SUMMER 2026

CEETLETTER

VSB TECHNICAL UNIVERSITY OF OSTRAVA | CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

ČESKÁ VERZE

FOREWORD BY THE DIRECTOR OF CEET

Every new issue of CEETletter serves as a further confirmation to me that the true value of research does not lie in publishing a scientific paper, but in the moment when new knowledge is transformed into methods and technologies that help people address specific modern-day challenges.

This is precisely the journey reflected in the latest edition of our newsletter. Inside, you will find stories of scientists exploring new possibilities for water purification, developing safer materials for energy storage, utilising artificial intelligence to manage modern energy systems, and discovering innovative ways to recycle materials that, until recently, were considered almost impossible to process. The common denominator of all these activities is the effort to connect cutting-edge science with practical application.

I am also delighted that, alongside major research projects, we are increasingly introducing the people behind them. Our doctoral students, early-career researchers, and experienced scientists demonstrate that the future of energy, materials research, and environmental technology is shaped not only by state-of-the-art laboratories, but primarily through talent, courage, and cross-disciplinary and international cooperation.

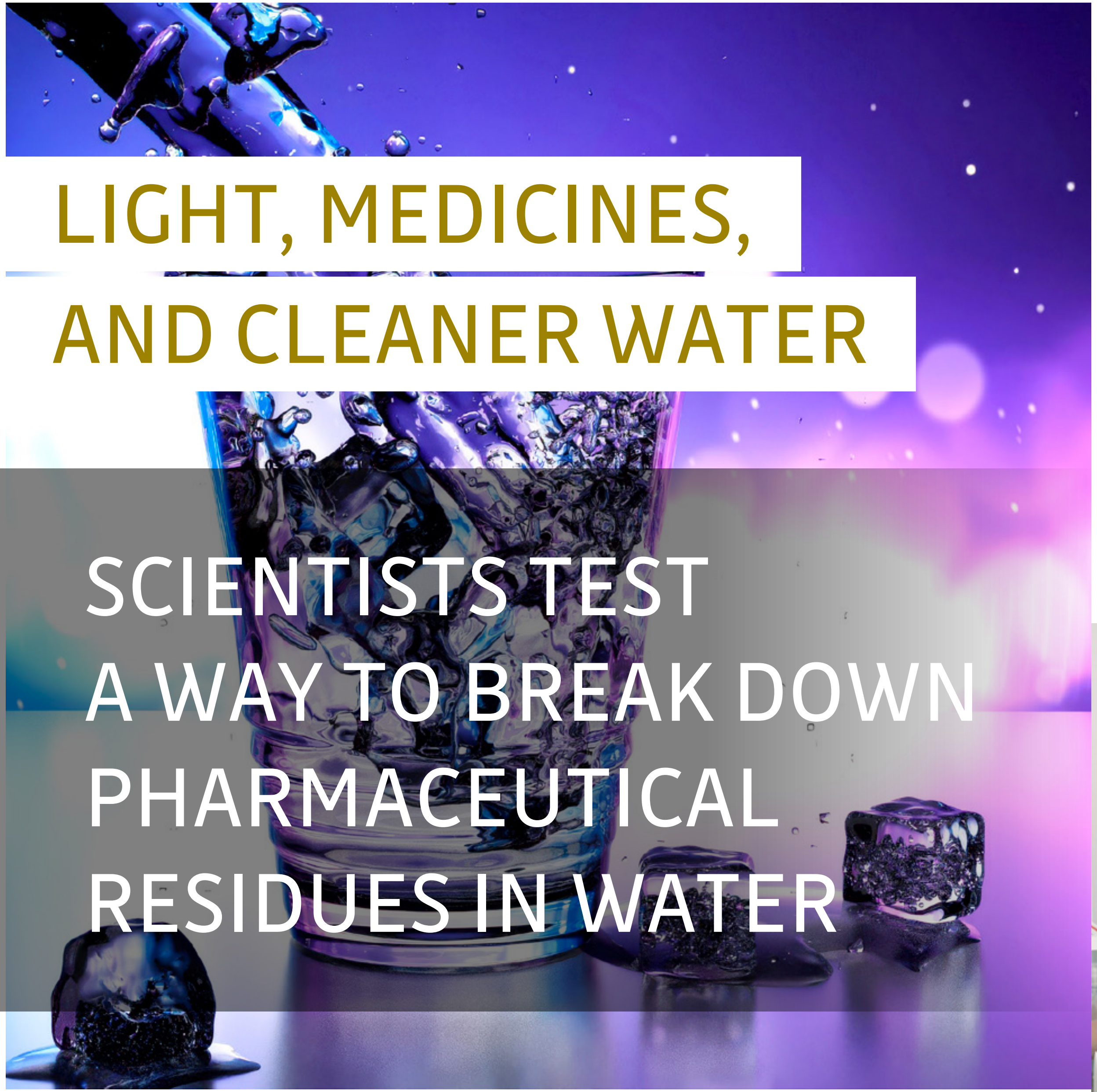
At the same time, CEET continues to strengthen its position as a research centre that brings together research, education and collaboration with industrial partners. The upcoming CEETe II infrastructure, new international projects, and increasingly close ties with businesses are proof of our commitment to creating an environment where technologies with long-term benefits for society and the competitiveness of the Czech Republic can emerge - technologies that can stand up to scrutiny and inspire on a global scale.

I would like to thank all my colleagues for their daily dedication, professional commitment and willingness to push the boundaries of knowledge. It is thanks to you that CEET can fulfil its mission: creating the energy future.

I wish you an inspiring read.

Stanislav Mišák
CEET Director

RESEARCH AND INNOVATION



LIGHT, MEDICINES, AND CLEANER WATER

SCIENTISTS TEST A WAY TO BREAK DOWN PHARMACEUTICAL RESIDUES IN WATER

Pharmaceutical residues in the aquatic environment represent a silent problem in our society. Antibiotics, painkillers, and stimulants help people, but trace amounts can reach rivers through the sewage system after use. A team of scientists from CEET and Palacký University Olomouc has now shown that some of these substances can be effectively broken down under laboratory conditions using light and a special carbon material.

When we take medication, its journey does not end in our bodies. A portion of the active substances or their metabolites ends up in wastewater. Conventional wastewater treatment works are vital for protecting rivers and public health, but they are not designed to completely remove all trace organic substances, such as certain pharmaceuticals, from the water. That is why increasing attention is being paid to so-called micropollutants. Substances that occur in low concentrations but can have biological effects. This topic is also highly relevant at the European level. The revised EU Urban Wastewater Treatment Directive, effective from 1 January 2025, calls for, among other things, stricter water treatment standards and the removal of micropollutants through more advanced treatment stages.

A new study by scientists from CEET at VSB-TUO and Palacký University Olomouc focused on a material (a photocatalyst) known as graphitic carbon nitride, chemically

Petr Praus

Petr Praus has long focused his scientific work on materials that can help protect the environment, particularly through water purification. He graduated from the University of Chemistry and Technology, Prague, with a degree in Silicate Technology, and completed his doctoral studies in Analytical Chemistry at the University of Pardubice. He is a professor of Materials Science and Engineering and currently works at the CEET Institute of Environmental Technology as part of the Water Treatment and Analysis research group. His main area of expertise is nanomaterials. He studies their preparation, characterization and application in processes that can help remove pollutants from aquatic environments. A significant part of his research concerns adsorption and photocatalysis-methods in which undesirable substances can be captured or broken down using suitable materials and light. His current research also includes the photoreforming of microplastics, investigating how light-activated processes can be used to transform tiny plastic particles that represent a growing environmental problem.

$g\text{-}C_3N_4$. Put simply, it can be imagined as a fine yellow powder made of carbon and nitrogen. Its interesting property is that, upon illumination, it can trigger chemical reactions that break down organic substances in water. It is therefore not a filter in the conventional sense. The material does not merely trap the substances; it helps to transform them chemically.

The scientists tested three model substances: ofloxacin, an antibiotic; diclofenac, a commonly used anti-inflammatory drug; and caffeine, which also serves as a readily detectable indicator of human activity in wastewater. The best results were shown by graphitic carbon nitride that had been thermally exfoliated for two hours. When irradiated with light at a wavelength of 420 nanometres, over 95% of the ofloxacin and diclofenac, and approximately 80% of the caffeine, were removed within 120 minutes.

IT IS NOT JUST THE SPEED OF POLLUTION REMOVAL THAT IS DECISIVE, BUT ALSO THE QUESTION OF WHAT EXACTLY REMAINS IN THE WATER AFTER THE REACTION. WHETHER THE HARMFUL SUBSTANCE HAS TRULY TRANSFORMED INTO LESS RISKY PRODUCTS.

What is important, however, is that the team did not merely observe whether the original drug “disappeared” from the water. That alone would not be enough. The breakdown process can create new compounds that, in extreme cases, could be more problematic than the original substance. Therefore, using liquid chromatography coupled with high-resolution mass spectrometry, the scientists identified the emerging intermediates and proposed transformation pathways for the monitored pharmaceuticals. The results indicate that most of the resulting substances pose a lower ecological burden than the original drugs. This is a fundamental difference compared to a simplified view of water treatment. With similar technologies, it is not just the speed of pollution removal that is decisive, but also the question of what exactly remains in the water after the reaction. We need to know whether the harmful substance has truly transformed into less risky products.

The photocatalyst used has several properties that make it an interesting candidate for further development. It contains no metals, is chemically stable, can function not only under UV light but also under visible light, and, according to the researchers, is relatively stable and reusable.

However, the results should be taken with a grain of salt. The study does not claim that we have a ready-made technology that can be installed in every treatment plant tomorrow. The tests took place under laboratory conditions and on selected model substances. Real wastewater is a much more complex mixture, as it can contain other organic substances, salts, solid particles, and many other components that can affect the efficiency of the photocatalyst. The authors themselves therefore point out that this is not a replacement for conventional treatment plants, but rather a potential targeted tool for removing substances that remain in the water after standard treatment.

Future steps should therefore be directed towards testing on real wastewater, expanding the monitored spectrum of pharmaceuticals, and thoroughly assessing the costs, lifespan, recycling, and safety of the material used. Nevertheless, the result is important because it shows that a combination of materials research, analytical chemistry, and environmental engineering can offer new ways to protect the aquatic environment from substances that current infrastructure cannot always effectively remove.

The study's results show that light and graphitic carbon nitride can help break down selected pharmaceutical residues in water under laboratory conditions. To better understand what this result means, what its limits are, and how similar research might one day help in practice, we asked the study's lead author, Petr Praus.

