CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

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

CONTENT

Dear readers,

the Centre for Energy and Environmental Technologies is an essential part of the innovation ecosystem, which aims to create a new strategy to ensure energy self-sufficiency and raw material independence of energy units from the level of municipalities and regions, up to the level of EU member states. The role of the Centre is clear, it is expected to support the transformation of the energy sector away from fossil fuels, using new methods and technologies in cooperation with scientific research centres, industrial partners, public and state administration as well as other members of the innovation ecosystem.

Together with partners, a timeline for the implementation of new methods and technologies, in the short up to the medium term has been developed and sub-objectives for this strategy have been defined for different levels of technological solutions from basic to applied research.

In the course of implementing the objectives of the Centre strategy, the direction and timing of its research agenda was clearly confirmed by the negative impacts of the Russian aggression in Ukraine, which has affected the economies of countries globally and exposed them to the potential risk of energy poverty.

Our Centre takes very seriously the need to fulfill its research agenda as quickly as possible, which, in collaboration with its partners, can mitigate the negative impacts of the current energy crisis and strengthen our society's resilience to external threats in the energy sector. To this end, our Centre is intensifying its cooperation in the field of science and research with foreign expert teams with a strong emphasis on its excellence and implementation potential.

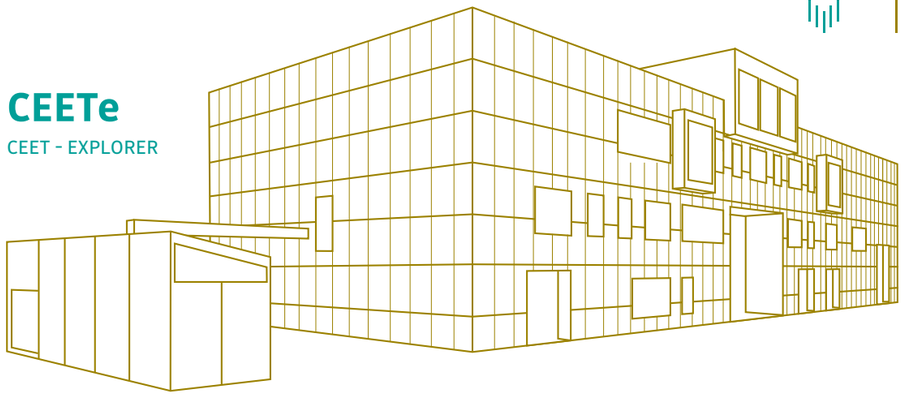
In order to make the research agenda more understandable, this document has been created to clearly summarize the focus of the Centre research groups that fulfill one or more research directions; i.e. for the field of materials, alternative fuels, energy transformation or environmental aspects on the horizontal line, with the global fulfillment of the Centre vision, mission and strategy on the vertical line. This articulation is the result of careful discussion across research teams with a clear description of the teams' excellence and ongoing collaboration.

I believe that, clearly defined focus and collaborative offerings of the research teams, the basic description of which is presented in this document, will accelerate the development of new and strengthen existing partnerships of excellence, which in a global context will help accelerate the energy transformation and strengthen our society's resilience.

Sincerely,

Stanislav Mišák

WE ARE CREATING THE ENERGY FUTURE



CEETe

CEET - EXPLORER

CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

CEET was established on 1 January 2021 through the merger of four university institutes: the Nanotechnology Centre, the Energy Research Centre, the ENET Centre and the Institute of Environmental Technology.

CEET is a research university institute at VSB - Technical University of Ostrava (VSB-TUO) focused on research and development in the field of low-carbon and sustainable energy and environmental technologies in line with the principles of the circular economy.

Thanks to the tradition and cooperation with the public and industrial sector, domestic and foreign universities and research organizations, we deliver practical innovations and solutions in many fields at the national and international level.

VSB-TUO is the fourth largest university in the Czech Republic and the holder of the „HR Excellence in Research Award“.

- 7 faculties, 2 university institutes
- tradition of more than 170 years
- modern study programmes linking technical, economic, science and art disciplines
- top level basic and applied research
- close cooperation with industry and Czech and foreign universities

VISION

Through research and development, we bring new opportunities for the practical application of modern technologies to companies and people in the areas of new materials for low-carbon and sustainable energy and environmental technologies in line with the principles of the circular economy.

MISSION

We actively seek and support cooperation with partners from the public sector, with companies from the application sphere, with universities and research organisations at national and international level. We are open to share our unique laboratory facilities with knowledgeable experts for research, development and education of students at all levels of study.

STRATEGY

All our activities are coordinated to meet priorities from the regional to the international level in accordance with strategic documents with a strong emphasis on cooperation between the research and application spheres.

OUR VALUES

THE COURAGE TO INNOVATE

We are a living laboratory, we have the courage to look for unconventional solutions. We validate and adapt the results of our research for use in practice.

QUALITY

We strive for quality in everything we do. Quality is not only our goal, but also the way we work with students, staff and partners, in line with the principles of diversity.

TEAMWORK

Thanks to the diversity of our teams, we inspire each other and bring new ideas, thoughts and solutions. We are united by respect and openness.

RESPONSIBILITY

We want to bring new solutions to the lives of people and companies, inspire responsible behaviour and positively influence the world around us.

SUPPORT AND STABILITY

We create a stable and secure environment for the development of innovative thoughts and ideas of individuals and teams. Learning for practice is an integral part of our work culture.

CEET
RESEARCH AREAS
RESEARCH GROUPS
CEET BOARDS
COLLABORATION EXAMPLES

UNIVERSITY STRUCTURE

Faculty of Mining and Geology

Faculty of Materials Science and Technology

Faculty of Mechanical Engineering

Faculty of Economics

Faculty of Electrical Engineering and Computer Science

VSB TECHNICAL UNIVERSITY OF OSTRAVA

Faculty of Civil Engineering

Faculty of Safety Engineering

IT4Innovations National Supercomputing Center

CEET CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

MANAGEMENT STRUCTURE OF CEET

Scientific Board — **CEET Director** — Board of Experts

Stanislav Mišák
Professor, Ing., Ph.D.

Secretary

Research and Development Director

Education Director

Industry Partnerships Director

ENET CENTRE
CEET-CENET

Director

Lukáš Prokop
Associate Professor, Ing., Ph.D.

NANOTECHNOLOGY CENTRE
CEET-CNT

Director

Gražyna Simha Martynková
Professor, Ing., Ph.D.

INSTITUTE OF ENVIRONMENTAL TECHNOLOGY
CEET-IET

Director

Lucie Obalová
Professor, Ing., Ph.D.

ENERGY RESEARCH CENTRE
CEET-VEC

Director

Tadeáš Ochodek
Associate Professor, Dr., Ing.

VISION
MISSION
STRATEGY

RESEARCH AREAS

- MATERIALS FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES
- ENERGY UTILIZATION OF SECONDARY RAW MATERIALS AND ALTERNATIVE ENERGY SOURCES
- ENERGY STORAGE, TRANSFORMATION AND MANAGEMENT
- ENVIRONMENTAL ASPECTS AND TECHNOLOGIES

