone.

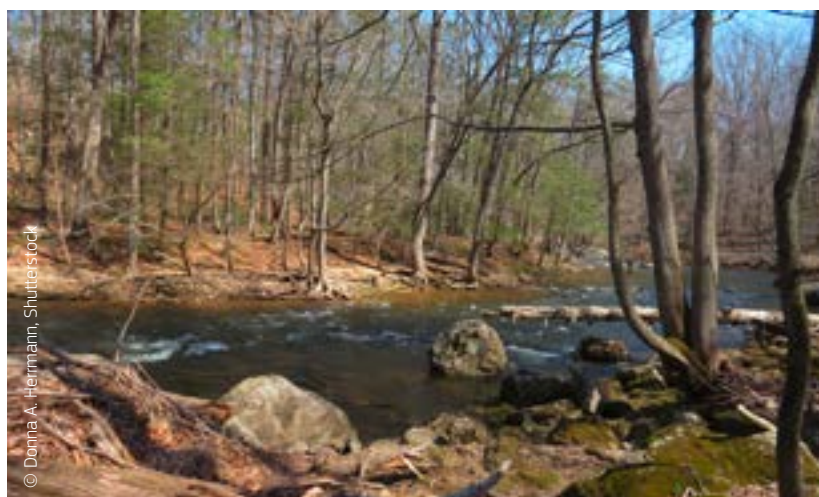
Dams, by their nature are artificial ecosystems and are rarely the subject of

environmental protection and as such they can have exotics released into them. In the case of these reservoirs, the team found rainbow trout (*Oncorhynchus mykiss*) and European minnow (*Phoxinus phoxinus*) that were introduced for different purposes: the first were released into the reservoirs for recreational fishing, and the second as fishing bait.

This case study feeds into the AMBER project's central objective, to address the complex challenge of river fragmentation. The tools the project has developed can be used, on one hand, to assess public opinion regarding water reserves, dams and resource management and, on the other, to identify species non-invasively wherever the need arises. The eDNA procedure could be a useful way to detect salmonids in places where these species are exotic and represent a danger to the local fauna. It could also serve to detect escapes from aquaculture, a big problem for local wild populations.

AMBER

- ★ Coordinated by Swansea University in the United Kingdom.
- ★ Funded under H2020-SC5.
- ★ <http://cordis.europa.eu/project/rcn/203267>
- ★ Project website: <http://amber.international/>
- ★ <http://bit.ly/2s9RI3n>



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EXPLORING THE ATMOSPHERE OF THE ANCIENT EARTH

EU-funded geochemists have a story to tell about the origins of the earth's atmosphere and its evolution through time.



EU researchers have created a window into conditions on the earth's surface more than three billion years ago by means of high-precision direct analysis of geochemical tracers. The NOGAT (Noble gas tracing of sources and sinks of volatile elements in the atmosphere) project team did so by looking at noble gases — elements which are chemically inert and so are not altered by geochemical reactions — and mainly stable elements such as nitrogen as part of a six-year project which ended recently.

To do so, the team developed a multi-collector mass spectrometry analysis of noble gas isotopes which achieved measurements at the per mill level, the first time this has ever been measured so precisely. This was complemented by the analysis of samples from comets, the moon, Mars, primitive meteorites and solar wind as well as ancient sediments and gases from the earth's deep mantle.

Asteroids and comets

The researchers demonstrated two cosmochemical origins of the earth's atmosphere. 'Probably the earth was formed in a dry environment and volatile elements were contributed by inner solar system bodies similar to asteroids,' says Bernard Marty, project coordinator and professor of geochemistry at France's Centre de Recherches Pétrographiques et Géochimiques of the French National Centre for Scientific Research or CNRS and the University of Lorraine. Comets provided a second source which, though minor, was significant for some materials. 'It was probably not significant for water or nitrogen, but it might have been significant for organic matter,' says Professor Marty. 'I am not saying that life came to earth on a comet but what I am saying is that pre-biotic material was contributed by comets.'

Tracing the evolution of the noble gas xenon through time gave special insights. Working with geologists, the team gathered Archean rocks from the earth's deep mantle and

analysed the gas trapped in tiny bubbles inside these rocks that were formed 3.5 billion years ago. They demonstrated that xenon in the Archean atmosphere was isotopically intermediate between that found in meteorites and modern-day xenon, providing evidence that xenon was lost to space through time 'through ionisation in the atmosphere by violet light from the ancient sun,' says Professor Marty.

Nitrogen, on the other hand, was found to be similar in both pressure and composition at that time compared to today's levels. 'This means that the earth was already shielded from interaction with outer space for nitrogen, but xenon was still interacting,' says Professor Marty.

New information

The evolution of atmospheric gases and what this says about the evolution of the earth itself has often been studied using indirect methods, but Professor Marty is confident that interpreting the direct analyses achieved by the NOGAT team is shedding plenty of new light on an age-old problem. 'We have got constraints on the interaction of the sun and the earth's atmosphere and on the so-called Faint Sun Paradox and the problem of greenhouse gases in the past,' he says.

The project has led to the publication of 33 papers, including six in 'Science', three in 'Nature' and three in 'Science Advances'. The work has been cited over 650 times since 2011. More recently Professor Marty has been contacted by various teams working on space missions and asked to contribute, indicating this area of research is a hot topic not just for the geochemists but also for astrophysicists.

NOGAT

★ Hosted by CNRS in France.

★ Funded under FP7-IDEAS-ERC.

★ <http://cordis.europa.eu/project/rcn/97610>

WILDFIRES OF THE PAST

EU scientists have studied fossil records to understand wildfire activity in the Earth's past. By doing so, they have improved our understanding of the wildfires we can expect in the future.



Scientists expect that climate change will alter the distribution and occurrence of wildfires.

One way to study the interaction between fire and climate is by researching past fires from periods of different climates. To reconstruct ancient fire records, scientists have mostly relied on an abundance of fossilised charcoal as a measure of past wildfire activity. However, factors other than fire activity influence fossilised charcoal abundance. This therefore makes it difficult to relate charcoal abundance back to fire activity.

Researchers from the EU-funded PYROMAP (Palaeofire danger rating maps and Earth's last major global warming event) project took up this challenge by investigating how fossilised

charcoal particles are formed. They also researched an alternative method for estimating past fire activity.

By studying the shapes of fossilised charcoal particles, the scientists found three factors that affect their formation: the vegetation type the charcoal came from; the dynamics of the fire that created it; and how long it was transported for.

These three factors also influence how much charcoal is deposited in fossil records. Therefore, the shape of a fossilised charcoal particle can tell researchers about its formation and how to interpret its abundance in fossil records.

This shows that scientists studying past fire activity should assess not only the abundance of fossilised charcoal but also its shapes.

The PYROMAP researchers also looked at using fossilised leaves from a specific location to infer information about its climate in the past. This in turn can inform them about the risk of a wildfire forming there at that time.

These findings improve our ability to interpret fossilised charcoal abundance and to quantify past fire activity. This will help researchers understand wildfire activity in the future, under the influences of climate change.

PYROMAP

- ★ Coordinated by the University of Exeter in the United Kingdom.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/102818>

AGRICULTURE & FORESTRY

SPY IN THE COW SHED AIDS FARMERS

A growing global appetite for meat has led to farms becoming bigger than ever before. Automatic round-the-clock monitoring of livestock using surveillance technology can help busy farmers better manage their animals, improve the food chain and save money.

Farmers struggle to cope with the increased size of their herds and flocks and have less time to keep an eye on the health and welfare of individual animals. The result is rising concern among consumers who demand safe but affordable milk, meat and eggs produced under clean, sustainable and animal friendly conditions.

'Precision livestock farming' (PLF) offers a solution to overworked farmers by employing sensors, cameras and microphones using sophisticated algorithms to continuously monitor every single animal. The EU-funded EU-PLF (Bright farm by precision livestock farming) project was established to realise the full potential of PLF tools by developing them into commercial products and services for use on dairy, fattening pigs and poultry farms.

Blueprint for success

'The main objective was to install PLF technology in commercial farms across Europe and analyse how it is used by farmers and creates value for them,' explains project coordinator Dr Daniel Berckmans. To achieve their objectives, project partners created a draft blueprint for farmers, high-tech 'Small and medium-sized enterprises' (SMEs), and other key actors who wished to design and develop PLF tools.

The blueprint was a valuable resource for advising farmers how to choose and install suitable PLF technology and identify which problems needed to be addressed. An online PLF e-Course for students, scientists and researchers was also produced, providing an important platform for the further development of knowledge and sharing experiences related to the technology.

Listening in on livestock

The consortium developed better algorithms for the camera and microphone systems to give a more detailed understanding of factors affecting livestock behaviour and health. 'It was shown that the camera system can now predict more than 90% of all problems, such as blocked feeder and drinking lines, and light and climate issues by continuous image analysis of broiler behaviour,' says Dr Berckmans.