Mr Praus, at first glance, the topic of pharmaceutical residues in water sounds quite distant from everyday life. Why should we pay attention to it?

In fact, it affects us more than it might seem. Every day we take medicines, a portion of which enters the wastewater after being excreted from the body. Modern treatment plants can remove most of the common pollutants, but some trace organic substances, including pharmaceuticals, remain in the water. Long-term exposure to these substances can affect aquatic organisms and contribute to the development of antibiotic resistance, for example. That is why we are looking for technologies that would further reduce their levels in the aquatic environment.

The media has used the analogy that graphitic carbon nitride works a bit like a solar panel. In what way is this analogy useful, and what are its limits?

The analogy is useful because graphitic carbon nitride also uses the energy of light. A solar panel converts light energy into electricity, whereas our material uses it to trigger chemical reactions. The limit of this analogy is that we are not producing electrical energy here but rather creating highly reactive particles that subsequently break down organic pollutants in the water.

When it is said that a certain material can use light to break down pharmaceuticals in water, it can sound surprisingly simple. What is actually the most scientifically demanding part of this process?

The hardest part is understanding what is actually happening during the reaction. It is not enough to simply find out that the concentration of the drug is decreasing. We need to know what intermediate compounds are formed, how long they persist, and whether they are more toxic than the original substance. That is why we combine materials research with advanced analytical methods, such as mass spectrometry.

The article mentions very high efficiency in removing certain substances. How cautiously should we interpret such laboratory figures?

Quite cautiously. Laboratory experiments take place under strictly defined conditions, which allow us to understand the basic principles of the process. Real wastewater, however, is a much more complex system containing many other substances that can reduce efficiency. High laboratory efficiency is therefore an important first step, not proof of immediate real-world applicability.

With similar technologies, it is often not enough to say that the original substance has disappeared. What interests you the most when monitoring the breakdown products?

The most important thing is to determine whether the emerging products pose a lower ecological risk than the original drug. In other words, whether we are actually solving the problem, or merely transforming one substance into another. Therefore, we try to identify individual intermediates and propose their transformation pathways.

Real wastewater is much more complex than a laboratory solution. What do you think will be the most difficult thing to verify when transitioning from laboratory tests to real samples?

We will need to verify how the photocatalyst copes with a large number of different substances that may compete with each other for active sites on its surface. The long-term stability of the material, its reusability, and, of course, the economic viability of the entire process will also be crucial.

Was there anything that surprised you about the study's results, either positively or in terms of further questions the research opened up?

We were pleasantly surprised that a relatively simple modification of the material -thermal exfoliation- led to a significant increase in photocatalytic activity. At the same time, we realised how complex the degradation mechanisms themselves are. Every medication breaks down slightly differently, opening up new questions regarding the fate of the emerging intermediates.

If you had to name one thing that a reader should take away from your research, what would it be?

Protecting the aquatic environment is not just a matter of wastewater treatment works, but also of developing new materials and technologies. Our research shows that light and appropriately designed photocatalysts can be part of future solutions for removing persistent micropollutants from water.

INFRASTRUCTURE

CEET WILL STRENGTHEN RESEARCH IN MATERIALS, ENERGY AND HYDROGEN TECHNOLOGIES

BUILDING N TO BECOME CEETE II

A major transformation is being prepared on the campus of VSB – Technical University of Ostrava. The existing Building N will undergo extensive reconstruction and become CEETe II, a new research facility for materials research, nanotechnology, energy technologies and environmental applications. The project builds on the long-term development of the Centre for Energy and Environmental Technologies, CEET, and is expected to strengthen not only the university's research infrastructure, but also the transformation ambitions of the Moravian-Silesian Region.

Practically only the load-bearing structure will remain from the original building. The facility will be stripped down to its reinforced concrete frame and then equipped with new technological distribution systems, electrical installations, low-current systems, HVAC systems and modern laboratory facilities. The seven-storey building, with an eighth technical floor, will provide spaces that meet the current requirements of modern university research.

The new premises will be used mainly by CEET, the Faculty of Materials Science and Technology, the Faculty of Electrical Engineering and Computer Science and the Faculty of Mechanical Engineering. This will create an interconnected research environment focused on advanced materials, nanomaterials and nanocomposites with applications in energy, industry and environmental technologies. CEETe II will also be closely linked to the already established CEETe testbed, which is used for testing modern energy technologies under conditions close to real operation.

CEETe II REPRESENTS ANOTHER STEP IN BUILDING MODERN RESEARCH FACILITIES THAT RESPOND TO THE NEEDS OF A MODERN AND RESILIENT SOCIETY.

The significance of the project extends beyond the university campus. The Moravian-Silesian Region has long been seeking new foundations for its industrial transformation, and research infrastructure of this kind can serve as one of the tools for connecting academic knowledge with the needs of companies, cities and the public sector.

The new facility will include laboratories focused, among other areas, on new methods of storing

electrical and thermal energy, the development of hydrogen technologies, self-cleaning surfaces, thermal analysis of materials and 3D printing of silicates. The research capacities will support the development of new materials for energy storage systems, particularly in battery technologies and the hydrogen economy, as well as for modern construction and environmental applications.

Cooperation with industrial companies, research organisations and universities in the Czech Republic and abroad will form an important part of CEETe II's activities. The modernised infrastructure is also expected to create conditions for involvement in strategic research and innovation activities, including projects supported under the National Centres of Competence programme and initiatives focused on long-term intersectoral cooperation.

The reconstruction will bring not only new laboratories, but also a significant improvement in the building's energy performance. According to the project, the building will move from its current energy classification C, with a value of 108 kWh/m² per year, to class A, with a projected value of −18 kWh/m² per year. The reduced energy demand will be supported by a new building envelope, LED lighting, energy-efficient HVAC systems and photovoltaic panels installed on the eastern, southern and western façades.

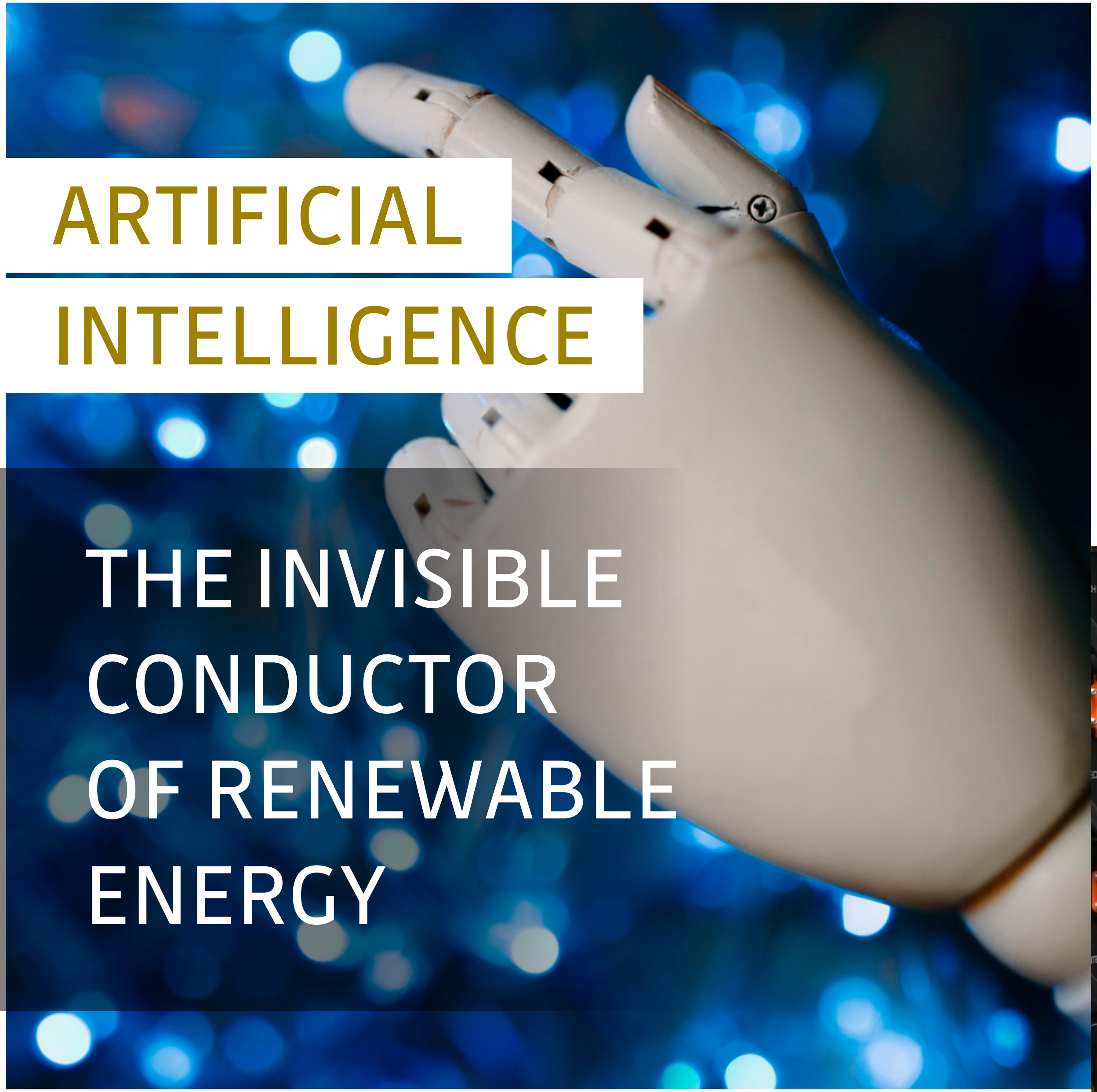
The photovoltaic system will consist of 489 panels with a total installed capacity of 130 kWp. The electricity generated will primarily be consumed directly in the building, while any surplus will be used in other buildings within the university campus.

The project also allows for the future use of rainwater for toilet flushing. Utility water distribution systems will already be prepared during the reconstruction, enabling connection to the planned rainwater treatment system.

The entire design and construction process is being carried out using the BIM method. This will create a detailed 3D model of the building, which will be supplemented during construction with actual operational data and subsequently used for building management and facility management. CEETe II is therefore intended not only to be a new research building, but also a modern, technology-driven facility that will itself demonstrate the direction sustainable university infrastructure can take.

CEETe II in Figures

7+1	Number of floors
1,130 m²	Built-up area
27,951 m³	Enclosed volume
4,940.36 m²	Total reconstructed, extended and newly built usable area
489	Number of photovoltaic panels
130 kWp	Total PV capacity



ARTIFICIAL INTELLIGENCE

THE INVISIBLE CONDUCTOR OF RENEWABLE ENERGY

A cloud passes over a row of photovoltaic panels. At the same moment, someone plugs in an electric car, a heat pump switches on, and the household battery is only half full. Electricity production falls, while consumption suddenly rises. In a large national grid, such changes are absorbed by thousands of power plants, substations and consumers.