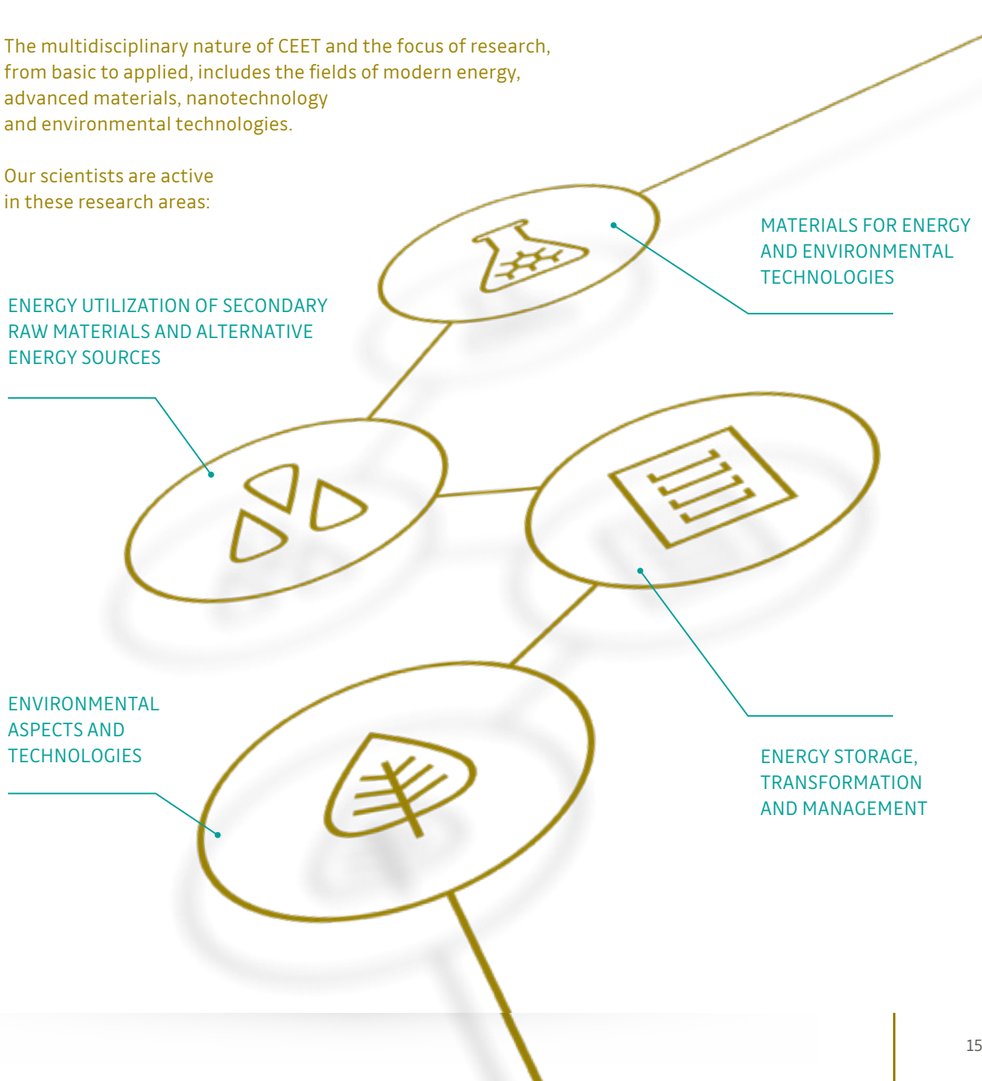
RESEARCH GROUPS

The vision, mission and strategy of CEET are fulfilled through the scientific activities of research groups with excellence in one of the four research areas.

RESEARCH AREAS

The multidisciplinary nature of CEET and the focus of research, from basic to applied, includes the fields of modern energy, advanced materials, nanotechnology and environmental technologies.

Our scientists are active in these research areas:



MATERIALS FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

The research is focused on advanced materials, nanomaterials, nanofillers and composite/nanocomposite materials. The research of these materials begins with their design using molecular simulations and continues with their preparation/synthesis, characterization, testing of their properties and possible applications, and concludes in the study of the effects of the nanomaterials on the environment. The studied materials include carbon nanomaterials, clay minerals, metal and metal oxide nanoparticles, polymers and biologically active substances. Applications of the developed products include materials with antimicrobial effects, sorbents, catalysts and photocatalysts, multifunctional polymeric materials and composite materials, conductive polymers, materials for the accumulation and storage of energy, etc.

MOLECULAR MODELLING AND DESIGN OF MATERIALS AND NANOMATERIALS

Molecular modelling using force fields is an effective tool for the study of nanomaterials. The use of force fields allows working with large models containing more than ten thousand atoms. In addition to the possibility of finding the lowest potential energy of the studied system and the corresponding geometry of the structure, non-bonding interactions between the individual components of the nanocomposite, mixture or solution can also be studied.

PREPARATION AND SYNTHESIS OF ADVANCED MATERIALS AND NANOMATERIALS

Physical, chemical and biological methods are used for the preparation and synthesis of advanced materials and nanomaterials. The physical methods are mainly various grinding methods according to the requirements for the size of the final fraction. Other methods include physical vapour deposition (PVD), water jet reduction, and lithography. The main chemical methods are precipitation, exfoliation, supercritical fluid technology and chemical vapour deposition (CVD). Biological methods then use (predominantly) plant organisms to prepare nanoparticles. The prepared materials include, in particular, nanoparticles of metals and their oxides or sulphides and graphene materials, which are further used, for example, as fillers/nanofillers in polymeric or ceramic composite materials or are anchored to clay supports for specific applications.

CHARACTERIZATION OF ADVANCED MATERIALS, NANOMATERIALS AND COMPOSITE MATERIALS

The prepared materials are characterized using methods for their structural and morphological properties (STEM, AFM, optical microscopy, XRD), physical properties (particle size distribution, Zeta-potential, surface size, etc.) and chemical properties (spectrometric methods, AAS, AES -ICP, ICP-MS, XRFS, UV / VIS, chromatographic methods GC / MS, GC / MS / MS, UPLC / DAD / FD, HPLC / DAD / RI, GPC method for determination of phase carbon, etc.).

TESTING AND APPLICATIONS OF ADVANCED MATERIALS, NANOMATERIALS AND COMPOSITE MATERIALS

Prepared materials, nanomaterials, nanoparticles and nanofillers are used for many applications, for example, as sorbents for wastewater and contaminated water and air treatment (contaminated by VOC, PAHs, petroleum substances, drugs and hormones, etc.), as catalysts and photocatalysts for pollutant removal, for preparation of composite materials with antimicrobial effects, for research and development of batteries and devices for energy storage and storage, for materials used in medicine.

IMPACT OF NANOMATERIALS AND NANOTECHNOLOGIES ON THE ENVIRONMENT

The impact of nanomaterials and nanotechnologies on the environment is studied using predominantly plants. In cooperation with other workplaces, the antimicrobial effects of the developed materials and nanomaterials are also monitored.

ENERGY UTILIZATION OF SECONDARY RAW MATERIALS AND ALTERNATIVE ENERGY SOURCES

Research in this area is focused in the following directions:

- Hydrogen technologies, ways of environmentally friendly production and safe use of hydrogen
- Plasma gasification technology for solid alternative fuels
- Thermal conversion of waste including catalytic pyrolysis and their impact on the environment
- Fuel cells implementation
- Waste treatment and the possibility of transforming waste into renewable energy products

HYDROGEN TECHNOLOGY

Fuel cells for electricity generation are very sensitive to the purity of fuel hydrogen. It is therefore necessary to solve the problem of the influence of individual impurities on the performance and life of the fuel cell. The effect of these impurities needs to be monitored both individually and within mixtures of these components due to the possibility of a synergistic effect and a significant reduction in fuel cell performance. Determining these characteristics requires a multidisciplinary approach and the involvement of not only electromechanics, but also physical chemistry and chemical engineering, because in addition to measuring the current characteristics of the cells and their design, it is important to know the chemical equilibria in individual cell types, as well as on the surface of the electrodes themselves. The sampling and storage of fuel hydrogen, including the analysis of impurities, is another separate issue.

CATALYTIC PYROLYSIS AND REFINING OF PRODUCTS

Hydrogen is produced mainly by steam natural gas reforming. The disadvantage of this method is, in addition to the large amount of CO_2 emissions, the consumption of fossil fuel (natural gas) itself. Therefore, it is necessary to focus on making use of waste CO_2 and the hydrogen produced by electrolysis with excess cheap energy to produce other substances with energy potential. Another problem is the chemical recycling of waste polymers, for which the catalytic pyrolysis method is often used today. Although a significant proportion of monomers can be obtained by this method, the resulting pyrolysis oil, however, contains a significant amount of impurities causing problems in the downstream petrochemical industry. This is yet another reason it is necessary to focus on streamlining catalytic pyrolysis and to conduct research into other refining processes for the use of pyrolysis oils in industry.