Furthermore, project partners found that continuous analyses of the sound produced by fattening pigs can detect an infected animal two

to 10 days before the farmer or the veterinarian notices it. Hence, PLF technology could reduce the use of antibiotics and enable farmers to respond more quickly in cases of infection, thereby decreasing production losses and thus saving money.

'Before the project many doubted this approach would work, believing it was unrealistic, but people's attitude towards PLF has now completely changed,' claims Dr Berckmans. 'We have shown that automated monitoring every second day and night is far more effective than human observers checking a livestock shed once a year.'


Farm data — a valuable resource

Researchers used new modelling tools and identified areas where different PLF applications could be of social and economic value on the farm and in supply chains. This valuable data, taken from farm measurements, can help unlock economic potential by improving the effectiveness of the food supply chain (feed-animal-food) and providing social and economic incentives for the adoption of PLF.

According to Dr Berckmans: 'Many different stakeholders have yet to discover what type of information they can select from all this data and more algorithms will be developed.' However, there has been a growth in interest shown by a range of sectors, including the pharmaceutical and animal feed industries, technology companies, veterinarians, slaughter houses and meat retailers. During the project four new high-tech PLF companies were started.

EU-PLF will reduce stress in farmers by enabling them to act more effectively and achieve a better work/life balance, while gaining greater recognition for their efforts. Benefits include healthier, happier animals and an improved economic performance for farms.

EU-PLF

- ★ Coordinated by KUL in Belgium.
- ★ Funded under FP7-KBBE.
- ★ <http://cordis.europa.eu/project/rcn/105333>
- ★ Project website:
<http://www.eu-plf.eu/>
- ★  <http://bit.ly/2s9NqUm>

NEW KNOWLEDGE AND TOOLS FOR SUSTAINABLE RURAL DEVELOPMENT AND A MORE COMPETITIVE BIOECONOMY IN EUROPE

Forests, which make up 35 % of the EU's landmass, are key to Europe's bioeconomy, particularly in rural areas. An EU initiative tapped into the potential of non-wood goods towards an innovative, resource-efficient and bio-based economy.

European forests provide income for about 16 million forest owners and form the basis for 3 to 4 million jobs, primarily in rural regions. However, the potential of 'Non-wood forest products' (NWFPs) such as mushrooms, berries, resin, aromatic and medicinal plants has been mostly neglected in favour of wood-based products.

Despite the fact that NWFPs significantly contribute to the creation of new business opportunities and jobs, their potential is somewhat unknown and untapped. Contributing to rural growth and the European bioeconomy requires new solutions to optimise the sustainable provision and profitability of NWFPs and services from 'multipurpose trees' (MPTs) — trees that are used for more than just wood production, like chestnut.

Sustainably exploiting NWFPs for financial and ecological gain

Thanks to EU funding, the STAR TREE (Multipurpose trees and non-wood forest products a challenge and opportunity) project 'aimed at providing better understanding, information, guidance and tools to support relevant stakeholders such as forest owners, resource managers, enterprises, decision makers, and other public and private entities,' says project coordinator Dr Robert Mavsar, Deputy Director of the European Forest Institute. 'This should help to optimise the management of MPTs and develop innovative approaches to increase the marketability and profitability of NWFPs for a more competitive rural economy.' To achieve its goals, STAR TREE relied on strong stakeholder engagement through case studies in 14 regions across Europe (10 Member States, Serbia and Turkey).

In each region, stakeholder groups, comprised of different actors along the NWFP value chain, received updates and reports on project developments, and participated in meetings and events related to activities in their region. They were fundamental to the consultation and knowledge exchange process essential to developing relevant solutions and new ideas through the regional case studies.

These case studies considered NWFP and wood sector development, different socioeconomic and policy contexts, and environmental characteristics. The cases provided an overview of the NWFP sector at EU and regional levels, and helped identify innovative approaches to MPT and NWFP management and use.

Key findings show that NWFPs provide benefits for rural development and opportunities for greener lifestyles, and sustainable NWFP use requires relevant actors to overcome institutional and regulatory fragmentation of NWFP governance. They also reveal that innovation in NWFP must go beyond sector boundaries, while improved understanding of their demand and production would offer fresh dimensions for marketed and non-marketed NWFPs.

First European perspective on potential of NWFPs and MPTs

A significant STAR TREE achievement was the first Europe-wide household survey on the collection and consumption of NWFPs. 'An important share of NWFP products is consumed directly by households and is not included in the latest State of Europe's Forests 2015 report, which gives the total value of marketed NWFP products for the continent's forests.

'Unfortunately, there is no reliable information to indicate how much this share is,' explains Dr Mavsar. Over 17 300 responses reveal that nearly 90% of households have consumed NWFPs in 2015, and about 25% of households have picked at least one of them in the same year. The figure equates to 20% of the population, further proof that collection of NWFPs is an important social activity.

STAR TREE succeeded in optimising the NWFP value chain by demonstrating how NWFPs and MPTs can be used to strengthen and diversify economic activities in rural areas. 'By considering the resource base, markets, institutions and innovations, we promoted existing and latent opportunities towards a more bio-based "circular" European economy,' concludes Dr Mavsar.



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STAR TREE

- ★ Coordinated by the European Forest Institute in Finland.
- ★ Funded under FP7-KBBE.
- ★ <http://cordis.europa.eu/project/rcn/104330>
- ★ Project website: <https://star-tree.eu/>
- ★  <http://bit.ly/2sBILwT>

HOW SEED DISPERSAL INFLUENCES ISLAND PLANT POPULATIONS

Plants are normally anchored to one location, so depend upon a variety of both biological and non-biological agents such as animals, birds, wind and ocean currents to disperse their seeds. Patterns of seed dispersal are therefore largely determined by the dispersal mechanism, which have important implications for plant and animal populations.

Researchers working on the EU-funded SEEDS (Closing the seed-dispersal loop: How does seed-dispersal affect plant population structure at the global, regional and local scales?) project studied how seeds are dispersed over short and long distances and how these affect plants' capacity to colonise new habitats.

'Characteristics of European plants were compared with those from the Azores, an archipelago of nine volcanic islands about 1 360 km west of mainland Portugal. The aim was to determine which agent is most favoured by plants for colonising these islands far out in the North Atlantic,' says project coordinator Dr Ruben Heleno.

The project set out to answer several important questions, including whether it is possible to infer how seeds are transported in nature by their shape and the most effective mechanisms by which plant seeds colonise islands.

'We found that only plants adapted to dispersal via ocean currents were favoured during the colonisation of the Azores by plants coming from Europe, while wind dispersed plants were negatively selected,' explains Dr Heleno. This discovery has helped to dispel the established belief that all dispersal events are largely determined by the seeds' traits giving rise to the conclusion that many islands have actually been colonised by random and non-standard processes.

A study of the Azores' 15 native fleshy fruited species further revealed that only *Corema alba*, commonly known as the Portuguese crowberry, and Juniper trees, have some potential to be dispersed by ocean currents. According to Dr Heleno: 'The other 13 species are probably dependent on birds for long-distance dispersal.'

Scientists also studied the relative importance of internal transport of seeds inside the birds' guts (endozoochory) and external adhesion of seeds to the outside of the birds (epizoochory). It was discovered that although both mechanisms can be important,



the former is 85 times more common than the latter. Not surprisingly, the study also revealed that in order to capture the inherent complexity of these species-interaction networks, adequate sampling efforts are indispensable.

Additionally, Dr Heleno and his colleagues found that many birds, even those that are not specialised nectar eaters, transported the pollen of many plant species on their beaks. Unspecialised consumption of flower resources was considered an important adaptation for surviving in the simplified island habitats, and also as a strategy to take advantage of underexplored resources on continents.

Furthermore, researchers found that in the Galapagos Islands off the coast of Ecuador in South America the decline in seed dispersal services depends on which disperser species become extinct, and also on the diversity and abundance of the remaining dispersers. However, overall it was shown for the first time that the loss

of disperser diversity (the number of species) and disperser abundance (the number of individuals) have both significantly negative and synergistic effects on the degradation of the seed dispersal service.

SEEDS results have been used by the national park authorities of the Galapagos Islands to improve their conservation efforts by helping to prioritise the conservation of key species. Some practical tools were developed, with particular emphasis on a 'Galapagos seed guide' that will be used by agriculture and sanitation authorities responsible for the biosecurity of these islands. The advanced training of students was also a most positive output of the project.

SEEDS

- ★ Coordinated by the University of Coimbra in Portugal.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/104839>



INDUSTRY

NEW INSIGHT INTO NATURAL SLATE SOLVES ROOFING MARKET'S PROBLEMS

Many historic buildings throughout Europe were built with slate, yet little is known about these building rocks used for roofing. An EU initiative shed important light on this stone, and proposed solutions to some of the European roofing slate industry's pressing issues.