In a small off-grid system, however, everything must be balanced locally and almost instantly. This is where artificial intelligence can help. It does not generate electricity itself. Instead, it acts as an invisible conductor, coordinating photovoltaic panels, batteries, appliances and other parts of the energy system.

Ibrahim Salem Jahan

Ibrahim Salem Jahan has been engaged in research related to artificial intelligence, particularly its applications in the field of renewable energy, for many years. He has authored and co-authored numerous journal and conference papers in cooperation with the ENET Centre CEET and the Faculty of Electrical Engineering and Computer Science VSB-TUO. His research focuses primarily on the design and testing of forecasting systems for power systems, which form an important component of smart energy management and control. He contributes to the development of forecasting methods used in the operation of off-grid energy systems, with the aim of improving system efficiency and reducing the environmental impacts associated with conventional energy sources.

To explore this topic in greater depth, we spoke with our colleague Ibrahim Salem Jahan, who has been working in this field for many years.

What does AI in energy actually do?

In simple terms, AI observes what is happening, predicts what may happen next and recommends, or automatically performs, the most suitable action by taking a smart decision. In a household, a smart energy management system can use information about weather, electricity consumption, battery charge and electricity prices. Based on these data, it can decide when to charge an electric vehicle, when to run a washing machine, when to store solar electricity and when to use energy from the battery.

At the level of an electricity network, similar algorithms can predict electricity demand, estimate renewable energy production, identify equipment that may require maintenance and help balance generation with consumption. AI can therefore be understood as a smart energy coordinator. Its role is to keep the system stable, efficient and economical without requiring the user to control every device manually.

Why is producing electricity no longer enough?

Electricity systems are changing rapidly. More solar and wind power is being installed, while electric vehicles, heat pumps and other electrical technologies are increasing demand. Renewable energy sources help reduce dependence on fossil fuels and their associated emissions. However, unlike conventional generators that can often be dispatched when needed, solar and wind power depend on natural conditions.

Photovoltaic panels produce electricity only when sufficient sunlight is available. Wind turbines depend on wind speed. Their production can change within minutes or even seconds.

For this reason, the challenge is no longer simply to generate enough electricity. The system must also decide: when electricity should be consumed, when it should be stored, when flexible loads should be postponed, and when another energy source should be activated.

Without intelligent control, a power system containing a high share of variable renewable generation becomes more difficult to balance. Smart algorithms can help coordinate all available resources and maintain reliable operation.

Off-grid systems and microgrids

An off-grid system operates independently of the main electricity network. It must produce, store and manage all the electricity required by its users. A typical off-grid system may include photovoltaic panels, a wind turbine, a battery, power electronic converters and, in some cases, a backup generator. Most importantly, it requires a control system capable of coordinating these components.

Such systems can supply remote houses, farms, research stations, telecommunications equipment or buildings located far from the public grid. A microgrid is a local energy system supplying several buildings or consumers—for example, a residential neighbourhood, university campus, industrial site or hospital. Unlike a purely off-grid system, a microgrid can remain connected to the public electricity network. Some microgrids can also disconnect from it and continue operating independently in an “island mode”.

The main engineering challenge is the same in both cases: production and consumption must remain balanced at every moment.

Weather becomes part of the control system

Weather plays a central role in renewable energy systems. For example, in photovoltaic installations, the most important factor is solar radiation. More sunlight generally means greater electricity production, while clouds, shading or poor panel orientation reduce output. The time of day, season, dust, humidity and local weather conditions can also influence production.

Temperature has a more complex effect. Strong sunlight increases generation, but high panel temperatures reduce photovoltaic efficiency. A very hot photovoltaic panel therefore produces slightly less electricity than the same panel would produce under equally sunny but cooler conditions. Weather also affects electricity demand. During hot periods, air-conditioning increases consumption. In cold weather, electric heating and heat pumps can place a greater load on the system.

A smart controller must therefore consider both sides of the equation: how weather influences electricity production and how it changes consumption. By combining weather forecasts with historical measurements, AI can estimate how much solar electricity will be available in the next few minutes, hours or days. The system can then prepare in advance—for example, by charging a battery before clouds arrive or postponing a flexible appliance until solar production increases.

Predictive modelling extends from energy production and consumption to power-quality indicators

Most people notice electricity only when it is unavailable. However, reliable electricity is not defined only by whether power is present. Its technical properties must also remain within acceptable limits.

Important power-quality parameters include: voltage, frequency, harmonic distortion, and rapid voltage variations known as flicker.

THE FUTURE OF ENERGY IS NOT JUST ABOUT GENERATING MORE ELECTRICITY, BUT ABOUT INTELLIGENTLY COORDINATING HOW IT IS PRODUCED, STORED, AND CONSUMED.

Harmonic distortion means that the electrical waveform is no longer perfectly smooth because it has been affected by electronic devices, converters or nonlinear loads. Flicker refers to repeated voltage changes that may, for example, cause visible changes in lamp brightness.

European standard EN 50160 describes key characteristics of the voltage supplied by public distribution networks, including frequency, voltage magnitude, voltage harmonics.

In an off-grid system, maintaining these parameters can be particularly challenging. There is no large external network to absorb sudden changes in production or consumption.

Our research therefore focuses on forecasting power-quality parameters. The aim is to detect a potential deviation before it becomes a real problem.

From prediction to automatic correction

Prediction is only the first step. Once a future problem has been identified, the control system must decide how to respond. Suppose that solar production suddenly exceeds electricity consumption. The controller may charge the battery, start charging an electric vehicle or activate another flexible load, such as water heating.

If production becomes insufficient, it can discharge the battery, postpone non-essential appliances, reduce selected loads or activate a backup generator. The power converter can also adjust its operation to help stabilise voltage and frequency. Ideally, all these actions take place before the user notices any interruption or deterioration in power-quality. The system does not merely react to a problem—it anticipates it.

The greatest challenge is often the data

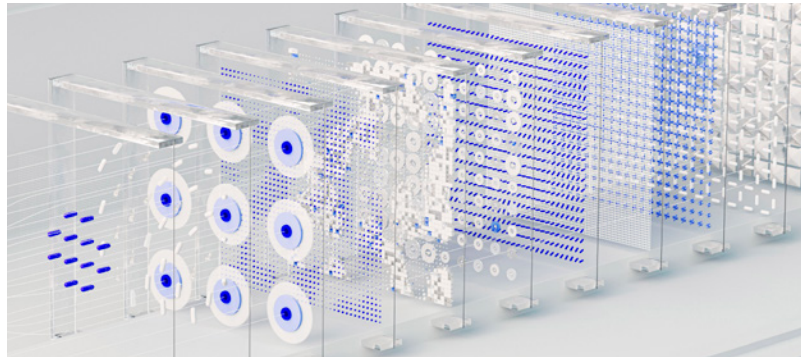
Advanced algorithms attract a great deal of attention, but the most difficult part of developing a reliable smart energy system is often obtaining suitable data.

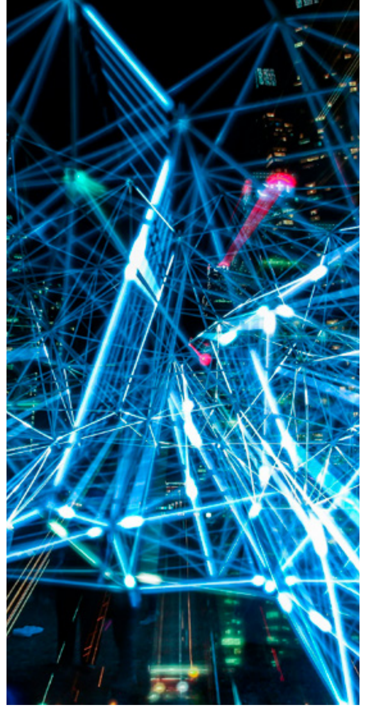
Designing a reliable forecasting model may require a big dataset measurement of: weather conditions, solar and wind production and household electricity consumption, battery state of charge, appliance operation, voltage, frequency and other power-quality parameters.

The measurements must be accurate, correctly synchronised and representative of real operating conditions. Missing values, sensor errors and incorrectly recorded timestamps can significantly reduce forecasting accuracy. Rare events are especially difficult. A model may perform well during normal operation but fail during an unusual combination of extreme weather, high consumption and low battery charge.

For this reason, a model must not only be accurate in laboratory testing. It must also be tested under realistic conditions and be capable of operating reliably in real time.

What will the energy system of the future look like?





Smart algorithms are likely to become a normal part of homes, community energy systems and renewable power plants.