PLASMA GASIFICATION

A big advantage of plasma gasification technology is the possibility of energy utilization of tertiary raw materials (waste) and their thermochemical conversion into synthetic heating gas, with the simultaneous generation of a large amount of heat. This technology will decompose the organic part of the waste into further usable syngas composed mainly of CO and H_2, and the inorganic part of the waste without greater energy value is vitrified and remains in the form of non-leachable, inert slag. The resulting syngas can be further used, e.g. after suitable purification to produce hydrogen. Although the system for cleaning gaseous substances, e.g., at waste incinerators, is very efficient and technologically mastered, the purity to which synthesis gas needs to be purified for further use brings considerable complications and requires a deeper analysis of current technologies and the development of techniques such as dry reforming, etc.

SEPARATION OF HYDROGEN FROM PROCESS GASES

Usage of process gases as an efficient source for hydrogen production is innovative and will bring new knowledge in this field. There are a wide range of technologies that make it possible to increase the share of energy-valuable gas, i.e., separate unwanted impurities from it. Research activities in our laboratory are focused on the recovery of various waste and process gases using membrane separation technology. Research and development in this area will bring new materials capable for efficient hydrogen separation with long application poten-

tial in the near future. The advantages of membrane separation include procedural simplicity, low energy costs and independence from slight changes in the composition of the gases. Main activities are focused on the development and testing of membrane processes with application potential and safety aspects.

BIOMASS PROCESSING USING MICROWAVE PYROLYSIS

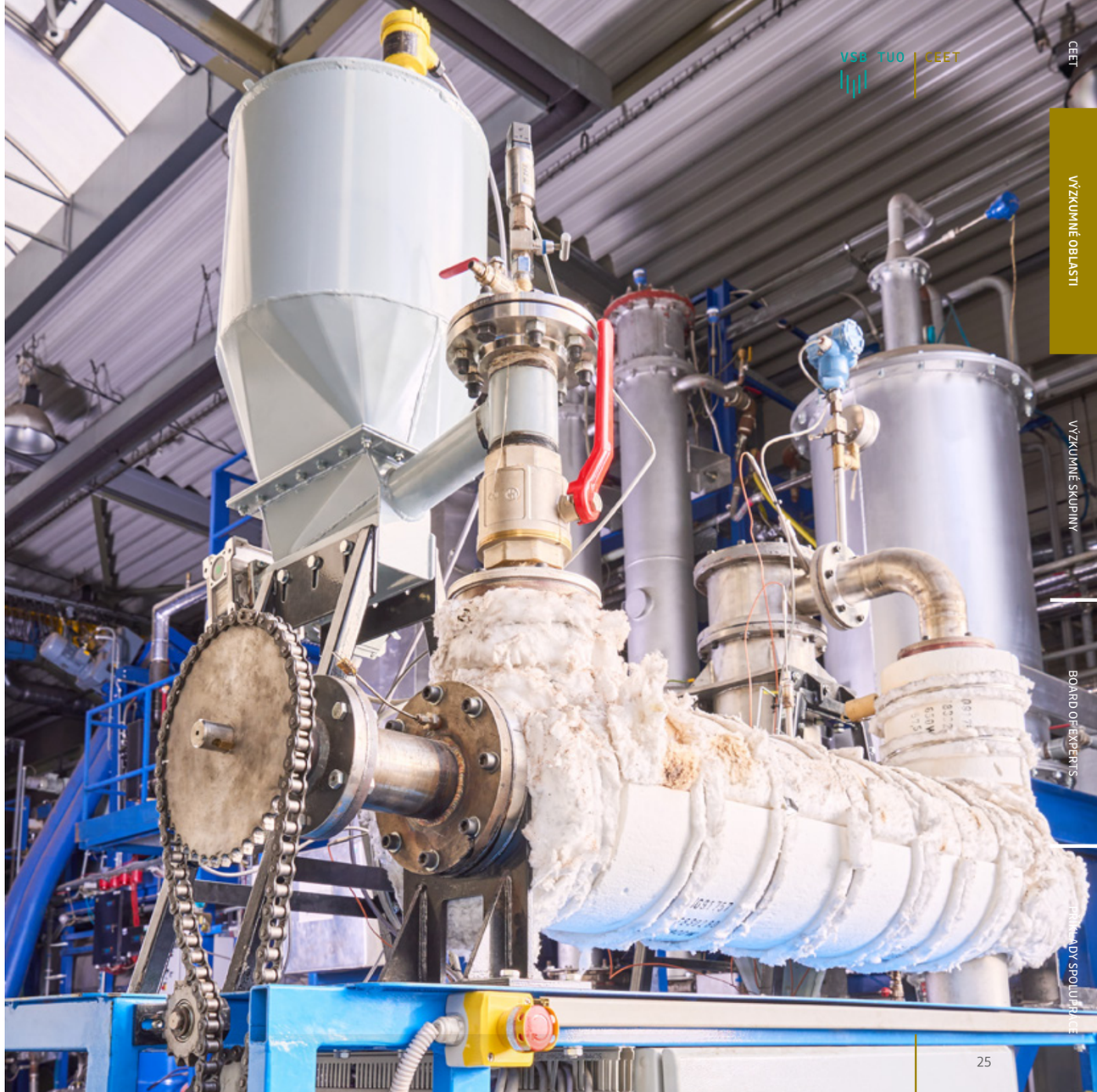
The research focuses on the influence of procedural parameters of microwave pyrolysis and copyrolysis, the procedural balance, the influence of input material/mixture composition on the quality of output products (pyrolysis gas, liquid and solid residue), the influence on the turbostratic carbon structure, etc., on a laboratory scale, including the transfer to a semi-operational scale.

THERMAL TRANSFORMATION OF WASTE INTO ENERGY UNDER OXIDIZING CONDITIONS

- Research into the incineration of waste and its components and the incineration of solid alternative fuels prepared from waste.
- Research into emission products produced during the incineration of the above waste/fuels and putting forth a proposal for measures to reduce the amounts of these products.

PROCESSING OF BIODEGRADABLE WASTE

- Pre-treatment of bio-waste and biomass before biological treatment (mechanical pre-treatment, biological pre-treatment, other methods such as physico-chemical).
- Treatment of bio-waste and biomass by anaerobic digestion to methane-rich biogas usable directly or after upgrading to biomethane or BioCNG.
- Processing of bio-waste and biomass by biochemical fermentation processes to hydrogen-rich biogas usable directly or after upgrade to $BioH_2$.
- Processing of hydrogen-rich gaseous products into more readily usable methane-rich biogas (hydrogen methanation).