Since the dawn of time, slate has been the most important natural stone and virtually the only one used for roofing. However, there is a lack of knowledge about this valuable material, in contrast with the abundant scientific literature for other stones such as marble or granite.

The EU-funded TOMOSLATE (New uses for X-ray tomography in natural building stones: Characterization, pathologies and restoration of historical and recent roofing slates) project aimed at 'filling the knowledge gap, while identifying the main problems of the roofing slate industry in Europe and providing answers,' says principal project investigator Dr Víctor Cárdenes. The characteristics of roofing slate were examined using X-ray 'Micro-computed tomography' (MCT), together with other analysis techniques.

Novel methods to tackle roofing slate industry problems

'Today, no standard classification exists for the different varieties of roofing slate,' notes Dr Cárdenes, a researcher at Belgium's Ghent University. The roofing slate industry uses commercial names, instead of the petrological denominations for each rock. This leads to overall confusion about the nature and characteristics of roofing slates. TOMOSLATE characterised and classified the existing roofing slate lithotypes.

According to Dr Cárdenes, this is the first ever classification of roofing slates to be performed anywhere in the world.

The project defined the pathologies that affect roofing slates in order to propose a methodology that mitigates the incidence of weathering on the stone. 'This is vital to preserve Europe's architectural heritage,' stresses Dr Cárdenes. The method to prevent iron sulphide oxidation — the main weathering culprit — is based on a new concept. Instead of applying a chemical product to the roofing slate during the production chain, this innovative technique is employed when the slate on the roof begins to show oxidation. A protective coating paint is applied using a spray can. The approach is easy to use and environment friendly.

TOMOSLATE analysed the standardised tests applied to roofing slates. 'These tests are mandatory for the roofing slate market,' he adds. 'However, they can be optimised to improve the information obtained from assessments.'

"The project defined the pathologies that affect roofing slates in order to propose a methodology that mitigates the incidence of weathering on the stone."

Dr Cárdenes says that the project also yielded an unexpected result. The use of MCT on slates highlighted a pyrite framboid population. Measuring and analysing these populations in a fast and reliable way has opened up new line of research which has important implications for other fields of geology, including palaeoecology and ore mining.

Unlocking the mystery of what roofing slate actually is

'TOMOSLATE will help the roofing slate industry, builders and architects to better understand their products,' explains Dr Cárdenes. When he and others visited slate quarries and gave talks at dedicated conferences, the overall impression was that nobody really knew exactly what roofing slate was. Some producers didn't even know what kind of stone they were quarrying.

'We now have greater awareness of a very important natural stone that's used abundantly in Europe and the rest of the world,' concludes Dr Cárdenes. Ultimately, TOMOSLATE outcomes will revitalise the economy of European slate-producing areas because of the added value given to their slates.

TOMOSLATE

- ★ Coordinated by Ghent University in Belgium.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/187735>

HOW TO TURN REFRACTORY WASTE BACK INTO RAW MATERIALS

Automating the sorting of used refractory bricks will make recycling a viable option, according to one EU-funded project.

Refractory bricks — specialised bricks used to line furnaces, kilns, incinerators and reactors for high temperature processes — are costly to make and difficult to recycle. EU-funded research project REFRASORT (Innovative Separation Technologies for High Grade Recycling of Refractory Waste using non destructive technologies) has spent the last three years finding a way to improve sorting of used refractories, aiming to turn industrial waste into a useful raw material.

The REFRASORT team has designed an automated system which uses 'Laser-induced breakdown spectroscopy' (LIBS) to grade the used refractory bricks and a system of pushers to handle them.

The need for better recycling is clear. 'Only the top 5-7% of the demand for raw material is met by recycled materials and this only covers a few applications, so a lot of material is lost,' says Liesbeth Horckmans, REFRASORT project coordinator and a researcher into sustainable materials at Belgian cleantech research company VITO. Currently most spent refractories are used for low-grade applications such as building road beds or go to landfill.

At the same time, European manufacturers of the bricks are highly dependent on importing the range of raw materials needed to make them — 90% of bauxite for instance is imported from China — and prices are volatile.

Contamination makes sorting hard

Sorting used refractories, currently done by hand, is complex. Extreme temperatures and interaction with hot steel and slag during use, and dust added during demolition, causes layers of contamination to build up on brick faces and makes identifying a brick's components difficult. This contamination means sensors which examine surface properties cannot be used.

The REFRASORT team has tackled this problem by using LIBS which points two bursts of laser at each fragment of waste as it moves down the conveyor belt. The first burst penetrates the contamination layer to a depth of 100 µm, allowing the second burst to generate the material for analysis without interference. 'One of the problems we had to overcome was the material had to be tracked very well as you have to make sure the second beam hits the exact same spot as the first one,' says Dr Horckmans.

Fast handling

Designing a mechanical handling system fast enough to keep up with the sensor was a second hurdle. 'Until now handling systems typically use mechanical flaps or air-based systems, but in this case, the bricks often weigh several kilos each,' says Dr Horckmans. Moreover every fragment has to be presented at a defined distance from the next. The team came up with a system consisting of four sub-processes — lining up, isolation, spacing and separation — based on a series of pneumatic pusher devices. It sorts eight



fragments at once and can identify one brick per second, giving an overall throughput of 10 tonnes per hour.

During 2016 the team used a demonstration built at Belgian recycling company ORBIX to sort 30 tonnes of material which was then used in an installation. 'We have proved the concept of using LIBS for identification and we have shown that we can do this on an industrial scale and that the results are good enough for reuse,' says Dr Horckmans. The project members are now seeking funding to do more technical development and upscaling. They report strong interest from industry and aim to see full industrial application within two to three years.

REFRASORT

- ★ Coordinated by VITO in Belgium.
- ★ Funded under FP7-ENVIRONMENT.
- ★ <http://cordis.europa.eu/project/rcn/110889>
- ★ Project website: <https://esites.vito.be/sites/refrasort/Pages/default.aspx>

LIGHTER AIRCRAFT FUSELAGES COULD CUT COSTS FOR AVIATION

An EU-funded project has advanced new aircraft fuselage structure technology, paving the way for lighter aircraft and cost reductions in the aircraft manufacture industry.

Improving manufacturing efficiency and driving down costs, while also ensuring aircraft safety are key challenges for the aircraft industry. One way to overcome these hurdles is with lighter and highly integral manufactured airframe fuselage structures — the aircraft's main body section which holds passengers, crew and cargo.

The EU-funded POLARBEAR (Production and Analysis Evolution for Lattice Related Barrel Elements Under Operations with Advanced Robustness) project focussed on developing light and low-cost airframe fuselage structures for civil transport aircraft.

Scientists working under the project aimed to improve the manufacture of geodesic technology — the lattice structures which are shaped into an aircraft's fuselage barrel shape. These are made with the latest generation of light but strong composite materials such as carbon fibre reinforced polymers. They aimed to develop highly automated processes for the manufacture of fuselages, which will help cut costs for the industry by boosting the efficiency of the manufacturing process. 'The key POLARBEAR project result is that we have helped increase the technology readiness level of the latest geodesic fuselage structures,' explains Christian Huehne, POLARBEAR project coordinator.

EU scientists, working alongside Russian scientists, developed a process that automates the shaping and positioning of the composite materials used in an aircraft fuselage. The process involves using very narrow grooves in a mould. Progress achieved by the project opens the door to the possibility of a one-shot fuselage structure manufacturing process. 'This would ultimately remove the need for more costly assembly-line airframe sections, significantly

decreasing production time and costs,' Huehne adds. Moreover, the sizing algorithms the project created are now ready for use and purchase, and one project partner is now taking this forward into their finite element software.

Throughout the project, scientists also explored ways to enhance the reliability and safety of the geodesic fuselage structures under operational load conditions. They investigated how the structure would buckle under loading and its overall damage tolerance level after impact. They also explored the different repair processes that a damaged structure could undergo. Huehne notes that the sizing algorithms project scientists created can also be used in other applications including the wind energy industry.

The project complements the work of another EU project — ALASCA — which investigated the global structural behaviour of composite geodesic structures. Overall POLARBEAR aimed to analyse the structures on a local level, improving their robustness — and hence safety — and readiness for roll-out.

"The key POLARBEAR project result is that we have helped increase the technology readiness level of the latest geodesic fuselage structures."