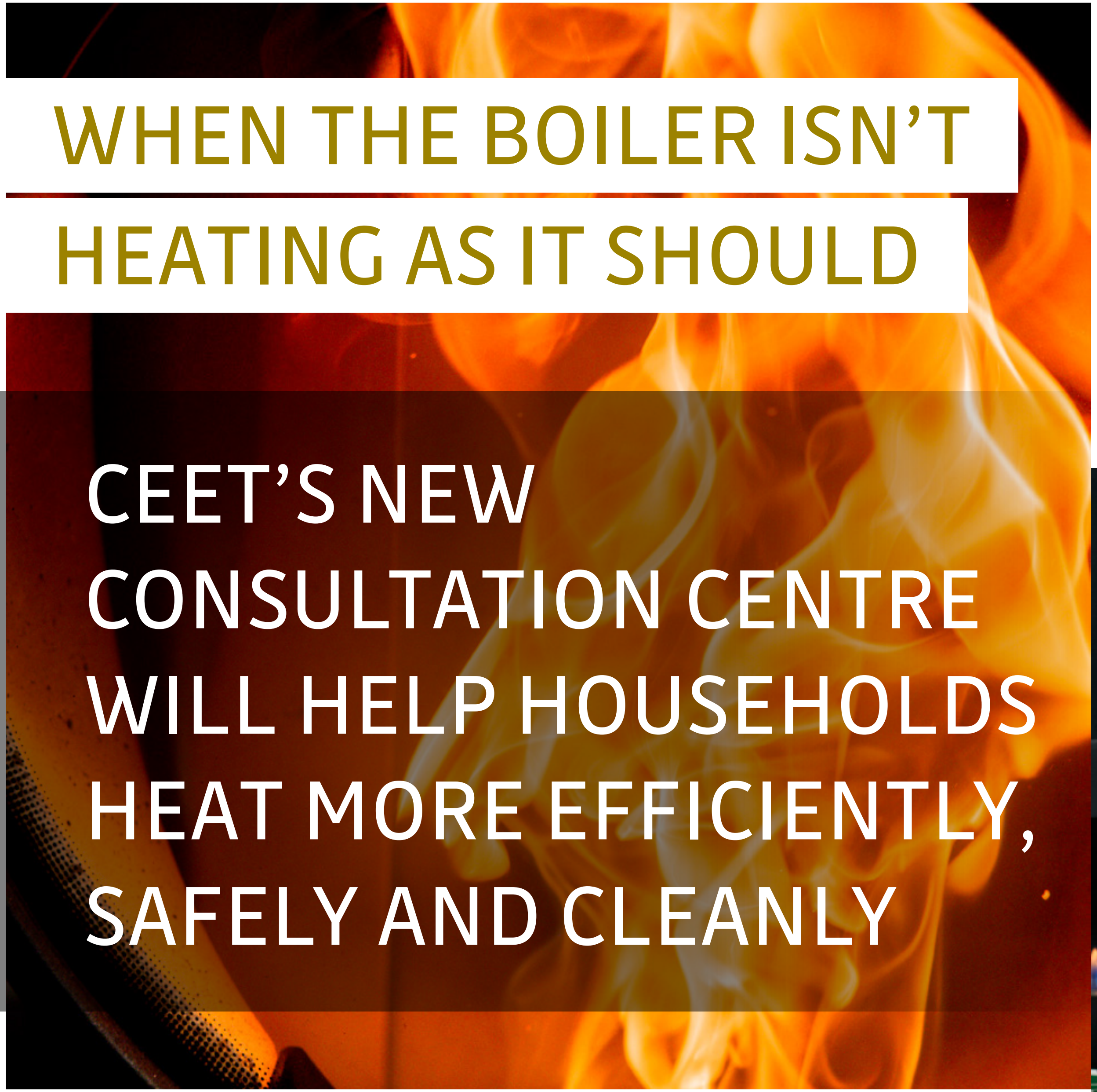
A future home may automatically decide whether electricity should be consumed, stored, purchased from the grid or sold to another consumer. The owner may define priorities—such as low cost, low emissions or a minimum reserve in the battery—while the control system manages everyday operation. Electric vehicles may also become active parts of the energy system. Through vehicle-to-grid technology, an electric car could charge when renewable electricity is abundant and, under suitable conditions, return part of its stored energy to a building or the grid when demand is high.

However, intelligent energy systems will also require reliable communication, cybersecurity, data protection and clear rules for cooperation among different devices and manufacturers. AI will not replace electrical engineering or the physical infrastructure of the power system. It will provide an additional decision-making layer that helps us use these technologies more effectively.

The future of energy is therefore not only about producing more electricity. It is about coordinating production, storage and consumption intelligently—often before the user even realises that a decision needs to be made.

How AI controls an off-grid energy system. The algorithm receives data from weather forecasts, renewable energy sources, batteries and household appliances. It predicts future production, consumption and power-quality conditions, and then decides which home appliance should be turned on or off, when electricity should be stored, consumed or supplied by another source.

RESEARCH AND INNOVATION



WHEN THE BOILER ISN'T HEATING AS IT SHOULD

CEET'S NEW CONSULTATION CENTRE WILL HELP HOUSEHOLDS HEAT MORE EFFICIENTLY, SAFELY AND CLEANLY

For many households, individual domestic heating is still a common part of everyday life. Solid-fuel boilers, wood-burning stoves and other household heating appliances can provide thermal comfort as well as a degree of energy self-sufficiency. At the same time, however, they can be a significant source of air pollution, especially when they are not operated correctly, are poorly adjusted, or do not match the actual needs of the building.

This is precisely the area addressed by the Proper Heating Consultation Centre project, implemented under the Centre for Energy and Environmental Technologies under the name TOP KONTROL. Its aim is to help households better understand how their heating

František Hopan

František Hopan works as a research scientist at the Research Energy Centre of CEET, VSB – Technical University of Ostrava, where for more than twenty years he has focused on solid fuel combustion, emissions from local heating appliances, and air quality. His research examines what takes place inside domestic boilers and stoves, why some sources produce almost invisible smoke while others significantly burden the air, and how the causes of emissions can be reliably identified and reduced. He contributes to the development of diagnostic methods, laboratory and field measurements, and research projects aimed at reducing emissions from domestic heating. In addition to his professional work, publications, and conference presentations, he has long been involved in science communication. Through lectures, educational projects, and practical demonstrations, he connects scientific knowledge with everyday practice and shows that cleaner air begins with proper heating.

system actually works, why excessive fuel consumption, higher emissions, smoke nuisance or low efficiency may occur, and how these problems can be addressed in practice.

This is not conventional energy counselling. The project has a research and methodological focus. In real households, a team led by František Hopan will test new procedures for diagnosing operational and emission-related problems in individual domestic heating systems. The intended outcome is a verified model of an expert consultation centre that will provide households with clear, technically sound and practically applicable support.

Why replacing the boiler alone is not enough?

Discussions about heating often focus mainly on the type of boiler, its age or its emission class. In practice, however, the actual operating condition of a household

heating appliance is influenced by many more factors. These include fuel quality, the way fuel is added, chimney draught, combustion air settings, maintenance, heat storage, the system configuration and the way the household normally uses the heating system.

As a result, two identical boilers may perform very differently in different houses. In one case, the operation may be stable, economical and associated with low emissions of pollutants into the surrounding environment. In another, the same type of appliance may show high fuel consumption, frequent fouling, poor combustion or increased emissions. This is why the heating system needs to be assessed as a whole, not merely as a separate appliance in the boiler room.

The Proper Heating Consultation Centre is based on this practical reality. Rather than offering general recommendations, it focuses on specific cases, individual households and the actual causes of problems.

Real "boiler-room stories" as the basis for research

The project includes the selection of up to ten households experiencing problems with the operation of an individual domestic heating appliance. These may include, for example, high fuel consumption, low thermal comfort, frequent fouling of flues, unstable combustion or suspected unsuitable operating habits.

In these households, a combination of technical assessment, measurements, interviews with users and analysis of operating practices will then be carried out. The aim is not to judge or criticise households, but to understand why a particular problem arises and

how it can be eliminated. Every boiler room has its own story: a different house, a different chimney, different fuel, different user habits and a different technical setup.

These "boiler-room stories" will make it possible to develop a practical methodology that can also be transferred to other households, municipalities and regions. The project will therefore connect research with the everyday reality of people who want to heat better, more affordably and with less impact on their surroundings.

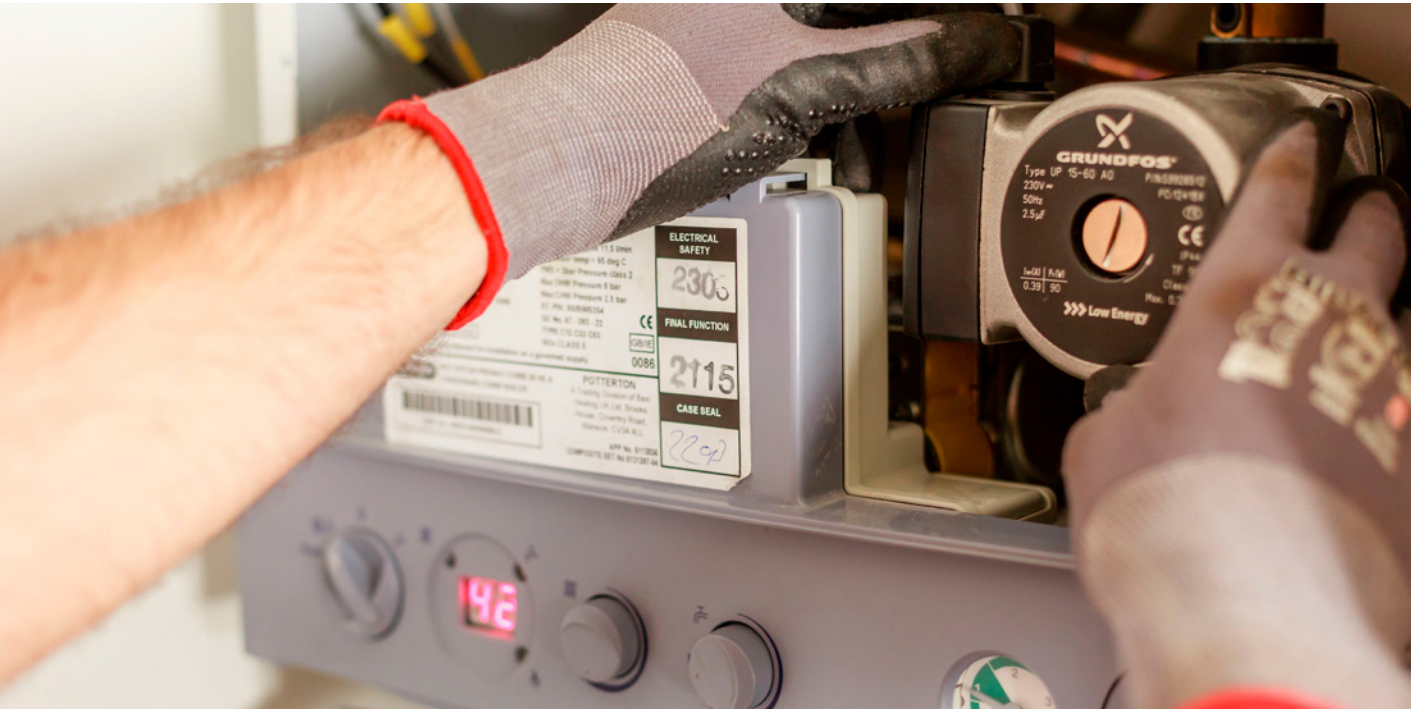
What the consultation centre can offer households

The Proper Heating Consultation Centre provides expert support to households that want to improve the operation of their heating system. Its services are based on a combination of measurements, technical expertise and practical recommendations.

Households can consult the centre especially on:

— the operation of a boiler, stove or other individual domestic heating appliance,
— identification of possible causes of increased emissions or smoke nuisance,
— heating-related operating habits,
— adjustments to fuel loading and combustion control,
— measures to reduce fuel consumption,
— operational safety and stability,
— steps to improve performance without unnecessarily complex interventions.