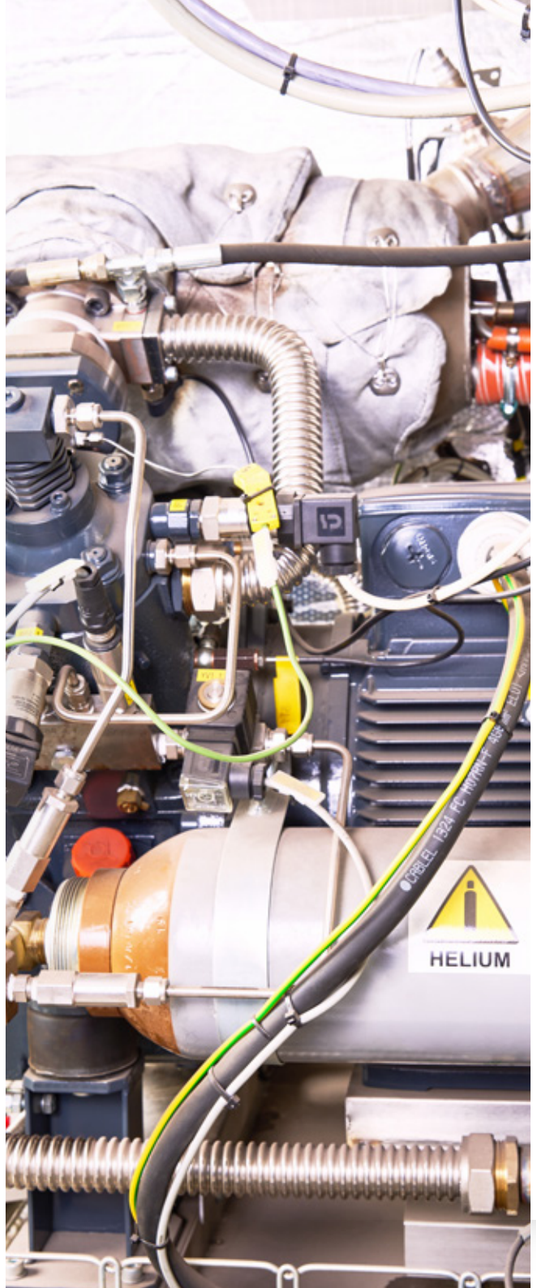


CONVERSION/PRODUCTION OF ALTERNATIVE FUEL FROM PROCESS GASES USING FISCHER-TROPSCH SYNTHESIS

The main goal of this research is the production of alternative fuels from process gases using F-T synthesis and its purification for use in various end equipment's. There is currently a worldwide demand for the development of energy-efficient, economical and environmentally-friendly processes for the sustainable production of liquid alternative fuels as a substitute for chemical compounds derived from oil. FTS is an example of a heterogeneously catalyzed reaction in which synthesis gas is transformed into a wide range of hydrocarbon products, and the process of producing this synthetic fuel is called GTL (Gas to Liquids). The first area of research is focused on the testing of various catalysts, where their catalytic activity and the effect on the composition of the resulting products are monitored. The second area of research is oriented on the testing the performance of manufactured FTS products with the aim of processing into motor fuels or petrochemical products.

SAFETY OF HYDROGEN TECHNOLOGIES

The risk of fire and hydrogen explosions is associated with many technological devices in various industries, especially in the energy and chemical industries, where the explosion of flammable gas is often considered one of the possible emergency scenarios. In the latter half of the 20th century, when the systematic study of fires and explosions of flammable gases began, numerous experimental and theoretical studies dealing with the nature of radiation and the transmission of an explosion wave were also carried out. From the perspective of the danger of its wide range of explosiveness, the problem with this gas is its low initiation energy and ignorance of its behavior under other than atmospheric conditions. The study of hydrogen explosions can be further combined with research on liquid hydrocarbon vapors and aerosol dispersions using a unique explosive autoclave and analytical techniques, and it can provide us with much information on the basic principles of combustion chemistry and characterize important factors in technical and fire safety practice.



ORGANIC RANKINE CYCLE TECHNOLOGY

The organic Rankine Cycle (ORC) is an alternative technology for electricity generation, which is applicable primarily in the use of low-potential heat. A special working fluid allows the ORC unit to recoverheat from low temperature (even below 100°C) energy sources such as waste heat, solar or geothermal energy. The research team is mainly engaged in the development and testing of prototypes of ORC units or micro-cogeneration systems. This is a technology of combined heat and power generation with an installed capacity of up to 50 kWe, which is still in the early stages of commercialization. The ORC unit of this size has great potential not only in industry but, with gradual miniaturization, also in the commercial and residential spheres. In this context, R&D activities focus on improving individual components and the overall optimization of thermodynamic cycle to achieve high energy efficiency and operational safety of ORC units with a power output of up to about 10 kWe. The main directions of research include the selection of a suitable working fluid and the energy transformation processes in an expansion device.

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ENERGY STORAGE, TRANSFORMATION AND MANAGEMENT

The aim of the research topic is research in the field of energy flow management in the energy platform of a complex system respecting the principles of a circular economy at the level of distribution grid for powering energy platforms of municipalities, cities or micro-regions.

A complete solution will consist of two main directions in the research and development of management methods:

- Technologies for the conversion of alternative fuels, waste and by-products into usable chemicals and useful forms of energy, their storage and efficient use with the support of digital twin.
- Electricity distribution networks within energy platforms of municipalities, cities or micro-regions. The use of modern technologies for energy storage in various forms is a given.

The latest trends will be used in areas such as high-performance computing, advanced data analysis, artificial intelligence and their use for the efficient self-organization of smart energy networks, the adaptive and floating adjustment of individual elements according to current needs. A given is the use of distributed calculations, mathematical modelling and optimization and digital twin technology of selected parts to speed up and increase the efficiency and reliability of the developed solutions. Our team consists of experts in the field of power engineering, measurement and control technology, computer science and mathematics.

OFF-GRID SYSTEMS, MICRO-GRID

Off-grid systems (future community energy) are a modern trend in electricity and are closely related to the transformation of energy from centralized to decentralized and generally to the transition and modernization of energy networks in the context of “smart grids”. The research team deals with the use of stochastic renewable electricity sources, storage systems and the management of all these technologies.

VEHICLE-TO-HOME, VEHICLE-TO-GRID, ELECTROMOBILITY

The research team deals with the development of technologies for systems that enable cooperation and the sharing of storage capacities between electric cars and stationary storage units for powering electrical networks (off-grid and distribution). In the field of electromobility, the research team focuses on research and development in the field of energy infrastructures, which are needed for charging electric vehicles and at the same time it pursues the development of supporting software applications that are used for effective assessments in the transition of large car fleets from internal combustion engines to electric vehicles.

DIAGNOSTICS OF ELECTRICAL EQUIPMENT

The research team is engaged in the research and development of modern diagnostic methods for a wide range of electrical equipment. The focus of the research and development on the issue of insulation systems for both cable and insulated overhead lines is extensive. We have numerous modern diagnostic devices at our disposal, which enable us to effectively determine the current technical condition of electrical equipment using several methods with different explanatory power. In this context, we provide extensive services in the field of diagnostics of electrical equipment, diagnostics of rotating and non-rotating electrical machines, including diagnostics of low-voltage and high-voltage electrical networks.

ENVIRONMENTAL ASPECTS AND TECHNOLOGIES

Research in the field of environmental-friendly technologies is focused on improving existing production processes to reduce the production of pollutants and developing new methods to reduce the content of pollutants already produced. In cooperation with industrial partners we are dealing with the optimization of technologies, such as replacement of toxic extractants or new design of rectification columns.

At the same time, we are working on increasing the efficiency of technologies that have been commercially used for decades to increase their efficiency or to develop completely new methods to comply with tightening emission limits. In the field of wastewater treatment, we focus on substances persistent in our environment (organic pollutants, xenobiotics). An integral part of our research is the development of new methods for detecting pollutants in both air and water.

PURIFICATION OF WASTE GAS BY CATALYTIC PROCESSES

Catalysts are substances widely used not only in the manufacturing industry, but also in the field of waste gas purification. Due to the increasing demands on emissions limit, it is necessary to improve currently used catalysts, and to study and develop new ones.

In terms of gas purification by catalytic processes we are dealing with:

- Investigation/ Study of catalysts for the reducing the nitrogen oxides (NO_x, N_2O) emissions by direct catalytic decomposition and selective catalytic reduction of NO_x with ammonia.
- Study of catalysts for reducing ammonia emissions by selective catalytic oxidation.
- Study of heterogeneous catalysts for the oxidation of toxic and chlorinated VOCs from the gas phase (e.g. dichloromethane, perchlorethylene, formaldehyde/methanol, etc.).
- Study of the effect of the preparation procedure and used (metal) precursors on the key physico-chemical properties of the developed catalysts.
- Testing the catalytic activity, selectivity and stability of prepared catalysts.
- Study of the mechanism and kinetics of catalytic reactions.
- Transfer of data obtained by laboratory measurements to larger scale and design of the supported catalysts.
- Correlation of experimental results with molecular modeling.

WASTE GAS PURIFICATION BY PHOTOCATALYTIC PROCESSES

One of the most desired strategies for reducing of CO_2 emissions, which production is connected with the problem of global warming, is the conversion of CO_2 into other, more useful chemicals or fuel-based products. This can be achieved by photocatalysis, in which photon energy from light sources is used to activate the catalyst during the reaction. Other pollutants such as N_2O, NO_x or VOC can also be photocatalytically removed from the environment.