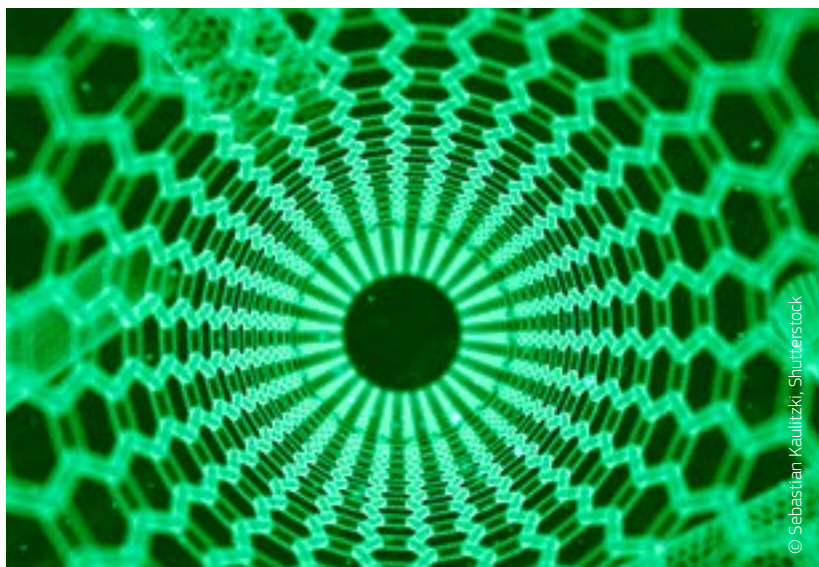
POLARBEAR

- ★ Coordinated by DLR in Germany.
- ★ Funded under FP7-TRANSPORT.
- ★ <http://cordis.europa.eu/project/rcn/111110>



NO LONGER SWEATING THE SMALL STUFF, FOR NANO-ENABLED DESIGN

The EU-funded MMP project has developed a modelling platform to solve multiscale and multi-physics engineering problems for nano-enabled design.



“This interface approach enables workflows which are extendable and modular, independent of a particular tool or data format.”

examples can be arbitrarily extended for other modelling. The versatility and power of the platform was further assessed through two case studies on the performance of phosphor light conversion in LEDs and the efficiency of CIGS thin film processing for photo-voltaic devices.

A platform from which to build the future

The development of an interoperative system was no easy task, as Mrs Wiegiersma recalls, ‘The main scientific challenge for building this platform lies in a proper definition of scale transitions and the associated information exchange between the relevant scales.’ However, she goes on to assert that, ‘The benefits consist in the significant reduction of manual coding, an interoperability based on standardised schema and the potential availability of many tools.’

Ultimately, the platform holds out the potential to producers of reducing development costs, decreased time to market and improved production yield. MuPIF has been distributed as open source software supported by online documentation. This will enable future users such as SMEs, to not only benefit from — but also contribute to — the project as well as new product designs.

Nano-enabled materials and devices hold out much promise in the high-tech industry, offering increased quality and functionality. However, nano-enabled design requires the application of the right numerical tools, alongside a better understanding of multiscale transitions and how best to treat simulations involving multiple physical models (multi-physics). Unfortunately, a tool which can combine software, both local and networked, tailor-made or licensed, does not currently exist in the marketplace.

The EU-funded MMP (Multiscale Modelling Platform: Smart design of nano-enabled products in green technologies) project was set up to address this gap by developing a modelling platform, equipped specifically to accommodate multiscale and multi-physics engineering problems. To enable the integration of existing modelling software and data repositories, the platform was designed to be generic and modular, supported by data standardisation and clearly defined application interfaces.

The pursuit of interoperability

Often the scientific knowledge gained in particular fields is contained within specialised simulation tools or databases. Individual scientific fields are currently witnessing efforts to consolidate this knowledge between their diverse sources,

facilitating the design and manufacture of new materials and products. There is however less focus on the combination of knowledge across scientific fields.

By its very nature nano-engineering is multidisciplinary, with various modelling and simulation resources distributed between entities such as companies and research institutes. To enable collaboration and innovation, MMP set out to provide infrastructure that allows these independent simulation tools and databases to be interoperable. In other words, allowing the models to communicate with each other. As the project coordinator Mrs Sjoukje Wiegiersma explains, ‘This will facilitate the development of complex multi-physics models and their fully automated runs, allowing mutual data exchange, communication and execution.’

The resultant MuPIF platform works through abstract interfaces developed by the team. These can be plugged into by simulation tools and data components used by existing tools and libraries. This interface approach enables workflows which are extendable and modular, independent of a particular tool or data format.

The project demonstrated the platform’s efficacy by taking the examples of a simple multi-physical thermo-mechanical coupling and a multiscale computation with homogenisation, partly as these

MMP

- ★ Coordinated by TNO in the Netherlands.
- ★ Funded under FP7-NMP.
- ★ <http://cordis.europa.eu/project/rcn/111027>
- ★ Project website: <http://mmp-project.eu/>

INFORMATION AND COMMUNICATION TECHNOLOGIES

AUDIO SKETCHING GOES HIGH TECH

A new way of 'sketching' audio is helping artists and designers become more innovative and creative. The technology is proving especially interesting for applications such as electric vehicles, computer games and human-computer interaction.

Creativity is changing rapidly with the advent of digital technology, enriching not only our evolving art world but also applications involving communication, gaming and computer interaction. Whereas pen and paper were once the de facto method of sketching, computers have added a myriad of ways for artists to express themselves.

One relatively novel way of doing so is by integrating the sonic behaviour of objects in artwork. This was the aim of an innovative EU-funded SKAT-VG (Sketching audio technologies using vocalizations and gestures) project. To explain, 'if Bob wants to communicate to Alice what a squeaky door sounds like, he may use words or, more directly, he may imitate that sound with his voice, possibly accompanied by gestures,' says project coordinator Davide Rocchesso from Università Iuav di Venezia. 'People are very good at mimicking sounds with voice and gestures, especially those that are difficult to describe using words,' he clarifies.

SKAT-VG worked on exploiting these natural capabilities in the field of sound design. The main idea from a technical standpoint involves digitally sketching audio technologies. 'Starting from a vocal sketch, a machine extracts a parametric sound model, which can be further manipulated by voice and gesture as well as by conventional knobs and sliders, to produce refined sound creations,' explains Rocchesso.

To achieve its aims, the project team included experts from a variety of complementary disciplines including cognitive psychology, gesture analysis, machine learning, audio application development, voice production and interaction design. It then analysed the way that people employ gestures and vocalisations to communicate sounds, assessing current approaches of sound designers, machine learning and sketching tools.

In effect, sound sketching can be considered a new medium that can support artists in innovating and creating. 'Sound artists and designers are involved in the development of complex products such as games, movies, or cars,' says Rocchesso. 'If properly assisted by SKAT-VG technologies, voice sketching becomes a creativity booster and facilitates the circulation of sound ideas.'


During the project, artists came together to collaborate and explore creative possibilities using sound sketching techniques. 'Several sound designers actually modified their work practices to introduce vocal sketching,' says Rocchesso. 'They discovered how voice and gestures are terrific means to work collaboratively on sound design projects.'

Indeed, enabling designers to use their voice and hands directly for sketching the auditory aspects of an object makes it easier to exploit sound's functional and aesthetic possibilities. 'Sound certainly contributes to the aesthetic character of a product and is often a key ingredient for making the product usable and safe,' confirms Rocchesso.

One interesting arena where the technology plays out is electric cars, which require a large repertoire of sounds to support the safety of drivers and pedestrians. Equally interesting, interactive environments such as those seen in computer games could also exploit SKAT-VG to couple sounds tightly with actions. Put simply, 'sketches, whether in relation to sound or to any other aspect of a product, are a means to let creative ideas emerge and be communicated,' says Rocchesso.

The project has advanced our understanding on how vocalisations — and vocal imitations in particular — are produced and perceived. It has shed light on the role of gestures in complementing voice-based communication within a variety of applications. A safer, richer, more stimulating and more exciting world could emerge from this new, innovative technology.

SKAT-VG

- ★ Coordinated by Università Iuav di Venezia in Italy.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110562>
- ★ Project website:
<http://skatvg.iuav.it/>
- ★  <http://bit.ly/2sjRolk>

NEW METHODS AND ALGORITHMS FOR ATOMISTIC COMPUTER SIMULATIONS

Thanks to EU-funded research, quantum-mechanical calculations of optical spectra are now more efficient and faster.

Over the course of the last two decades, density functional-based linear response approaches have become the de facto standard for calculating optical properties of small and medium-sized molecules. At the heart of these methods is the eigenvalue equation in the space of single-orbital transitions solution.

The problem with this solution is that its quickly increasing number makes such calculations costly — if not infeasible — for larger molecules. This is particularly true for ‘Time-dependent density functional tight binding’ (TD-DFTB), where the evaluation of the matrix elements is inexpensive. For the relatively large systems that can be studied, the solution of the eigenvalue equation determines the cost of the calculation.

To solve this problem, the EU-funded PROPAGATE (New Propagation Techniques for the simulation of dynamical processes in extended systems) project used an oscillator strength-based truncation of the single-orbital transition space to reduce the computational effort of the TD-DFTB based absorption spectra calculations.