The emphasis is on measures that households can understand and implement. In some cases, changing operating habits, using more suitable fuel or adjusting the settings may help. In others, technical additions to the system, maintenance, inspection or more extensive modification of



the system configuration may be appropriate. The purpose of the consultation centre is to identify a solution that corresponds to the real cause of the problem.

Benefits for households, municipalities and air quality

Proper heating has several important effects at the same time. Households can reduce fuel consumption, improve thermal comfort and limit operational problems. At the same time, the amount of pollutants released into the air is reduced, which is particularly important in municipalities and regions where individual domestic heating significantly affects air quality during the heating season.

The project is therefore relevant not only for individual households. Its results may also be useful for municipalities, towns, advisory organisations, expert institutions and public administration. They can support the preparation of awareness-raising activities, local programmes promoting proper heating, or communication with residents in areas with poorer air quality.

Importantly, the project does not rely on bans or general appeals. It is based on explanation, measurement and practical assistance. It shows that improvement can often begin directly in the household, by understanding its own heating system and eliminating specific mistakes in its operation.

DISCUSSIONS ABOUT HEATING OFTEN FOCUS PRIMARILY ON THE TYPE OF BOILER, ITS AGE, OR ITS EMISSIONS CLASS. IN PRACTICE, HOWEVER, THE ACTUAL OPERATING CONDITION OF A HOUSEHOLD HEATING APPLIANCE IS INFLUENCED BY MANY OTHER FACTORS.

Research that is meant to be visible in practice

TOP KONTROL is an example of applied research that does not stop at laboratory findings, but verifies its results in real-world conditions. The aim is to create a methodology for systematically identifying emission-related and operational problems in individual domestic heating and to verify the effectiveness of proposed measures directly in households.

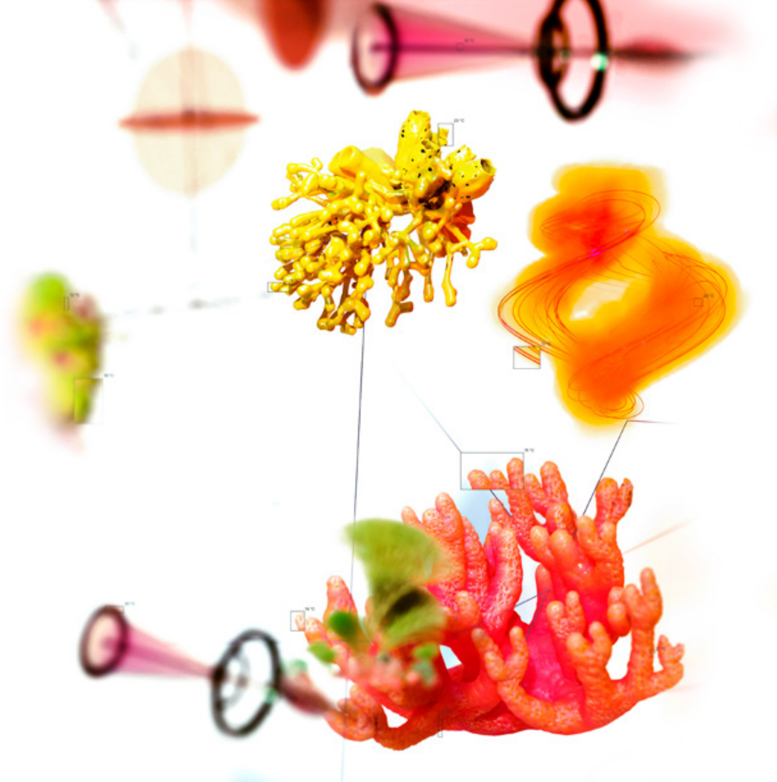
Heating properly means understanding your own system

Modern and responsible heating does not always have to mean immediately replacing the entire appliance. It often begins with the household gaining a better understanding of what is actually happening in its heating system. The Proper Heating Consultation Centre aims to be exactly this kind of expert partner: helping to define the problem, explain its causes and propose solutions that make sense both technically and practically.

OUR SCIENTISTS

INVISIBLE WORLD, VISIBLE RESULTS

DOCTORAL RESEARCHERS FROM THE NANOTECHNOLOGY CENTRE



In everyday life, we usually think about materials in terms of what we can see and touch. In the world of nanotechnology, however, the properties of materials begin to change depending on how they are arranged at a scale roughly a million times smaller than the width of a human hair. This is the world in which the doctoral researchers at the Nanotechnology Centre work. They are not “just” studying tiny particles. They are looking for ways to prepare materials that could one day help store energy, purify water, improve disease diagnostics, make cars lighter, or replace less environmentally friendly chemical processes. Their work brings together chemistry, physics, materials engineering, and modern analytical methods.

CEET

Lukáš Plesník

MEMBRANES THAT MAY DETERMINE BATTERY SAFETY

Batteries are now found almost everywhere: in phones, laptops, electric cars, and large energy storage systems. Inside each of them are materials that ordinary users never see, yet these materials have a crucial influence on the safety and efficiency of the entire device.

Lukáš Plesník focuses on the development of advanced membrane nanocomposite materials for energy applications. In simple terms, he studies materials that can help separate the individual parts of a battery so that it operates more reliably and safely. In his work, he uses methods ranging from solution casting to electrospinning, a process that produces extremely fine fibres. The result may be new types of battery separators for more efficient energy storage.

Shamal Sabah Kareem Kareem

A PATH TOWARDS HIGHER-QUALITY GRAPHENE

Graphene is often described as one of the most fascinating materials in contemporary science. It is extremely thin, strong, and has exceptional electrical properties. For it to be truly useful in practice, however, researchers must be able to prepare it in high quality and control its properties.

In his doctoral research, Shamal Kareem focuses on advanced methods for preparing graphene in scalable quantities. His work aims to ensure that high-quality graphene is not merely a laboratory curiosity, but a material that can be used in future technologies, for example, in energy, electronics, or sensor technologies.

Petr Běčák

WHEN A PROTEIN HELPS CREATE NANOPARTICLES

Petr Běčák works at the interface of chemistry, nanotechnology, and biomedicine. His research focuses on the biosynthesis of metallic nanoparticles and nanoclusters using bovine serum albumin, a protein that can bind metal ions under suitable conditions.

The result may be extremely small particles with interesting optical or magnetic properties. Some of them can fluoresce, while others can serve as contrast agents for imaging methods such as magnetic resonance imaging. This is an example of research in which a biological molecule helps create a material with potential use in medical diagnostics.

Shaho Salah Hwayyiz Drezh

CARBON STRUCTURES INSPIRED BY GEOMETRY

Some materials are interesting not only because of what they are made of, but also because of their internal shape. Shaho Salah Hwayyiz Drezh works on preparing new carbon materials inspired by structures known as schwarzites. In simplified terms, these can be imagined as very lightweight and porous carbon networks with a specific internal geometry.

In his research, he uses minerals such as zeolites, clays, or diatomite as temporary templates. These help create the desired structure, which may have interesting mechanical, electronic, or adsorption properties. In the future, such materials could be useful, for example, in energy applications, filtration, or as fillers in composites for transport.

Vít Kubáň

ENERGY STORED IN CARBON FROM BIOMASS

Vít Kubáň works on porous carbon materials with a graphitic structure. Although this may sound complex, the principle is easy to understand: the aim is to prepare materials with a suitable structure and porosity for efficient electrical energy storage.

An interesting aspect of his work is the important role played by waste cellulose biomass. This can serve as a starting material for preparing carbon materials that may be used, for example, to improve separators or optimise electrode materials in batteries. His research therefore connects energy, materials engineering, and the idea of a sustainable natural raw-material base for industry.

Amisha Singh

LIGHT AS A TOOL OF CHEMISTRY

Amisha Singh works in organic chemistry, photochemical transformations, and heterogeneous catalysis. Her research is based on the idea that light can be used as a tool to initiate or control chemical reactions.

This approach is of interest for modern sustainable chemistry. It can help identify reaction pathways that are milder, more efficient, and better aligned with the need to reduce energy and material demands.

Pavel Czernek

LIGHTER CARS AND CLEANER WATER THANKS TO CARBON MATERIALS

Pavel Czernek focuses on carbon fibres and nanocomposite materials. One of his goals is to develop cost-effective composites for the automotive industry. A lighter car can mean lower fuel or electricity consumption.

At the same time, he also works on materials for capturing pollutants from water. His research therefore shows two very practical sides of nanotechnology: lighter structural materials on the one hand, and materials for environmental protection on the other. For his scientific achievements, he received the Talent of the Year 2024 award from the City of Ostrava.

Muhammad Aashir Awan

GRAPHENE FOR ENERGY AND TECHNICAL APPLICATIONS

Muhammad Aashir Awan works in the EBEAM team, which focuses on electron-beam technologies and graphene research. His work is centred on the development of new graphene materials for energy and technical applications.

Graphene is a material with extraordinary potential, but its use depends on whether we can prepare it with the required structure, quality, and stability. This is precisely what his research addresses: how to improve the properties of graphene materials so that they become more efficient and more durable.

Pavel Kuzník

PRODUCING GRAPHENE USING AN ELECTRON BEAM

Pavel Kuzník focuses on the preparation of thin polymer layers that can serve as a starting material for the formation of graphene 2D structures. Scanning electron microscopy plays an important role in his work. This is a technique normally used to observe very small structures, but here it also becomes a tool for their targeted transformation.

This line of research shows that modern microscopes are not only the “eyes” of scientists. They can also be tools for modifying materials and producing new structures with potential applications in electronics, energy, or sensor technologies.

Vít Kvasnička

GRAPHENE DERIVATIVES FOR EFFICIENT ENERGY STORAGE

With the transition to renewable energy sources, there is a growing need to store vast amounts of electricity. Although current lithium batteries dominate the market, they are hitting limits associated with high costs, raw material availability, and safety risks. A solution could lie in entirely new types of batteries that utilise significantly more abundant elements.

Vít Kvasnička focuses on electrochemistry and the study of modern technologies for electrical energy storage. He investigates the application of graphene derivatives which, thanks to modifications at the atomic level, offer a wide range of material properties tailored to specific battery systems. This approach is crucial for developing next-generation energy storage devices that could replace lithium-ion technologies with cheaper, safer, and more sustainable alternatives, such as zinc-based systems.

Sajjan Kumar Sathish

SAFER LITHIUM-ION BATTERIES

Lithium-ion batteries are now among the key technologies for energy storage. Their safety, however, depends not only on capacity or lifetime, but also on the materials inside the cell. The electrolyte plays an important role here, as it enables ions to move between the electrodes. In conventional liquid electrolytes, mechanical and thermal stability can be a particular challenge.