Research is focused on the following areas:

- Study of CO_2 photocatalytic reduction of in the presence of various photocatalysts.
- Photocatalytic removal of N_2O and NO_x in reactors with different geometries.
- Photochemical removal of VOC in the gas phase.

PURIFICATION OF WASTE GASES USING SORPTION PROCESSES

In addition to their ability to remove the pollutant from the waste gas or water, sorbents also allow recover the pollutant by its targeted desorption from the sorbent surface by its regeneration. In addition, sorbents are often made from waste materials, which leads to the reduction and recovery of solid waste. For these reasons, the development of new types of sorbents and the study of new technological processes for the solid waste processing leading to development of new sorbents for waste gas treatment are very important parts of environmental research.

In the context of this research,
we are dealing with:

- Study of the possibility of using biomass, animal residues and petroleum coke processed by pyrolysis as sorbents for volatile organic compounds (VOC).
- Targeted preparation of sorbent with optimized structure.
- Study of the adsorption of Hg and other heavy metals on solid sorbents in flue gases from fossil fuel combustion.
- Study of the sorption of volatile organic compounds (VOC).
- Correlation of experimental results with molecular modeling.
- Transferring data from the laboratory to a larger scale.

WASTEWATER TREATMENT

In nature, wastewater treatment is an important step in the water cycle. To maintain the natural balance of the environment, wastewater must be properly treated before being returned to the natural cycle. This process takes place in several stages, during which solid particles, organic matter and chemical pollution are removed.

In the context of this research,
we are dealing with:

- Development of analytical methods for the determination of persistent and potentially hazardous substances in water.
- Study of the treatment and purification of wastewater using biological methods – biosorption, microbial decomposition.
- Study of the treatment and purification of wastewater using physical methods – adsorption, decomposition by UV radiation, the use of microwave radiation.
- Study of the wastewater treatment and purification using chemical methods.

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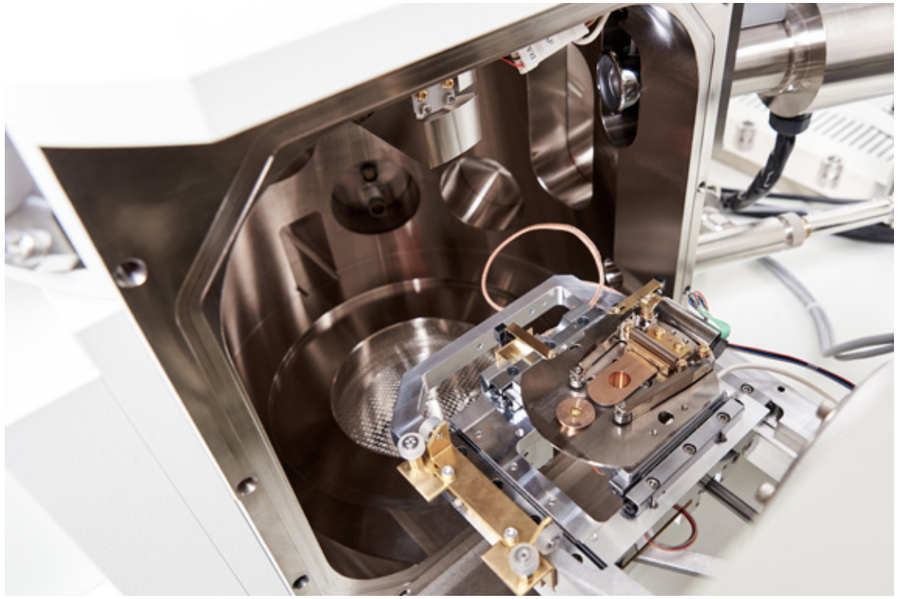
RESEARCH GROUPS



Our researchers from the four participating research centres are divided into a total of 18 research groups according to their areas of expertise, with a main assignment to one of the four CEET research areas.

ADVANCED NANOTECHNOLOGY

Daniela Plachá
Professor, Ing., Ph.D.

nanotechnology, nanomaterials, nanocomposites, nanoparticles, nanofibers

CEET-CNT

MATERIALS-ENVI LAB

Radek Zbořil
Professor, RNDr., Ph.D.

heterogeneous catalysis, solar energy, water treatment, single atom engineering, biomedicine

CEET-CNT

EBEAM

Mark Hermann Rümmeli
Professor

nanoscale materials, electron beam fabrication, advanced microscopy, additive manufacturing, in situ characterization

CEET-IET

THERMOCHEMICAL AND HYDROGEN CONVERSION

Jan Najser
Ing., Ph.D.

waste gasification, pyrolysis, alternative fuels, hydrogen, combustion

CEET-CENET

ENERGY BY-PRODUCTS

Helena Raclavská
Professor, Ing., CSc.

organic markers, air pollution, environmental impact, thermal processes, combustion

CEET-CENET

BULK MATERIALS

Lucie Jezerská
Ing., Ph.D.

bulk materials, powders, processing, DEM simulations, transport

CEET-CENET

MODERN HEATING SYSTEMS

Jiří Horák
Ing., Ph.D.

source of thermal energy, boiler, dust particles, efficiency, pollutant emissions

CEET-ERC

INNOVATION AND SAFETY

Tadeáš Ochodek
Associate Professor, Dr., Ing.

hydrogen, biomass gasification, technologies, energy, safety

CEET-ERC

WASTE TO ENERGY

Jozef Vlček
Professor, Ing., Ph.D.

energy recovery of waste, solid recovered fuel, waste to energy, emissions, energy balance

CEET-IET

BIOCHEMICAL PROCESSES

Jiří Rusín
Ing., Ph.D.

biowaste, aerobic and anaerobic fermentation, biogas, biomethane, biohydrogen

CEET-IET

INDUSTRIAL CHEMISTRY

Pavel Leštinský
Ing., Ph.D.

chemical and process engineering, pyrolysis, catalysis, chemical recycling, chemical technology

CEET-IET

HETEROGENEOUS CATALYSIS

Kateřina Pacultová
Ing., Ph.D.

heterogeneous catalysis, temperature-programmed techniques, reaction mechanism, waste gas cleaning, laboratory and pilot plant testing

CEET-IET

HETEROGENEOUS PHOTOCATALYSIS

Kamila Kočí
Professor, Ing., Ph.D.

photocatalytic processes, CO_2 reduction, hydrogen generation, N_2O decomposition, advanced oxidation processes

CEET-IET

PREPARATION OF MATERIALS AND WASTE RECOVERY

Lenka Matějová
Ing., Ph.D.

nanostructured photo/catalysts and sorbents, natural substances with added value, green high-pressure technologies, microwaves

CEET-IET

WATER TREATMENT AND ANALYSIS

Martina Vráblová
Mgr., Ph.D.

wastewater, adsorption, bioremediation, micropollutants, trace analysis

CEET-IET

TECHNOLOGIES FOR ENVI-RONMENTAL PROTECTION

Karel Borovec
Ing., Ph.D.

emissions, efficiency, best available technology, alternative fuels, CO_2

CEET-ERC

SMART GRIDS

Lukáš Prokop
Associate Professor, Ing., Ph.D.

solar power, wind power, energy storage, hydrogen technologies, electromobility

CEET-CENET

APPLICATIONS FOR INDUSTRY AND MUNICIPALITIES

Zdeněk Neufinger
MBA

energy management, design engineering activities, feasibility study, energy conception, cost benefit analysis

CEET-ERC

ADVANCED NANOTECHNOLOGY

nanotechnology
nanomaterials
nanocomposites
nanoparticles
nanofibers

Advanced Nanotechnology focuses on the research and development of nanomaterials, nanocomposites, nanostructured materials and other advanced materials for applications in electrical energy storage, solar energy conversion, catalysts, photocatalysts and sorbents, membranes and filters for gas and water separation and purification, coatings and antimicrobial surfaces, and nanocomposites for biomedical applications. The laboratories are equipped with sophisticated instrumentation for chemical, structural and phase analysis as well as for application testing, including validation of experimental results by computer simulations based on molecular mechanics and dynamics.

Research Group Leader

Daniela Plachá
Professor, Ing., Ph.D.