New methods of study

What PROPAGATE researchers set out to do was develop advanced methods for the first principles of atomistic computer simulations and their

application to such environmentally important topics as nanotechnology and biophysics. ‘What we wanted to show was that even a sizeable truncation does not destroy the principal features of the absorption spectrum, while naturally avoiding the unnecessary calculation of excitations with small oscillator strengths,’ explains Project Coordinator Thomas Heine. ‘Our argument was that reduced computational cost of intensity-selected TD-DFTB, together with its ease of use compared to other methods, lowers the barrier of performing optical property calculations of large molecules and can serve to make such calculations possible in a wider array of applications.’

During the course of its research, the project developed methods that allowed for the studying of the first-principles molecular dynamics of the ground, thermally excited and photo-excited states, along with extended simulations using hybrid methods that combined quantum and classical mechanics. These methods were then used for two applications in the fields of nanotechnology and biophysics to study the high-temperature formation and solubility of mixed metal oxide hetero particles.

‘Computer technology has become increasingly more complex, both in terms of software and hardware, and end users expect a comfortable “Graphical user interface” (GUI),’ explains Heine. In order to keep up

with modern software standards, the project used a combination of modern scripting (python) with traditional Fortran language. As to the development of the hardware, where the power of the individual CPU was only slowly increasing in the past years, a completely parallel implementation paradigm had to be followed. ‘The result is that the software could be used by GUI, but also in a command-line version that allows scripting and automated output processing,’ adds Heine.

More efficient calculations

The end result of this research is the successful development of new methods and algorithms for atomistic computer simulations for dynamical processes in nanoscale systems at the quantum-mechanical level. These methods and algorithms have been implemented into the ADF Modelling Suite — a modern scientific software package ready for commercialisation. ‘Due to PROPAGATE, quantum-mechanical calculations of optical spectra are computationally more efficient, faster and capable of being studied,’ says Heine.

In addition, the project also developed software for the computer-aided design of such molecular framework compounds as ‘Metal-organic frameworks’ (MOFs) and ‘Covalent-organic frameworks’ (COFs) — both of which are promising new materials composed of individual molecules.



PROPAGATE

- ★ Coordinated by Leipzig University in Germany.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/105057>

“The project used a combination of modern scripting (python) with traditional Fortran language.”

GREENING URBAN DISTRICTS MADE EASIER WITH NEW SOFTWARE

EU researchers have developed new digital tools which allow a coordinated approach to sustainable urban renewal.

Making our cities more sustainable is key to the fight against climate change and to a more environmentally-friendly future. Today, much of the work to reduce carbon emissions and integrate more nature in cities focuses on the small-scale. This includes retrofitting buildings with energy efficient windows or solar PV panels.

However, much more progress could be achieved if changes could be coordinated at city-district level. For example, renewable district heating systems could be incorporated and open green spaces could be expanded.

The EU-funded ECODISTR-ICT (Integrated decision support tool for retrofit and renewal towards sustainable districts) project is hoping to boost coordination by creating new software that allows a variety of stakeholders to get involved and plan a more environmentally-friendly urban community together. 'We thought that if the different stakeholders concerned could work together, green measures could be implemented on a much broader level and economies of scale would kick-in, boosting the financial viability of projects,' says Han Vandevyvere, ECODISTR-ICT Project Coordinator from VITO EnergyVille, Belgium.

Throughout the project, the researchers developed new, open-source software called the ECODISTR-ICT Integrated Decision Support System (IDSS). The system is accessible via a password login for citizens and decision makers in the specific district concerned. The IDSS connects the main decision makers in an urban district and allows them to develop a coordinated approach to retrofitting buildings and renovating districts.

It also gets local citizens involved via web-based questionnaire tools that collect relevant data such as energy consumption figures. Moreover, citizens' opinions can be factored in by putting possible future district designs to vote.

The software was designed to be a common data platform that takes local climate, local policies and local culture into account. To do this, decision makers can set their own 'Key performance indicators' (KPIs) such as energy consumption, affordability or available green spaces and chose which calculation tools to add to the software.

'The platform unites users in a single online environment to overcome current fragmentation, to design a vision for a district. It analyses the costs and benefits of various design options that plan for the entire life cycle of buildings,' explains Vandevyvere.

'Expert users' such as architects and urban planners, can then use the tools included in the software such as a map-based editor to create new scenarios for the district.

During the project, the IDSS was implemented in five different locations across Europe: the Kiel neighbourhood in Antwerp, Belgium; Rubroek in Rotterdam, the Netherlands; Campanar in Valencia, Spain; Służewiec Przemysłowy in Warsaw, Poland and Hovsjö, near Stockholm, Sweden.

In each case, the project demonstrated how the ECODISTR-ICT IDSS can help plan urban district renewal. The case studies



"The platform unites users in a single online environment to overcome current fragmentation, to design a vision for a district."

also confirmed the need for location-specific urban renewal objectives, as opposed to a one-size-fits-all planning approach.

Project partners are now exploring the opportunities to use ECODISTR-ICT's software in urban retrofitting projects across Europe and beyond. Meanwhile, several research projects are interested in using the IDSS as part of their urban planning toolset.

A small team of project partners are planning to offer an ECODISTR-ICT web service as a commercial spin-off from the project. The team would take care of ICT-related tasks including setting up servers and offering helpdesk support so future IDSS users such as city administrators, architects and urban planners could focus on content.

ECODISTR-ICT

- ★ Coordinated by VITO in Belgium.
- ★ Funded under FP7-ENVIRONMENT.
- ★ <http://cordis.europa.eu/project/rcn/110674>
- ★ Project website: <https://ecodistr-ict.eu/>

CRDTs FOR NON-SYNCHRONISED NETWORKED APPLICATIONS

Historically, the only way to prevent two computers using the same online application from modifying the same data at the same time has been synchronisation. Claiming that this system is inefficient and a waste of resources, the SYNCFREE project suggests a better approach, using 'Conflict-free replicated data types' (CRDTs).

CRDTs have been around for a while. These data structures can be replicated across multiple computers in a network and updated independently without the need for synchronisation, and can prevent inconsistencies by merging their respective updates. Yet, critical applications such as virtual wallets, advertising platforms, social networks or online games still tend to resort to synchronisation.

'Synchronisation is antinomic to fast response and availability,' says Marc Shapiro, computer scientist at UPMC-LIP6 and Inria, and coordinator of SYNCFREE (Large-scale computation without synchronisation). 'As one computer awaits update permission from another, it does nothing useful, wastes resources, and does not even respond to the user. Worse, if the network breaks, the wait may last indefinitely, and the application is stuck.'

Thanks to CRDTs, the two above-mentioned computers can make their updates independently and at the same time: one sends its updates to the other; and each one merges the remote updates it receives with its own. 'This requires careful programming, and does not work for all types of data. But it has proved to be very useful in practice. Plus, CRDT-based programs are "Available under partition" (AP), meaning that each computer can do its job even when the network is broken. Since a computer running CRDTs does not ask for permission, it can always respond immediately, which also brings down cost,' Shapiro explains.

Unlike previous AP approaches, which were very complex to use for software developers, a CRDT has clear semantics, and encapsulates the details of remote communication and merging into an intuitive interface.

One challenge on the path to increased commercial exploitation of CRDTs was the lack of applications and systems entirely based on this technology. This posed various problems, in particular with regards to how to build a CRDT-based

communication and storage system, how to maintain desirable properties when updating different pieces of information in an AP system, how to program CRDT-based applications effectively, and how to scale to geo-distributed cloud computing systems with hundreds of computers.

These obstacles are precisely those that SYNCFREE aimed to overcome. 'The project has positive results in all these areas,' Shapiro explains. 'Among other things, we have built an effective open-source cloud database, Antidote, which has been demonstrated on hundreds of machines distributed worldwide. We developed new, more scalable approaches for storing CRDTs and transmitting updates. We have built large programs, in particular a demanding distributed benchmark called FMKe (patterned after the Danish healthcare network FMK). We have demonstrated a dataflow-style distributed programming language called LASP, and, finally we have designed a methodology — called Just-Right Consistency — for ensuring that data stored in this system actually behaves as intended by the application.'

Even before the project started, some of its concepts had already been picked up by industry, including the four industrial partners of SYNCFREE who have extensively contributed application requirements, development suggestions, and data from real, cloud-scale,

deployed applications. One of them is using Antidote in one of its products.