Sajjan Kumar Sathish therefore focuses on developing new types of composite electrolytes as safer alternatives to the liquid electrolytes currently used in lithium-ion batteries. He works on materials that are more stable from both a mechanical and thermal perspective and that may also be more sustainable thanks to the use of readily available mineral components. His research thus contributes to the development of batteries that could be safer, more durable, and more sustainable in use.

Vijay Prabhakaran Nallan

CATALYSTS MADE FROM INDIVIDUAL ATOMS

Vijay Prabhakaran Nallan works on nanocatalysis and so-called single-atom catalysis. This means that he studies catalysts in which individual metal atoms can play an active role.

Catalysts are substances that allow chemical reactions to proceed more efficiently, with lower energy demands, or in a more environmentally friendly way. Research in this area may contribute to more sustainable organic synthesis and to the use of more accessible metals instead of rare or expensive elements.

Mina Rasteragaralam

POLYMER COMPOSITES FOR ENERGY CONVERSION

Modern energy technology is looking for materials that can convert different forms of energy into electricity more efficiently. In addition to photovoltaic technologies, thermoelectric materials are also of interest, as they enable the direct conversion of thermal energy into electrical energy without the need for moving mechanical components.

Mina Rasteragaralam focuses on new polymer composites for energy applications. She works on modifying these materials with metal nanoparticles, which can improve their operating properties, such as electrical conductivity or overall performance. Her research therefore points towards materials that could be used in technologies for more efficient energy production and conversion.

THE CITY AS A LIVING LABORATORY

DIGITAL TOOLS FOR RIGA'S ENERGY TRANSITION

A workshop held as part of CONECT 2026, where the European ExPEDite project was also presented, showed how digital twins can help cities plan Positive Energy Districts. Participants at the CONECT 2026 conference in Riga had the opportunity to test the tools currently under development and provide feedback directly to their creators.

Integrated neighbourhood energy transition planning: buildings, consumption, local sources, storage, transport and user behaviour

This is the question addressed by the European ExPEDite project, which is developing digital tools to support the creation of so-called Positive Energy Districts. The project is based on the premise that the path towards energy-efficient and climate-neutral cities cannot rely solely on isolated technological measures. At the level of an urban district, a wide range of areas need to be connected: the energy efficiency of buildings, renewable energy sources, energy flexibility, storage, mobility and the active involvement of users. In this context, a digital twin serves as a tool that makes it possible to monitor,

Ondřej Kabot

Ondřej Kabot is a researcher at the ENET Centre, part of CEET at VSB – Technical University of Ostrava. For the past seven years, his work has focused on partial discharges, electrical equipment diagnostics, and modern energy systems. He investigates the processes occurring within the insulation systems of electrical equipment under various external conditions and electric-field stress. His research aims to prevent equipment failures and extend its service life. He is also involved in developing diagnostic methods, conducting laboratory and field measurements, and participating in related research projects both in the Czech Republic and abroad.

model and evaluate energy flows within a given area and to test different scenarios before they are implemented in practice.

As part of the project, several tools were presented that are designed to help cities, urban planners, energy experts and building managers make data-driven decisions. These included a platform for the design and operational visualisation of a digital twin, a decision-support system, an energy modelling and simulation tool, and a mobile application focused on citizen engagement. Participants were able to try out how these tools can be used when planning the energy transition of an urban district, and how data can contribute to a better understanding of the impacts of proposed measures.

The project's pilot site is the Riga Technical University campus in the Ķīpsala area, which serves as a real urban environment for testing the concept of a Positive Energy District, or PED. It is here that technical infrastructure, smart metering, buildings, energy sources, electromobility and user behaviour come together. Riga is therefore becoming not only a place for validating digital tools, but also an example of how the energy transition of urban districts can be addressed in a systemic way.

Positive energy district in practice

In simple terms, a Positive Energy District can be understood as an urban area that aims to achieve a positive energy balance through a combination of energy savings, renewable energy sources, flexible demand management, energy storage and user engagement. In practice, however, this is not only a matter of technical optimisation. It is equally important that the proposed solutions are understandable, acceptable and usable for those who will work with them or live in the area.

This is precisely why the workshop at CONECT 2026 was important not only as a demonstration event, but also as part of the development process itself. Participants were able to comment on the individual tools, point out their strengths and weaknesses, and contribute to their further improvement. This way of working shows that a digital twin is not merely a visualisation of an urban district, but can become a practical decision-making infrastructure for cities that want to plan their energy transition based on data, scenarios and dialogue with stakeholders.

A DIGITAL TWIN IS MORE THAN JUST A COMPUTER MODEL OF A CITY; IT ALLOWS PROPOSED CHANGES TO BE TESTED VIRTUALLY BEFORE IMPLEMENTATION AND PLANNED TOGETHER WITH THE PEOPLE THEY WILL DIRECTLY AFFECT.

The ExPEDite project thus combines technological innovation with a participatory approach. It shows that successful urban transformation towards sustainable energy is not created only in laboratories or computational models, but also through open dialogue between developers, cities, experts and users. The workshop in Riga put this philosophy into practice: the city became a living laboratory in which digital tools are tested in direct contact with the real needs of their future use.

We spoke about the workshop with Ondřej Kabot, one of the researchers involved in the ExPEDite project.

Ondřej, what do you see as the main benefit of the ExPEDite workshop at the CONECT 2026 conference?

I see the main benefit of the workshop in the fact that it enabled us to involve a broader range of stakeholders in the discussion. Given the nature of the project, it is essential that representatives of different groups are involved in the design, development and subsequent implementation of the individual tools, from experts and building managers to city representatives and potential users. In this respect, the conference helped us extend feedback beyond the *project consortium itself. The input we received was important not only for the further direction of the project as a whole, but also for the developers of the specific digital tools.*

The workshop was designed, let's say, in a rather unconventional way, as a living laboratory. How did this approach differ from a standard conference presentation?

A standard conference presentation is usually based mainly on presenting results, followed by questions and possibly a discussion. The ExPEDite workshop retained this basic structure, but went a step further. Participants were not merely passive listeners; they could try out the individual tools directly and actively take part in the prepared interactive activities. This made it possible to better understand how different user groups perceive the tools, what needs they associate with them, and what impacts they expect from them. At the same time, this approach provided input for assessing social impact, which is very important in projects focused on urban transformation.

Which of the tools presented attracted the greatest interest among participants, in your view, and why?

Each of the tools presented has its place in the project, and its importance depends on the perspective from which we look at it. A citizen will have different expectations from a building manager, an energy expert or a city representative. For public engagement, the mobile application is particularly important, as it can simplify communication with the city and make selected information accessible to a wider group of users. For energy experts and planners, by contrast, the key tools are those that enable scenario modelling, simulations and the evaluation of the impacts of different measures.

In my view, the greatest interest during the workshop was shown in the modelling and visualisation tools. Given the composition of the participants, which included students, university staff, and representatives of municipal and professional institutions, this makes sense. These tools show very clearly how a digital twin can be used when planning the energy transition of a specific area.

As one of the researchers involved in the project, what type of feedback was most valuable for the developers?

The most valuable feedback was the kind that did not merely provide a general assessment, but also offered specific suggestions for improvement. For developers, it is very important to know not only what users find unsuitable, but also why this is the case and what they would consider a more appropriate solution. Feedback from people in different roles is especially useful, because each type of user works with the tools in a different way and pursues different objectives. It is precisely this kind of feedback that increases the chances that the final solution will be practically usable and acceptable to a wider range of future users.

Do you feel that this meeting helped advance the use of digital twins in the energy transition of cities?

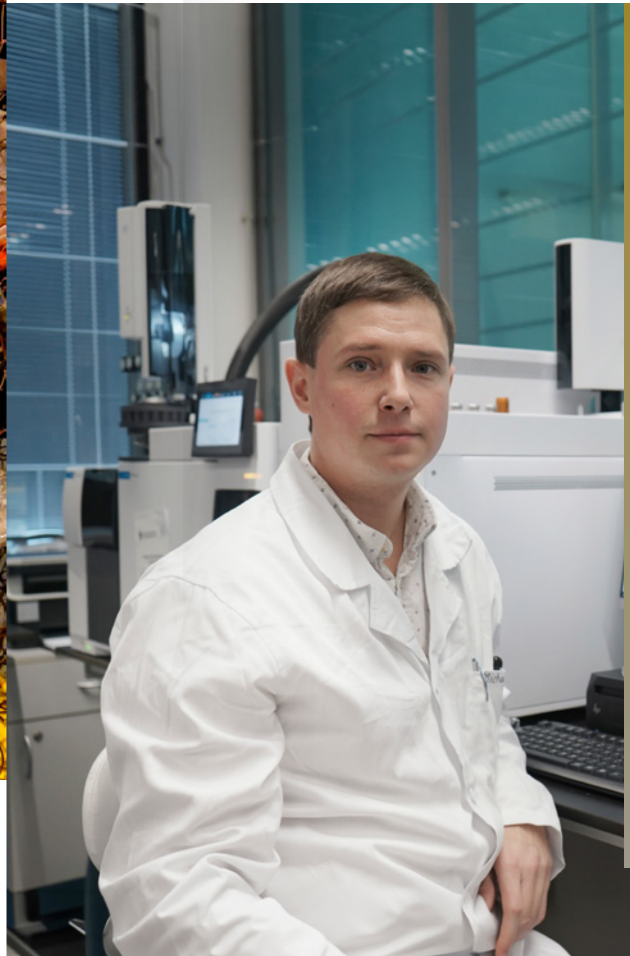
Yes, definitely. The workshop showed that a digital twin can be useful not only as a technical or visualisation tool, but also as a means of supporting discussion between different actors involved in urban transformation.
A number of ideas emerged during the meeting, some of which will be incorporated into the next phases of development. At the same time, thanks to the activities focused on social impact, we gained a better understanding of what participants expect from a solution such as ExPEDite and which areas they consider most important.

This is crucial for further development, because the goal is not merely to create a technologically advanced tool, but a solution that responds to the real needs of cities, experts and users.

MICROWAVES INSTEAD OF INCINERATORS

A NEW METHOD FOR RECYCLING INDESTRUCTIBLE PLASTICS

It performs flawlessly in aircraft or joint replacements, but once it reaches the end of its service life, we are at a loss for what to do with it. The highly durable engineering plastic polyetherimide (PEI) represents a massive challenge for current recycling processes. New research by Michal Vaštyl from the CEET Institute of Environmental Technology is trying to change this. In collaboration with the University of Calgary, his team has come up with an elegant solution: using microwaves and special absorbers, they can not only break down this "superplastic" but even recover valuable secondary raw materials from it. In this interview, he explains how the technology works, the pitfalls of transferring it into practice, and why dead ends are incredibly meaningful in science.