CEET-CNT

MATERIALS-ENVI LAB

2D materials
heterogeneous catalysis
solar energy
water treatment
single atom engineering
biomedicine

Materials-Envi Lab focuses on the development of new carbon- and metal-based materials using materials chemistry, advanced deposition techniques and single atom engineering. Low-dimensional (2D, 1D, 0D) materials are created with the use of computational design allowing a precise control of their structural and physicochemical properties on an atomic level. New technologies are applied in solar energy conversion, solar cells, hydrogen production by the photochemical way, energy storage, heterogeneous catalysis, water treatment, and biomedicine.

Research Group Leader

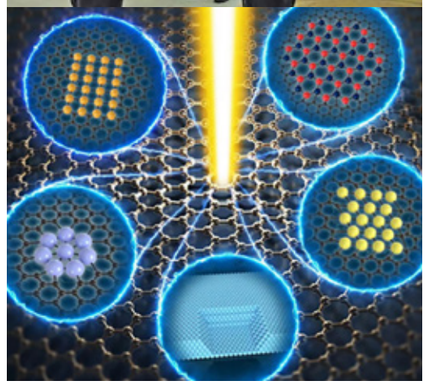
Radek Zbořil
Professor, RNDr., Ph.D.

CEET-CNT

EBEAM

nanoscale materials
electron beam fabrication
advanced microscopy
additive manufacturing
in situ characterization

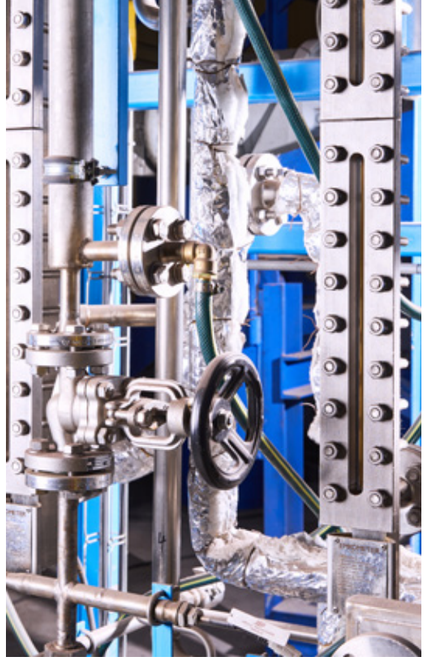
The group is dedicated to pioneering research in electron beam precision manufacturing (EBEAM). Our focus is on revolutionizing nanoscale materials fabrication through cutting--edge electron microscopy techniques, such as SEM and TEM. We strive to develop advanced in situ control and monitoring systems, pushing the boundaries of additive manufacturing at the atomic and nanometer scale. We aim to understand the fundamental science behind this emerging technology. With a strong emphasis on applications, we explore the synthesis of 2D materials and precision-manufactured materials for diverse fields, electronics, renewable energy, catalysis and beyond.



Research Group Leader

Mark Hermann Rümmeli
Professor

CEET-IET



Research Group Leader

Jan Najser
Ing., Ph.D.

CEET-CENET

THERMOCHEMICAL AND HYDROGEN CONVERSION

waste gasification
pyrolysis
alternative fuels
hydrogen
combustion

The research group focuses on the investigation in the field of engineering and processing technologies for the thermal treatment of waste and alternative fuels, with an emphasis on maximising the efficiency of the entire process. Furthermore, it deals with the fundamental and applied research of combustion, fluid dynamics, heat transfer, drying, and the sorption of pollutants in fluidised bed boilers, as well as substituting conventional fuels with alternative ones. It also dwells on developing mathematical models of individual processes and verifying them through experimental measurements.

ENERGY BY-PRODUCTS

organic markers
air pollution
environmental impact
thermal processes
combustion

The group specialises in research into the environmental effects of anthropogenic activity in the field of thermal processes with regard to the occurrence of organic compounds. We conduct a detailed study of the properties of fuels and combustion products with the aim of better understanding the combustion process itself and limiting the emergence of technological problems. The group is engaged in assessment of atmospheric pollution, soil, sediments, and combustion products with the aim of developing strategies for reducing anthropogenic environmental impacts. The research is focused on biodegradable materials and their potential for utilisation in energy technologies.

Research Group Leader

Helena Raclavská
Professor, Ing., CSc.

CEET-CENET

BULK MATERIALS

bulk materials
powders
processing
DEM simulations
transport

The group conducts basic and applied research on process treatment, storage, and transport of bulk materials. The team's focus is to explore their mechanical, physical, and geometric properties to generate an assessment of the initial state, and subsequently to analyse design, engineering, and mathematical models of their processing. The group is researching the optimal relationships between bulk properties, geometric shapes, applied materials, and the laws of production, transport, and storage. The team is also involved in research in the field of material pelletisation, especially biomass.

Research Group Leader

Lucie Jezerská
Ing., Ph.D.

CEET-CENET

MODERN HEATING SYSTEMS

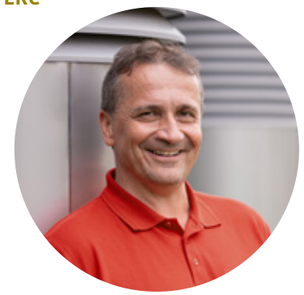
source of thermal energy
boiler
dust particles
efficiency
pollutant emissions

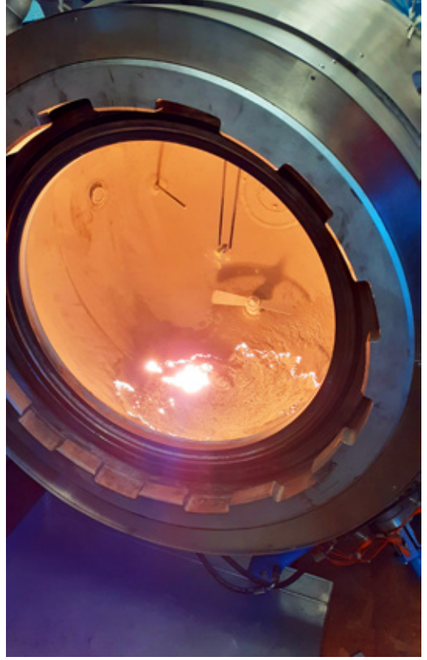
The group carries out research, development and testing in the field of thermal-energy equipment for interior space heating up to an output of about 300 kW. In an excellently equipped testing laboratory, devices are examined as a whole unit so that as a source of thermal energy including the parts out of the devices such as a flue gas path and operators as well. The basic activities are devoted to maximising efficiency and minimising pollutant emissions, special attention is paid to the design of new methods for their determination. Optimisation of emission parameters of the source is solved by both primary and secondary measures. The group also includes the laboratory of fuels.

Research Group Leader

Jiří Horák
Ing., Ph.D.

CEET-ERC





INNOVATION AND SAFETY

hydrogen
biomass gasification
technologies
energy
safety

The research group is engaged in the latest technologies and directions of research and development, with a general focus on the best available energy conversion technologies, biomass gasification, production of liquid fuels of the second generation, technologies for waste heat recovery, and safety of systems, technologies, and materials. Moreover, the group concentrates on hydrogen energy and its complex safety and purity. It runs the Technology and Energy Safety Laboratory. The research focus of the department is dynamically changing according to the latest global and domestic trends.

Research Group Leader

Tadeáš Ochodek
Associate Professor, Dr., Ing.

CEET-ERC

WASTE TO ENERGY

energy recovery of waste
solid recovered fuel
waste to energy
emissions
energy balance

The group focuses on experimental research on oxidation processes of thermal treatment of waste or other fuels from chemical, environmental and energy perspectives, including physicochemical characterization of waste and fuels. The workplace enables the implementation of energy recovery experiments on waste and waste-based fuels on a semi-operational scale with a complete evaluation of the emission load, and the results of the work provide a material and energy balance of the process.

Research Group Leader

Jozef Vlček
Professor, Ing., Ph.D.

CEET-IET

Research Group Leader

Jiří Rusín
Ing., Ph.D.