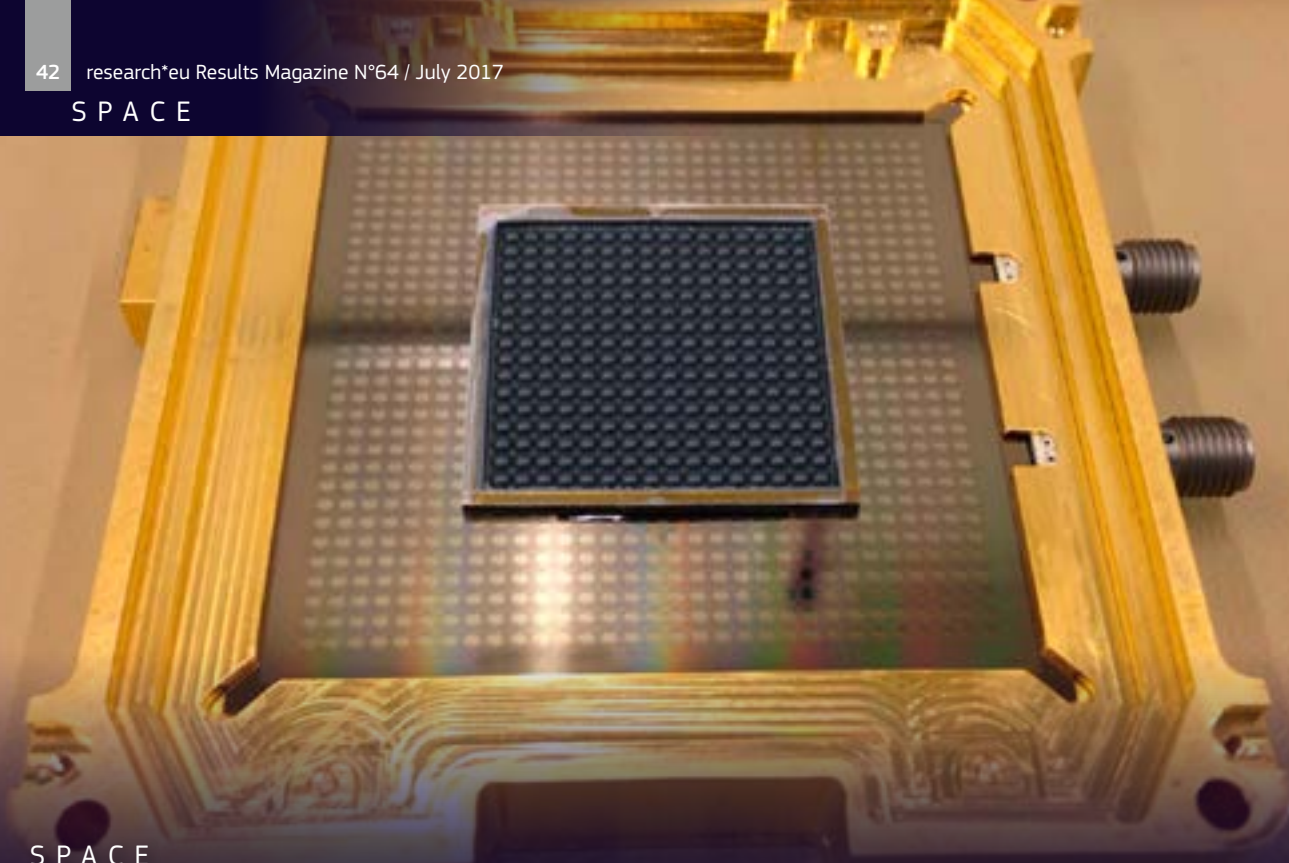
'Now that the SYNCFREE project is finished, there is a follow-up H2020 project named LIGHTKONE that we have just started, with more industrial partners. The aim of it is to enable massive, distributed general-purpose computing "at the edge". Whereas SYNCFREE focused very much on a datacentre environment, LIGHTKONE aims to keep the data and computations as close as possible to the users. This raises some exciting new challenges when scaling from a few hundred computers in a well-controlled environment, to millions, located in unpredictable environments,' Shapiro says. 'Independently, a company is using LASP in production, and we have high hopes for adoption of Antidote. We are even discussing plans for a start-up to further commercialise the results of the project.'

In the meantime, most project contributions, including Antidote, LASP, FMKe, and the Just-Right Consistency tools, are already available on GitHub under the Apache licence.

SYNCFREE

- ★ Coordinated by Inria in France.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/110627>
- ★ Project website: <https://syncfree.lip6.fr/>





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SPACE

NEW SUPERCONDUCTING DETECTORS FOR FUTURE SPACE MISSIONS

EU-funded scientists have developed and demonstrated the capabilities of 'Kinetic inductance detectors' (KIDs) operating at far infrared and millimetre wavelengths for use in Earth observation missions.

Until now, the choice of detector technologies available in the far infrared to millimetre wavelength range has been limited, and detector systems have been costly to implement. KIDs are a relatively new piece of superconducting detector technology suitable for detecting electromagnetic radiation at wavelengths between 30 μm and 3 mm.

Before the SPACEKIDS (Kinetic inductance detectors — A new imaging technology for observations in and from space) project, basic operational concepts had been demonstrated for ground-based applications. The EU-funded project worked to advance KIDs technology to the next stage.

World-leading research groups from four European countries joined their efforts to extend the capabilities of state-of-the-art far infrared detectors. They focused on the developments needed for implementing KIDs in a new generation of space-based instruments.

Various detector materials were explored to optimise the far KIDs' performance. Tests showed that aluminium films could achieve the required sensitivity over the entire far infrared to millimetre wavelength range.

The performance of KIDs in the presence of a cosmic ray flux, representative of different space environments, was optimised through modelling and testing. Furthermore, detailed optimisation of the efficient coupling of electromagnetic radiation to different implementations of KIDs — antenna-coupled and lumped-element — was carried out.

The researchers also identified a number of space mission concepts for astronomy and Earth observation for which KIDs could be a competitive detector choice. They analysed several mission scenarios, for each of which they also defined KID requirements.

Ultimately, KID pixel and array designs were developed together with readout electronics necessary for reading out large numbers of pixels for low backgrounds (typical of astrophysical applications) and high backgrounds (typical of Earth observation applications).

The SPACEKIDS team used two laboratory demonstrators to evaluate KID array characteristics and performance in the space environment. The successful results open the way for a new generation of scientific instruments, promising a better understanding of our planet and the universe.

SPACEKIDS

- ★ Coordinated by Cardiff University in the United Kingdom.
- ★ Funded under FP7-SPACE.
- ★ <http://cordis.europa.eu/project/rcn/106575>
- ★ Project website: <http://www.spacekids.eu/>

IN THE BIRTHPLACE OF EXTRASOLAR PLANETS

EU-funded scientists have shed new light on circumstellar discs spinning around newly born stars that, like modern-day alchemists, transform dust and gas into astronomical gold: extrasolar planets.

Circumstellar discs are the extrasolar analogues of the dust complex in the Kuiper belt encircling our solar system. They have been observed from optical up to millimetre wavelengths, from the ground as well as space. Numerous theoretical models have also been developed to describe how circumstellar discs evolve, giving their place to planetary discs and, eventually, planets. However, past studies relied on poor statistics, with only a few known objects.

The EU-funded DISCANALYSIS (Analysis and modelling of multi-wavelength observational data from protoplanetary discs) project was launched with the aim of combining a wide range of observations to constrain different aspects of disc structure and dust content. For the first time, 85 circumstellar discs were probed from optical through near-infrared wavelengths in scattered light to the millimetre regime corresponding to thermal emission.

In addition to archived data, scientists exploited the latest data from ongoing observational programmes, such as the Herschel Space Observatory and the Hubble Space Telescope. All these data were folded in to find quantitative evidence of disc evolution. Scientists followed grains growing up to millimetre-sized particles and larger grains to fluffy aggregates that ultimately create kilometre-size planetesimals.

Furthermore, they developed theoretical models of 45 selected objects, reproducing dust evolution in discs as coherently as possible. An unprecedented level of completeness was reached with the inclusion of physical, chemical and radiative processes. The multi-wavelength data sets compiled and the model results cover all evolutionary stages until discs start to dissipate.

All aspects of circumstellar disc evolution through to the first stages of planet formation, which were poorly understood,

had been explored by the time the project ended. DISCANALYSIS capitalised on its team expertise in observation analysis and modelling, and provided long-awaited answers to fundamental questions related to planet birth.

DISCANALYSIS

- ★ Coordinated by the University of St Andrews in the United Kingdom.
- ★ Funded under FP7-SPACE.
- ★ <http://cordis.europa.eu/project/rcn/100937>

“They developed theoretical models of 45 selected objects, reproducing dust evolution in discs as coherently as possible.”

ACCURATE SATELLITE MEASUREMENTS OF GREENHOUSE GASES

The lack of suitable laser sources has been one of the main challenges in space missions designed to measure sources and sinks of greenhouse gases. However, a new generation of all-semiconductor laser sources promises optical instruments with the required measurement accuracy.

Existing optical instruments for measuring atmospheric gases are based on bulky solid-state lasers. The EU-funded BRITESPACE (High brightness semiconductor laser sources for space applications in Earth observation) project was launched to demonstrate the suitability of all-semiconductor lasers to be used as space-borne laser transmitters.

Researchers developed such semiconductor lasers emitting at two different wavelengths between 1500 and 1600 nm for satellite ‘Light detection and ranging’ (LIDAR) measurements. With their compact size and high level of reliability, these high-brightness laser sources offer significant advantages over other laser sources.