Michal Vaštyl

Michal Vaštyl works in the Material Preparation and Waste Valorisation research group at the CEET Institute of Environmental Technology, where he primarily focuses on the microwave and thermochemical processing of waste materials, polymer pyrolysis, carbonaceous materials, and catalytic processes. In his work, he concentrates on the possibilities of converting difficult-to-recycle plastics and other waste raw materials into valuable products, such as hydrogen, hydrocarbons, liquid chemical feedstocks, or carbonaceous materials with potential further uses. Simultaneously, he acts as a lecturer and practical instructor at the Department of Environmental Engineering at the Faculty of Mining and Geology, VSB-Technical University of Ostrava, where he participates in teaching students within the Instrumental Methods of Analysis course. In both his teaching and professional activities, he links his knowledge of analytical methods with experimental laboratory work. As part of his international collaborations, he completed research stays at the University of Calgary, where he collaborated with Prof. Josephine M. Hill, and also at the National University of Tumbes. He has been establishing long-term international collaborations with researchers from foreign institutions, including Queen Mary University of London (QMUL). His research operates at the intersection of thermochemical processes, microwave technologies, catalysis, engineering plastic recycling, and the development of materials for sustainable energy.

Michal, in your new study, you focus on the recycling of polyetherimide. Can you tell me what makes this "superplastic" exceptional and why it poses such a massive challenge as waste?

Polyetherimide, or PEI for short, is a high-performance engineering polymer. It combines high thermal stability, mechanical strength, and chemical resistance whilst boasting excellent properties for demanding applications. That is why it is used, for example, in aviation, the aerospace industry, the automotive industry, electrical engineering, and medicine.

However, these very same excellent properties become a fundamental problem at the end of their life cycle. PEI is designed to withstand extreme temperatures, aggressive chemical environments, and long-term stress. This means it is very difficult to break down, and conventional recycling methods are not ideal for it. Mechanical recycling struggles with the limited quality of the resulting material, whilst traditional thermal processing requires disproportionately high temperatures. Therefore, we looked for a way to convert this durable polymer into usable products more efficiently.

You ultimately found the solution in microwave radiation. How does this approach differ from conventional plastic waste processing methods?

The main difference lies in the method of heat transfer. Conventional thermal methods primarily heat the material from the outside in (from the surface to the core). With microwave heating, the principle is reversed: energy can be transferred directly to materials that absorb microwave radiation well, and the heat spreads from the core to the surface. This allows for rapid, volumetric, and, in some cases, highly selective heating.

Since you mention selective heating, a layperson might think that an ordinary plastic bowl in a microwave doesn't usually melt or even heat up significantly. How did you manage to break down a durable plastic using microwaves?

You are right; most plastics are so-called microwave-transparent, which means they absorb radiation poorly or not at all, and therefore they do not heat up on their own in a standard microwave (they only heat up from the food placed inside). The trick is that we did not only heat the plastic itself.

EVEN A HIGHLY DURABLE PLASTIC DOES NOT HAVE TO END UP IN AN INCINERATOR AT THE END OF ITS SERVICE LIFE. WITH THE RIGHT PROCESS, VALUABLE RAW MATERIALS CAN BE RECOVERED FROM IT.

We added materials to the system that absorb microwave radiation very well, so-called microwave absorbers, sometimes also referred to as susceptors. These materials act as converters in which high-frequency non-ionising electromagnetic waves are transformed into thermal energy. Simply put, the microwaves do not primarily heat the PEI, but the absorber. The absorber then transfers heat to its surroundings and can create very intense local temperature zones (hot spots) where the polymer breaks down. In addition to the thermal effect itself, the catalytic nature of some materials, such as iron oxides on activated carbon, can also play a role.

So, microwave absorbers play a significant role in this process. What other materials did you test, and which one ultimately proved to be the most effective?

We tested several types of materials (susceptors): activated carbon, petroleum coke, graphite, silicon carbide, and activated carbon modified with metal oxides. The most interesting results came from the system based on activated carbon with iron oxide, specifically AC–Fe_3O_4.

This material was highly effective in terms of both PEI decomposition and hydrogen production. We managed to achieve complete polymer conversion whilst securing a high hydrogen yield, approximately 20 mmol of H_2 per gram of PEI, which corresponds to roughly 76% of the theoretical amount of hydrogen available in the polymer.

It was surprising how significantly the absorber's properties influenced not only the decomposition rate but also the composition of the products. For instance, petroleum coke promoted the formation of aromatic hydrocarbons, particularly toluene, whereas with graphite and silicon carbide, we observed lower hydrogen production alongside a higher proportion of polycyclic aromatic hydrocarbons.

The result of this process is therefore not just „broken-down plastic," but also valuable secondary raw materials. What exactly have you managed to recover, and what other practical applications do you see for them?

Exactly, it produces a mixture of gaseous, liquid, and solid products, each with its own potential. In the gaseous phase, hydrogen is the most interesting, but light hydrocarbons like methane and other gaseous components can also be formed. The liquid fraction can contain valuable aromatic hydrocarbons, such as benzene derivatives, toluene, or other compounds usable as chemical raw materials.

Alongside this, a solid carbonaceous residue is also produced. This is not necessarily just waste. It can be further investigated as a carbonaceous material, or perhaps as a component of catalytic or sorption systems. However, it depends on its composition, purity after separation, and properties post-processing.

For us, the important thing is that we managed to obtain value-added products from a highly durable plastic. This differs from the approach where plastic is merely incinerated or used for energy recovery without deeper thought about what else we could extract from it.

Recovering valuable secondary materials from waste sounds brilliant. Hydrogen is often cited today as one of the fuels of the future. But what is the significance of hydrogen produced specifically from plastic waste?

I see the greatest significance in the fact that this hydrogen is not produced from a conventional fossil raw material, but from a material that would otherwise represent hard-to-process waste. PEI contains a significant amount of carbon, hydrogen, oxygen, and nitrogen. If we can convert a portion of the bound hydrogen into molecular gas, it is no longer just „waste disposal," but its chemical valorisation.

Our goal is not to compete with large-scale hydrogen production, such as steam reforming of natural gas or electrolysis. Rather, we want to show a new direction, in which even such a durable plastic can be a source of a high-value gaseous product, where we deliberately monitor the formation of a specific molecule, in this case, hydrogen. Moreover, from a scientific perspective, hydrogen is an excellent indicator for us. Its yield shows us how well our microwave absorber is working and how effectively it is breaking down the polymer structure.

The practical significance, therefore, lies in combining two things: on the one hand, processing a difficult-to-recycle plastic, and on the other, obtaining an energetically and chemically valuable product. And it is exactly this combination that I believe is interesting for future circular economy technologies.

This research is also backed by close international collaboration with the University of Calgary. How did this partnership come about, and what has been its greatest benefit?

It all started with my research stays in Calgary, Canada, in 2021 and 2022. A crucial role was played by my long-term collaboration with Professor Josephine M. Hill from the Schulich School of Engineering, University of Calgary, who specialises in catalysis and the thermochemical processing of raw materials. Over time, we became close friends, so our collaboration today is built not only on a professional level but also on mutual trust and a shared enthusiasm for pushing research forward.

I see the benefit of international collaboration primarily in that it allows one to look at one's own research through different eyes. In science, it is vital not to be narrow-minded and to remain open to alternative approaches. An international team naturally enables this because each of us comes from a different research environment, has different experiences, different work habits, and often a different way of thinking about the same problem. Thanks to this, a very valuable „aha moment" can occur on both sides. What is standard procedure for one workplace might be a new perspective or inspiration for another. This is partly why we were able to grasp our study much more comprehensively.

The study's results seem very promising. How far is this technology from real industrial application, and what still needs to be resolved?

At the moment, it is still a laboratory concept. The results are promising, but there is still a long way to go between *a laboratory experiment and a functional industrial technology. Several hurdles will need to be overcome: the stability and regeneration of absorbers or catalysts, the energy balance of the process, continuous operation, product separation, and working with real waste, which is always more complex than model material. A careful economic and environmental analysis will also be decisive, showing whether the entire process makes sense not only chemically but also operationally.*

Microwave technologies have great potential but, scaling them up is not easy. That is exactly why it is necessary to conduct systematic research from the ground up, from decomposition mechanisms right through to the design of an industrial reactor.

Will overcoming these technological obstacles be the focus of your follow-up research? What specifically do you plan to focus on in the near future?

We want to focus primarily on the preparation and optimisation of catalytic materials that would allow us to control the decomposition process even better. Our ambitious goal is to maximise hydrogen production. We would like to reach a state where we obtain at least 85 % of the theoretically available hydrogen from 1 gram of plastic. Such a value would represent a figurative "gold standard" for the efficiency of converting hydrogen chemically bound in plastic materials.

A major topic for us is the aforementioned material stability. It is not enough for a catalyst to work perfectly in a single experiment. We need to find out how repeated use affects its efficiency and how easily it can be regenerated. We are trying not to draw premature, grandiose conclusions just yet, but the results clearly indicate that microwave processing combined with the right catalysts is a very promising avenue.

Before these goals can be met, you still have many experiments and months of intensive work ahead of you. What helps you recharge your batteries after a demanding day in the lab and maintain long-term motivation?

In science, finding a balance between professional and personal life is absolutely essential. Research rarely ends the moment you close the laboratory door, you continue to think about the results. That's why it's important for work to be not just a duty, but also, to a large extent, a hobby. Without inner enthusiasm, it's not sustainable in the long run.

At the same time, you must have healthy boundaries in place. Stepping back from a problem often helps you see things more clearly. Personally, spending time with my family, doing sports, and having an occasional change of scenery recharge my batteries.

However, having a good support system also plays an undeniable role in maintaining motivation. I deeply appreciate the support of my management and the entire team. A published study is not an individual's success; it is the result of many people's hard work, from analysts to technical support. You might start with a good idea, but without a functional support network and great colleagues, you won't be able to turn it into a quality result.

A great team is certainly invaluable. However, CEETletter is also read by many students and early-career researchers. Based on your experience, what advice would you give them if they want to succeed in science?

I would advise them not to be afraid to ask questions and not to be deterred if things don't work out the first time. In science, a failed experiment is often just as valuable as a successful one - as long as you can learn from it.

It is important to be patient, thorough, and open to collaboration. Nowadays, very little good research is produced in isolation. You need a team, discussion, critical feedback, and sometimes the courage to embark on a path that might not seem certain at first glance.