CEET-IET

BIOCHEMICAL PROCESSES

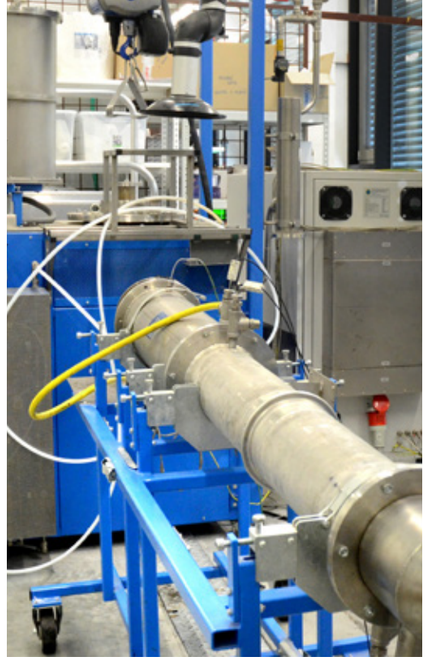
biowaste
aerobic and anaerobic fermentation
biogas
biomethane
biohydrogen

The group conducts research on biogas production from various biomass sources including bio-waste. Moreover, the team focuses on downstream processes such separation of methane or hydrogen, etc. Composting processes aim at the most efficient recycling of organic matter into the soil. Problematic waste, such as sludge from sewage treatment plants, should also be used. Anaerobic digestion aims at the same goal in the efficient production of biogas. For example, the organic fraction of municipal waste should also be processed. Dark fermentation is currently the most promising biochemical method for hydrogen production. Membrane processes make it possible to efficiently separate methane or hydrogen from biogas.

INDUSTRIAL CHEMISTRY

chemical and process engineering
pyrolysis
catalysis
chemical recycling
chemical technology

The research group focuses on development of chemical processes for transforming materials e.g. waste polymers, and biomass into valuable products. The group deals with hydrogen production by catalytic dry reforming of gases that evolve during thermochemical treatment of materials, but also catalytic hydrogenation of carbon dioxide. Furthermore, the group designs and optimises unit operation equipment for chemical and environmental technologies which are used in different industries to process, refine or produce new substances.



Research Group Leader

Pavel Leštinský
Ing., Ph.D.

CEET-IET

CEET
RESEARCH AREAS
RESEARCH GROUPS
CEET BOARDS
COLLABORATION EXAMPLES

HETEROGENEOUS CATALYSIS

heterogeneous catalysis
temperature-programmed techniques
reaction mechanism
waste gas cleaning
laboratory and pilot plant testing

The group specialises in studying waste gas treatment processes using catalytic and adsorption techniques (catalytic decomposition of N_2O and NO, selective catalytic reduction of NO_x by ammonia, catalytic oxidation of CO and NH_3, adsorption and catalytic oxidation of VOCs, etc.) including the study of reaction mechanisms. Additionally, the research team offers services in the field of industrial catalysts testing, analytical services that include gas mixture analysis and solid catalyst characterization based on temperature-programmed methods.

Research Group Leader

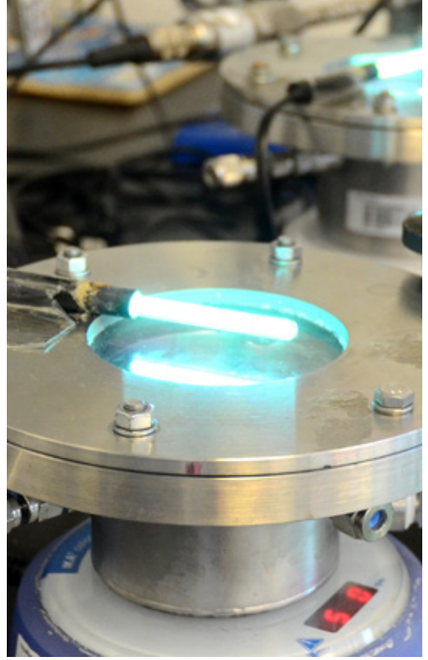
Kateřina Pacultová
Ing., Ph.D.

CEET-IET

HETEROGENEOUS PHOTOCATALYSIS

photocatalytic processes
CO_2 reduction
hydrogen generation
N_2O decomposition
advanced oxidation processes

The group deals with photocatalytic processes. The group studies the efficiency of photocatalysts for photocatalytic reduction of carbon dioxide, photocatalytic decomposition of nitrous oxide, photocatalytic water splitting in presence of methanol, degradation of pollutants from water. The group also researches the kinetics of photocatalytic reactions and the use of advanced oxidation processes for waste gas treatment. The laboratory is equipped with batch photocatalytic reactors with different geometries for gas and liquid phase reactions, flow reactor for gas phase testing, photoelectrochemical spectrometer, Kelvin probe and a semi-operating unit for advanced oxidation processes.



Research Group Leader

Kamila Kočí
Professor, Ing., Ph.D.

CEET-IET

PŘÍPRAVA MATERIÁLŮ A ZHODNOCOVÁNÍ ODPADŮ

nanostructured photo/catalysts and sorbents
natural substances with added value
green high-pressure technologies
microwaves
volatile organic compounds degradation

The group specialises in the preparation and optimisation of preparation of various nanostructured materials in different macroscopic forms using various inorganic precursors and waste materials to enhance adsorption, photocatalytic and catalytic oxidation of organic waste gases as well as the photocatalytic reduction of greenhouse gases. Besides conventional approaches, the group utilises supercritical and pressurised hot solvents, subcritical water, or microwaves in their processes to prepare materials and recover waste. Moreover, the group provides analytical services material texture determination.

Research Group Leader

Lenka Matějová
Ing., Ph.D.

CEET-IET

WATER TREATMENT AND ANALYSIS

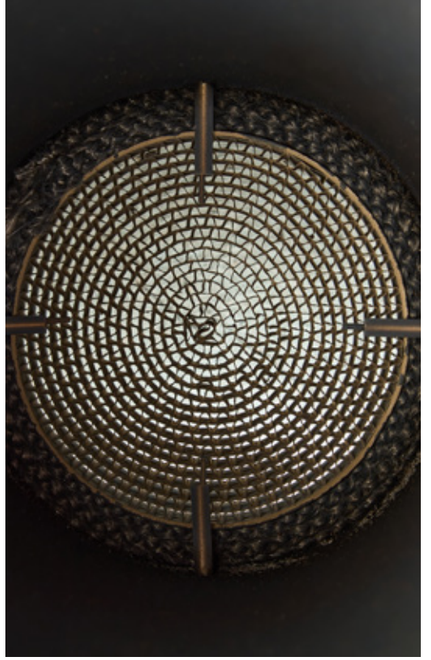
wastewater
adsorption
bioremediation
micropollutants
trace analysis

The group is focused on basic and applied research in the field of water treatment, including analytical determination of the quality of surface and wastewater. The subject of research is mainly adsorption and bioremediation processes, photocatalytic decompositions, and membrane processes. Research is done using materials (sorbents, catalysts) prepared with regard to substances to be removed (especially drugs and pesticides). In the analytical area, metals, ions, and organic pollutants are determined, and their interactions and influence on organisms present in the water are also monitored.

Research Group Leader

Martina Vráblová
Mgr., Ph.D.

CEET-IET



Research Group Leader

Karel Borovec
Ing., Ph.D.

CEET-ERC

TECHNOLOGIES FOR ENVIRONMENTAL PROTECTION

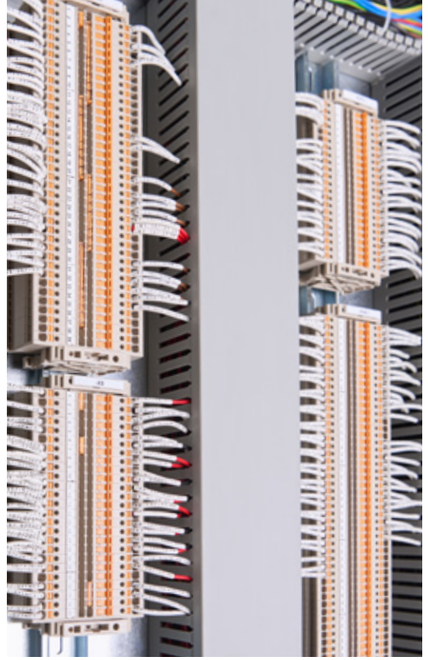
emissions
efficiency
best available technology
alternative Fuels
CO_2

The research group deals with the development and research of measuring methods, equipment and technologies for the greening of the operation of energy and industrial sources of air pollution, including the thermal use of alternative fuels. It is an authorised testing laboratory for measuring emissions according to the applicable legislation. In its activities, it uses accredited procedures, the unique ones of which are continuous analysis of the gaseous phase of mercury in emissions, continuous analysis of ammonia concentration in ash and continuous analysis of hydrogen purity. The team is also involved in the development and verification of the effectiveness of procedures for energy storage in the form of hydrogen and CO_2 separation.