The BRITESPACE systems consist of a commercially available laser as the transmitter and optoelectrical elements for signal detection (integrating sphere, photon counting detector, filter and guide laser for alignments). These can be used as the transmitter unit of a LIDAR system enabling measurements of ‘carbon dioxide’ (CO₂) in the atmosphere.

The parametric studies conducted promise a relatively high level of sensitivity for CO₂ measurements from both a space-borne and a ground-based platform. However, theoretical modelling and dynamic simulations revealed that the performance of the proposed LIDAR system suffers from ambient light noise and noise from the detector dark counts.

BRITESPACE work has enhanced our knowledge of semiconductor lasers and successfully addressed issues surrounding the detection of CO₂ for future Earth observation space missions. Advanced LIDAR technology enabling reliable monitoring of key greenhouse gases in the atmosphere will help in the struggle against global warming.

BRITESPACE

- ★ Coordinated by the Technical University of Madrid in Spain.
- ★ Funded under FP7-SPACE.
- ★ <http://cordis.europa.eu/project/rcn/106606>
- ★ Project website: <https://www.britespace.eu/>



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"Throughout the project, scientists developed new molecule modelling techniques that could quantify the interactions between the different photochromes inside a molecule."

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FUNDAMENTAL RESEARCH

MORE EFFICIENT 'MULTI-SWITCHABLE' MOLECULES COULD BOOST DATA STORAGE

EU scientists can now model how complex molecules switch from one state to another when exposed to light, potentially paving the way for more efficient data storage devices and other novel technologies.

Photochromes — or molecules that can exist in two forms — can be switched from one form to another by being exposed to light. They are used for a wide range of purposes from colour-changing sunglasses to data storage. Scientists are now working on how to increase the potential of photochromes by improving their switching possibilities.

The EU-funded MARCHES (Modelling of Architectures Ruled by Coupled or Heightened Excited States) project has laid the foundations for more efficient 'multi-photochromes'. These are molecules that combine several switchable units onto the same molecule core, potentially boosting the amount of data one molecule could contain from one bit of information to one byte or more.

'Under current technology, most compounds with two or more molecular switches are inefficient — usually only one of their switches works properly. Our main goal was to design improved multi-switchable molecules using chemical-modelling tools, in particular Time-Dependent Density Functional Theory, a quantum theory. These molecules could then pave the way towards

more complex and efficient devices,' explains Denis Jacquemin, MARCHES project coordinator.

Throughout the project, scientists developed new molecule modelling techniques that could quantify the interactions between the different photochromes inside a molecule. This allowed them to discover the physics behind the current limitations of multi-photochrome molecules.

'The challenge MARCHES set itself was particularly high since the switching processes are induced by light and therefore require the calculations of many coupled electronically excited states. However, we succeeded in establishing a series of new complementary models for several scenarios and we obtained results that matched the experiments,' says Jacquemin.

These models can now be used to design more efficient photochromes which could later be used in more efficient data storage devices or other technology sectors like photochromic colour-changing objects showing more than two colours, novelty toys and clothing.

MARCHES has also led to other results, including three new patents in alternative cycles to porphyrins for optical applications like solar cells, materials able to generate white-light for new lighting devices, and photo-responsive paper with hidden marks which could find applications in packaging.

With the project now over, researchers have moved on to exploring fluorescent dyes that could be used for medical applications, as well as to the semi-quantitative prediction of reaction yields at excited-states. This will allow more accurate theoretical predictions that could advance experiments in creating better fluorescent molecules. 'Researchers have made some exciting progress in model compounds,

and we believe that applications in real-life systems, such as improved lightning devices, are now definitely within reach,' concludes Jacquemin.

MARCHES

- ★ Hosted by the University of Nantes in France.
- ★ Funded under FP7-IDEAS-ERC.
- ★ <http://cordis.europa.eu/project/rcn/101847>
- ★ Project website: <http://www.sciences.univ-nantes.fr/CEISAM/erc/marches/>

A NEW LOOK AT MULTI-ELECTRON INTERACTIONS

An EU-funded project has built a powerful theoretical framework with notions derived from physical, chemical and mathematical studies to describe the complex dynamics in laser-matter interaction.

Attosecond science has opened the door to real-time observation and time domain control of atomic-scale electron dynamics. Studies of the electron correlation — electron interactions — through ultra-short laser pulses are ideal for investigating both quantum and classical approaches. The results obtained using both frameworks can be compared with the latest experimental results.

The EU-funded TRANS-MI (Transition states for multielectron ionization phenomena) project built a unified theoretical framework analogous to the transition state theory for chemical reactions. The work improves our understanding of the role of electron-electron interactions in strong-field laser physics.

Atoms and molecules generally undergo multiple ionisations when exposed to intense electromagnetic fields. The mechanism that regulates correlated emission follows the recollision process. First, the electron is ionised by the field. Then, by reversing the field direction, it is hurled back to the core, colliding with the second electron and thus triggering correlated emission. This is also referred to as 'Non-sequential double ionisation' (NSDI).

The TRANS-MI team successfully uncovered the dynamical mechanism responsible for electron recollisions, which describes the energy exchange between the laser and the atom or molecule. For the first time, they demonstrated that phase-space structures can give rise to highly correlated NSDI, enhancing understanding of the recollision process. Future work will further explore how this discovery links with research into applied mathematics and celestial mechanics.

Another focus was on studying how different environments can influence chemical reactivity of phase-space structures. Expanding on the success of previous research on an elusive phenomenon known as the Kramers turnover, which studies the relation between molecule friction and density of a heated bath, scientists provided new insight into the reactions of small polyatomic molecules in an all-atom heated bath.

The team also established a relationship between the stability of the transition

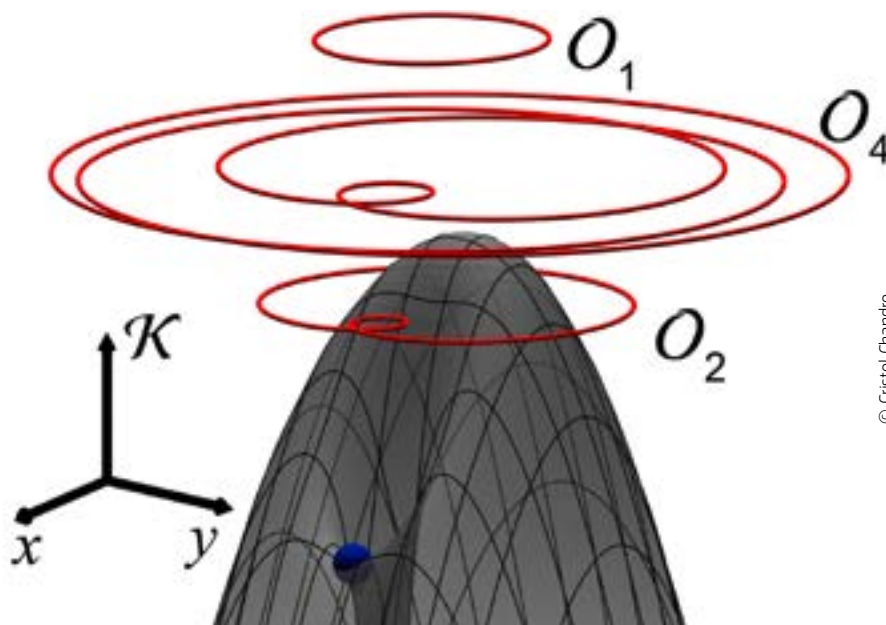
state of chemical reactions and their rate. Based on this, they devised a sophisticated computational approach that simplifies the calculation of molecule reaction rates. This eliminates the need to compute millions of reactive trajectories as most other computational schemes would require.

TRANS-MI approaches reduce the complexity of studying the chaotic electron interactions in atoms or molecules that involve many degrees of freedom. Furthermore, understanding how molecules interact with their environment enables scientists to selectively control chemical reactions and get rid of undesirable side-products.

TRANS-MI

- ★ Coordinated by CNRS in France.
- ★ Funded under FP7-PEOPLE.
- ★ <http://cordis.europa.eu/project/rcn/102629>

"Scientists provided new insight into the reactions of small polyatomic molecules in an all-atom heated bath."



NANOPHOTONIC ANTENNAS UNVEIL THE NANOSCALE MECHANISMS OF DISEASE

Full understanding of the living cell is now within reach thanks to recent advances in nanophotonics. EU researchers have managed to bring nano-antennas to the biological domain — something that had never been achieved before. Collaborations with major industry players have already begun.

Observing biological processes in the living cell is pretty much the holy grail of molecular and cell biologists. These processes — which involve interactions between molecules at the nanometre scale — are very difficult to visualise with current imaging technology, and the same also goes for interactions between proteins, nucleic acids or enzymes.