And perhaps the most important piece of advice: do not let initial complications discourage you. Science is often a slow and sometimes frustrating process, but its magic lies precisely in the gradual piecing together of the fragments. I like to say: "Someone has to find the path that leads nowhere." Even dead ends serve a vital purpose. They show others which paths they no longer need to take, and in doing so, they move the entire field a giant step forward.

THE STORY OF A SINGLE CALL

RESEARCH AND INNOVATION

HOW A JET MILL BROUGHT TOGETHER THE KLOKNER INSTITUTE AND THE NANOTECHNOLOGY CENTRE

A single phone call sparked a co-operation that today yields new patents, functional samples, and paves the way for more eco-friendly anti-corrosion protection of metal structures. For nearly ten years, scientists from the Nanotechnology Centre (CNT), the Centre for Energy and Environmental Technologies (CEET), VSB-TUO, and the Klokner Institute at the Czech Technical University in Prague, have been working together for nearly a decade to demonstrate that even well-known materials can acquire entirely new properties thanks to new technologies, paving the way for safer and more sustainable materials.

Karla Čech Barabaszová

Karla Čech Barabaszová is an Associate Professor at the Nanotechnology Centre CEET, where she has been working in the field of materials science since 2005.Her research focuses on nanocomposite materials with structurally defined nanofillers. She specialises in the sonochemistry and mechanochemistry of nanostructured materials, as well as structural and surface characterisation. Her expertise also encompasses the dynamic analysis of the mechanical properties of nanomaterials. She plays a key role in transferring scientific knowledge into the educational process and bridging the gap between academia and the industrial sector. Since 2008, she has been the founder and co-organiser of the international NanoOstrava conference. She is an active educator focusing on materials chemistry and the preparation of nanostructured materials. She has successfully supervised the final theses of bachelor's and master's students and provides consultancy services within her professional field. Currently, her research is directed towards the development of new nanostructured materials for energy applications and their recyclability. She is the author and co-author of numerous scientific publications in international academic journals, as well as several functional samples, utility models, and patents.

A Jet mill as a window into the submicron world

At the very beginning was Adam Zabloudil, a doctoral student at the Klokner Institute at the time. For his research, he needed to prepare zinc phosphate with the smallest possible particle size. This material has been used as a component of anti-corrosion protection for steel structures since the middle of the last century; however, its potential was far from exhausted.

While searching for suitable equipment, he came across the website of the Nanotechnology Centre, where he discovered a unique jet mill capable of the dry micronisation of materials without the risk of contamination. What followed was a nearly hour-long phone call with Karla Čech Barabaszová from CNT, which laid the foundations for what is now a long-standing cooperation.

The jet mill is specific in its ability to prepare materials with a precisely defined particle size using a dry process. This eliminates contamination by other reagents and milling bodies, and submicron to nanometric fractions of the material can be prepared in a single cycle.

From protecting buses to medical fixators

The joint research focuses on perfecting the tricationic phosphating process, which, in its final stage, protects steel parts from corrosion. The technologies used to date often contain ecologically problematic substances, such as carcinogenic nickel or cobalt. The objective, therefore, was to find a safer alternative without compromising the quality of protection.

WE DO NOT HAVE TO ABANDON WHAT WORKS. EVEN THE MOST FAMILIAR MATERIALS CONCEAL AN UNIMAGINED FUTURE WHEN WE GIVE THEM A NEW DIMENSION.

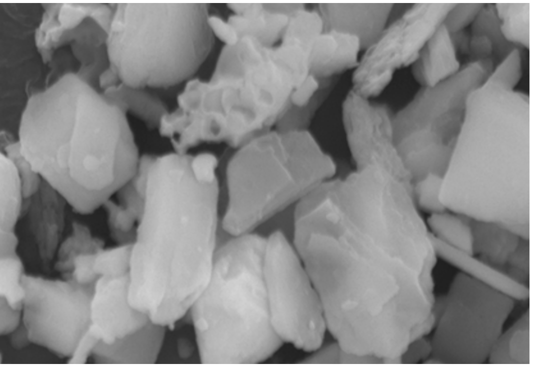
Using the jet mill, researchers from the Nanotechnology Centre prepared submicron particles of zinc phosphate and subsequently conducted a detailed analysis of their structure, size, specific surface area, and zeta potential, which is a key factor in determining the surface properties of the particulate material. The modified material was then sent back to the Klokner Institute, where experts incorporated it into protective coatings for steel structures.

The results exceeded expectations. The mechanically activated zinc phosphate created an exceptionally homogeneous and stable protective layer on the metal surface, effectively preventing moisture penetration. Furthermore, thanks to the larger active surface area of the particles, a significantly smaller amount of material was required.

At the same time, it became apparent that mechanically activated zinc phosphate also exhibits interesting antimicrobial and antibacterial properties, broadening its potential applications beyond traditional anti-corrosion protection. Thus, the new coatings have found use not only in protecting vehicles and industrial structures but also paved the way for materials coming into contact with the human body.

Patents as the natural outcome of cooperation

The ability to look at a well-known material from a fresh perspective is indeed one of the greatest be-



nefits of this entire collaboration. Zinc phosphate has been used in the industry for decades. However, it was only its reduction to a submicron size that revealed properties that had previously remained hidden.

The joint efforts of both institutions soon yielded tangible results. The team successfully completed a project supported by the Technology Agency of the Czech Republic (TA CR) and can boast a number of outputs. The researchers published scientific articles, developed working prototypes in collaboration with an industry partner, and obtained two utility model patents.

The most significant achievements to date are two Czech patents. One protects the method of mechanical activation of zinc phosphate, whilst the other covers the new surface and structural properties of the material resulting from this process. The researchers are also awaiting a decision on the granting of a European patent.

Ecological and economic benefits

Research findings show that innovation can bring about significant changes even without the need to develop entirely new materials, which tend to be both financially and technologically demanding. In the case of zinc phosphate, scientists were able to expand its range of applications by modifying its surface properties. At the same time, it was found that production requires approximately two-thirds less material, while the resulting protective coating exhibits even better properties.

Furthermore, the new solution delivers substantial ecological benefits. It allows for the replacement of substances containing carcinogenic nickel and cobalt in anti-corrosion protection, thereby contributing to safer technologies and more sustainable resource management in the spirit of the circular economy.

When people and technology just click

However, the success is not solely due to first-class equipment, but above all, the people. While the experts from the Klokner Institute brought years of experience in the surface protection of metal structures, the Nanotechnology Centre team offered know-how in the preparation and characterisation of materials on the micro- and nanoscale. It was exactly the combination of these two areas of expertise that produced a solution which would likely never have emerged at a single workplace.

Even though the two institutions are hundreds of kilometres apart, they managed to form a highly coordinated team. The crucial factor for this success was, above all, a mutual willingness to learn new things and seek joint solutions. The collaboration between the two institutions is therefore far from over. Both teams are already currently preparing further joint projects and striving to secure new national and European grants.

WE MET

CEET Sports Day

At the end of April, we set out together to enjoy the fresh mountain air of the Beskydy Mountains. The destination of this year's CEET Sports Day was the summit of Mount Radhošť. Along the way, we admired the unique Art Nouveau architecture of Dušan Jurkovič, especially Libušín and Maměnka, and also stopped by the statue of the pagan god Radegast. The purpose of the day was to strengthen team spirit, promote a healthy lifestyle, and give everyone a well-deserved break in nature.

Earth Day Celebrations

This year, we once again took part in Earth Day celebrations and introduced the public to topics related to environmental protection. In Ostrava, Vysoké Mýto and Jablonec nad Nisou, we offered interactive programmes focused on waste sorting, organic waste, water and air protection, and environmentally friendly home heating.

Open Day for CEET Employees

In May, we opened the doors of laboratories across CEET. Colleagues had the opportunity to visit other teams' workplaces, learn more about their equipment and get an insight into their current research topics. The day took place in an informal atmosphere, creating space for meetings and discussions, and brought many new contacts as well as ideas for future cooperation.

Kopřivnice Technology Days

At the end of May, we took part in the Kopřivnice Technology Days, held at the Tatra Trucks testing grounds. At our stand, visitors could use a digital microscope to explore the microworld of insects and plants, and try a knowledge-based matching game linking nature with modern technologies.

New Trends in Industrial Materials Recycling

CEET, in cooperation with the Recycling Cluster, organised a seminar on industrial materials recycling, the circular economy, and the sustainable use of resources. The programme brought together scientists and industry representatives and focused, among other topics, on modern waste processing, the recycling of end-of-life batteries, and the circularity of critical raw materials.

CEET Employee Meeting

In June, the second informal meeting of CEET employees took place. CEET Director Stanislav Mišák reviewed the past period and presented the future direction of our research institute. An important part of the programme was also the evaluation of the spring employee satisfaction survey, which provided valuable feedback from colleagues. The meeting concluded with an open discussion, offering space for questions, opinions and suggestions for improvement.

Chemistry and Other Natural Sciences at Silesian Ostrava Castle

The 20th anniversary edition of this science outreach event attracted hundreds of pupils as well as the general public to Silesian Ostrava Castle. Alongside a number of partners, our colleagues once again actively participated in organising the event. At their stand, our researchers presented hands-on experiments focused on environmental protection, new materials, and energy. Students could visit more than thirty interactive stations and themed laboratories, or try out first aid and techniques used by volunteer firefighters.

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WE ARE PLEASED
TO INVITE YOU
TO THE CONFERENCE

NanoOstrava Meeting 2027

18th–20th May 2027

FUTUREUM
Vítkovice 3044,
Ostrava-Vítkovice 703 00

THE CONFERENCE WILL PROVIDE A SPACE FOR EXPERTS IN NANO-TECHNOLOGY, ENERGY, MATERIALS RESEARCH, INDUSTRIAL APPLICATIONS AND ENVIRONMENTAL TECHNOLOGIES TO MEET AND EXCHANGE IDEAS.

The programme will focus on current challenges that connect research with practice, **from energy management and storage, sustainable resources and raw materials, to the environmental impacts of industry** and the dual-use potential of modern technologies.

- ENERGY MANAGEMENT, ACCUMULATION AND STORAGE
- SUSTAINABLE RESOURCES AND RAW MATERIALS
- ENVIRONMENTAL CHALLENGES IN INDUSTRIAL PRACTICE
- DUAL-USE POTENTIAL OF CURRENT TECHNOLOGIES
- APPLICATIONS OF NANOMATERIALS IN ENERGY, THE ENVIRONMENT AND ADVANCED INDUSTRIAL SOLUTIONS

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