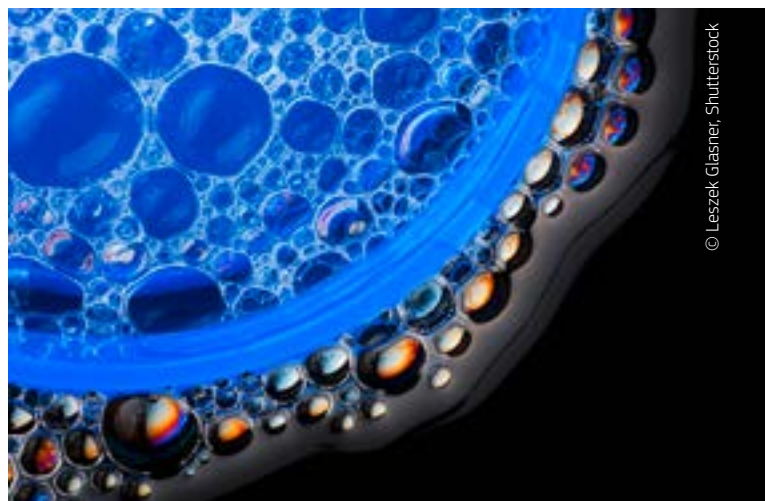
‘There are many examples of the limitations of current technology,’ says Dr Maria Garcia-Parajo, coordinator of the NANO-VISTA (Advanced photonic antenna tools for biosensing and cellular nanoimaging) project and Group Leader at ICFO in Spain. ‘For instance, we have a limited knowledge of how receptors organise in cell membrane. This is a fundamentally important question since cells in our body communicate with each other and with their extracellular milieu through a multitude of receptors expressed on the cell surface, enabling them to perform specialised functions.’

Evidence also exists that aberrant changes in organisation and dynamics of cell surface receptors are the source of an overwhelming number of diseases such as cancer, neurological and neurodegenerative diseases, auto-immune disorders and pathogenic infections. ‘Visualising these events taking place at the nanometre level and over different temporal scales in real-time requires imaging techniques with an ultra-high level of resolution,’ Dr Garcia-Parajo continues. A super-resolution of sorts.

Dr Garcia-Parajo and her team believe the solution lies in photonic nano-antennas — intense nanoscale hotspots of illumination that can be used to image a sample at a scale of around 20 nm and probe interactions between molecules. Whilst these are not the only route to super-resolution, other forms of super-resolution microscopy rely on very specific fluorescent labels. They might therefore not reach the full spectrum of biological applications, a limitation that photonic antennas do not suffer from. Additionally, these antennas can be used in combination with other techniques such as fluorescence correlation spectroscopy to provide a microsecond time resolution.

Whilst the physics of nano-antennas were already well-mastered, NANO-VISTA is the first successful attempt to bring them into the realm of biology thanks to innovative designs.

Dr Garcia-Parajo details the process that led to this breakthrough: ‘We devised novel routes for the fabrication of large scale arrays of antennas so that we could interrogate at the nanoscale multiple cells coping with their inherent heterogeneity. We did this while keeping in mind designs that would provide high reproducibility on the optical performance of the antennas, scalability to fabricate thousands on antennas in a single substrate, re-usability and low cost. Finally, we combined these nanostructures with novel forms of fluorescence spectroscopy to provide not only spatial but also importantly, ultrahigh temporal resolution.’



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The results of demonstrations run under the project were outstanding. The team notably showcased single biomolecule (DNA & different proteins) detection in zepto-litres illumination volumes, enhanced the fluorescence signal from individual molecules by factors 105 times larger than the emission of a single molecule when excited by conventional confocal illumination, revealed excitonic coupling in individual light harvesting complexes, and collaborated with immunologists to provide insights into the processes of immune cell adhesion and migration.

Several collaborations were already initiated with major industry players worldwide, notably in the USA, India, the UK and Spain. In the crosshairs: NANO-VISTA technology exploitation in cell membrane biology and cell signalling, integration in standard microscopes, or high-throughput screening platforms for rapid testing of specific antibodies, ligand interactions or even drugs. Side-products are being prepared for future commercialisation, although full commercialisation of all project outcomes still poses some challenges.

‘The NANO-VISTA consortium is very much alive,’ Dr Garcia-Parajo enthuses. ‘NANO-VISTA has provided the means to go down to the nanoscale with microsecond time resolution. Now, we need to interlace this information with micro- and meso-scale imaging on single cells and cell populations. Hopefully new sources of funding from the European Commission will permit this dream to come true.’

NANO-VISTA

- ★ Coordinated by ICFO in Spain.
- ★ Funded under FP7-ICT.
- ★ <http://cordis.europa.eu/project/rcn/99806>
- ★ Project website: <http://www.nanovista.eu>

EVENTS

SEPTEMBER
11►14

Ghent, Belgium

CONFERENCE

1ST MYCOKEY INTERNATIONAL CONFERENCE 'GLOBAL MYCOTOXIN REDUCTION IN THE FOOD AND FEED CHAIN'

The MYCOKEY project will be holding its first International Conference in Ghent, Belgium from 11 to 14 September 2017.

Mycotoxins have a significant impact on food and feed safety. Both legislative limits and the emergence of new strains lead to an increase in the number of official controls deriving from national food safety plans and for trade.

The EU-funded MYCOKEY project will be setting out some concepts to address the current challenges. The Conference will consider the following key areas, among others, in mycotoxin research: the global impact of mycotoxins, biodiversity and toxigenic fungi monitoring, prevention, animal health and toxicology, impact of climate change, human health and toxicology, and modelling and ICT solutions.

An exhibition of sample treatment and chromatographic equipment, test kits and other materials is being organised; interested exhibitors should contact the secretariat.

For further information, please visit:
<http://mytox.be/conferences/#toggle-id-1>

SEPT.
26►29

SEPTEMBER
15►23

Piombino, Italy

COMPETITION

EMERGENCY ROBOTS COMPETITION

The European Robotics League (ERL), supported by the EU-funded ROCKEUE2 project, will run their Emergency Robots competition, 15-23 September, 2017, in Piombino, Italy.

The ERL Emergency Robots 2017 tournament is a civilian, outdoor robotics competition, with a focus on realistic, multi-domain emergency response scenarios. The competition sees International teams of various disciplines and organisations surveying the scene, collecting data, searching for missing workers and identifying critical hazards, all in a race against the clock.

The challenge was inspired by the 2011 Fukushima accident and is designed to showcase land, marine and flying robots working cooperatively. This competition builds upon the success of the euRathlon 2015 Grand Challenge, the world's first robotics multi-domain competition.

It is open to universities, companies and industry interested in applying the results of robotics research and development to real world challenges. It will also provide a forum where roboticists from different areas can exchange ideas, show the state-of-the-art and outline the future of robotics research not only in Europe, but also globally.

For further information, please visit:
https://eu-robotics.net/robotics_league/erl-emergency/about/index.html

SEPTEMBER
20►21

Malmö, Sweden

CONFERENCE

GREEN SURGE FINAL CONFERENCE

The EU-funded GREEN SURGE project will host its final conference in Malmö, Sweden, from 20 to 21 September 2017.

The conference themes are related to emerging issues and future challenges of nature-based solutions and sustainable urban development.

The conference aims for interactions and critical discussions between a mix of researchers, decision-makers, planners and practitioners.

The conference environment and programme will provide opportunities for dynamic presentations and discussions, moderated by international professionals.

The conference organisers also welcome proposals for presentations of research, as well as of projects from practice on any aspect of the broad area of nature-based solutions and sustainable urban development.

For further information, please visit:
<http://greensurge.eu/international-conference/>

EVENTS

For more forthcoming events:
<http://cordis.europa.eu/events>

ROME, ITALY

CONFERENCE

PICQUE/QUCHIP FINAL PROJECT CONFERENCE

The EU-funded PICQUE and QUCHIP projects will host their final conference in Rome, Italy, from 26 to 29 September 2017.

Quantum information has the potential to revolutionise information processing, especially for computer simulations which require system sizes that are currently impossible in classical machines. Consequently, there is a need for a suite of powerful and precise instruments enabling this improved computation. Europe is a world-leader in this field.

This final conference will include tutorial lectures, invited seminars on scientific results, presentations and posters. Around 100-150 senior scientists and young researchers are expected to attend.

The PICQUE project was set up to harness the quantum nature of information and learn how to process it using physical systems, operating according to quantum mechanics laws. The project particularly investigated integrated photonic circuits for quantum information processing in optical systems.

The QUCHIP project was set up to develop new photonic technologies, ranging from on-chip sources of single photons to complex waveguide architectures and on-chip detectors.

For further information, please visit: <http://www.picque.eu/iqconf2017/>

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For more information, go to <http://cordis.europa.eu/article/id/400202>

Resource efficiency

We are also pleased to announce that we have recently updated our Results Pack on Resource Efficiency (originally published in October 2016) with two new project articles.

To find it, please go to <http://cordis.europa.eu/article/id/400140>



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