SMART GRIDS

solar power
wind power
energy storage
hydrogen technologies
electromobility

The group is engaged in complex interdisciplinary research, development, and implementation of new sophisticated technologies in terms of reliability, resilience, and diagnostics of electrical grids, machines, and equipment. The research aims at optimising electrical grid operation with renewable energy sources and storage systems and creating service infrastructure for vehicles with alternative drives. Research activities include examining hydrogen technologies for energy storage and transportation.



Research Group Leader

Lukáš Prokop
Associate Professor, Ing., Ph.D.

CEET-CENET

APPLICATIONS FOR INDUSTRY AND MUNICIPALITIES

energy management
design engineering activities
feasibility study
energy conception
cost benefit analysis

The group's expertise extends to optimising energy production and consumption in industry and energy savings through new technologies in municipalities. It performs energy audits, studies, monitors, and optimises energy usage. Additionally, the team analyses the operational characteristics of photovoltaic power plants and the downstream use of storage units. The group designs energy management systems for industrial enterprises, cities, and heating plants, and deals with the problems of local distribution systems. It provides comprehensive design and engineering services in the energy sector.

Research Group Leader

Zdeněk Neufinger
MBA

CEET-ERC

CEET BOARDS

BOARD OF EXPERTS

Advisory body to the CEET Director for setting and reviewing the guidelines for CEET scientific research activities, its international status, funding system and evaluation methods.

The main tasks of the Board of Experts are to provide recommendations and suggestions to improve the quality of scientific activity and international prestige of CEET and to improve its position as an internationally recognised scientific institution. The Board of Experts also provides recommendations for newly established research areas and groups and for the overall evaluation of CEET scientific activities.

The Board of Experts has a minimum of 12 members, appointed and dismissed by the CEET Director on the basis of nominations from the Research centres Directors. Members are eminent scientists working in top international and domestic research organisations and universities. The function of the Board of Experts members is honorary and their activities are not remunerated.

SCIENTIFIC BOARD

The members of the Scientific Board are appointed and dismissed by the Director of CEET after the prior approval of the Academic Senate of VSB-TUO. The Scientific Board has seven members, at least three of whom are not members of the academic community of the VSB-TUO. The term of office of the Scientific Board is four years and the Director of CEET is the Chairman of the Scientific Board.

The Scientific Board discusses, among other things, the draft strategic plan of CEET and the plan of implementation of the strategic plan of CEET for the relevant calendar year, approves the organizational regulations of the research centres and expresses its opinion on other matters submitted to it by the Director of CEET.

The Scientific Board shall meet at least once a year, shall be convened by the Director of the CEET and shall be governed by the Rules of Procedure of the CEET Scientific Board, which are annexed to the CEET Statutes.

COLLABORATION EXAMPLES

CEET has a long-standing collaboration with the public sector and industry partners, mainly through joint scientific research projects and contract research. Unique facilities consisting of state-of-the-art equipment provide scientists with the background and potential for research across four defined research areas and ensure efficient transfer of methods and technologies from the scientific to the commercial sphere. The volume of collaborations with industry and the public sphere accounts for more than half of the funds raised across the university. Selected examples of collaboration provide an insight into these.

INSULATION FAULT DETECTOR IN HIGH VOLTAGE DISTRIBUTION NETWORKS

Partner **ČEZ Distribuce a.s.**
Field **Power engineering**

The current development of electromobility and decentralised energy sources places high demands on the reliability and robustness of the high-voltage distribution network. One of the options to increase the operational reliability of these lines is to replace the currently used AlFe ropes with insulated overhead wires. This conductor is made of aluminum alloy AlMg-Si wires and is coated with XLPE or HDPE based insulation material.

The use of insulated suspension wires offers a number of advantages over AlFe ropes. Insulated conductors are not susceptible to contact with surrounding vegetation, which is one of the most common sources of distribution line failures. Especially in densely forested areas, situations arise where a tree falling on the line can cause an interphase short circuit or a ground fault or ground connection. The use of insulated overhead conductors also reduces the environmental impact in the vicinity of the line route, as the necessary vegetation clearances are reduced.

However, the widespread use of insulated suspension conductors is still hampered by the lack of a simple and affordable system for online diagnostics of the conductor's insulation system. CEET-CENET has therefore developed an insulation fault detector in cooperation with ČEZ Distribuce, which is directly designed for use on distribution lines with insulated conductors. It uses single-layer coils as sensors, which are wound on the surface of the insulated conductor. These sensors are capable of detecting the imminent risk of failure of a conductor's insulation system, up to a distance of several kilometres.

PARTNER'S NOTE | **Milan Jelínek** | ČEZ Distribuce a.s.

„The high voltage distribution lines owned by ČEZ Distribuce have a total length of over 50,000 km. A part of this network consists of overhead lines with insulated conductors. These lines represent an interesting alternative. Compared to bare conductors, they have the advantage of a smaller protection zone, which is used in forest clearings due to the insulation of the conductors, and their investment costs are lower compared to underground cables.

However, the operation of overhead HV lines with insulated conductors is very specific in terms of network management. Conventional digital protections are not able to detect some non-standard operating conditions that can cause damage to the conductor insulation - for example, branches or trees falling into the line. Therefore, in cooperation with CEET-CENET, a device has been developed that can detect impending damage to the overhead conductor insulation. With the insulation fault detector, our dispatchers have a tool in their hands that can warn them of the potential risk of a fault on the line. In the event of an imminent risk of a fault, a timely response by the dispatcher can prevent damage to the conductors insulation and thus interruption of power supply to customers.“

SUPPORT FOR THE DEVELOPMENT OF NEW SURFACE BLASTING EQUIPMENT

Partner **WISTA s.r.o.**
Field **Mechanical engineering**

According to a market survey conducted by our Bulk Materials research group CEET-CENET, almost 65% of companies in the Czech Republic deal in some way with particulate materials (also known as „bulk materials“). These are a relatively wide range of materials with particle sizes ranging from centimetres to nanometres. One of the physical problems of particulate materials that strongly affects their practical use is their abrasiveness. On the one hand, it causes surface degradation (abrasion contamination and loss of wall thickness in transport, storage and process equipment). On the other hand, however, abrasiveness can also be useful, for example for cleaning surfaces by blasting.

The design team at WISTA, a company that manufactures and supplies innovative technologies and services for surface blasting, painting and metallization, has been working on the development of a new mobile container unit for surface blasting in industry and construction. As part of the development, issues related to the circulation of the blasting material had to be addressed, up to a point of degradation where the blasting process was still functional. During the development process, a number of questions had to be answered related to the use of different types of abrasive materials and their behaviour in the conveying, screening and storage sections of the newly developed unit. It was also necessary to determine how the intended abrasive materials would interfere with the actual operation of the various parts of the plant. And, also, how to adjust the downstream process control to avoid material overwhelming the routes and consequent loss of operational function and reliability of the conveying and sorting systems of the new unit under development.

The scientific research team of Bulk Materials provided technical and consultancy support to WISTA. We used modern methods and state-of-the-art measurement technology from our BSC-ENET laboratory. Our laboratory used the DEM (Discrete Element Method) simulation method to solve all these tasks and then to verify the functionality of the technical solution. Supporting the development and design of equipment using DEM computer simulation is nowadays a highly demanded procedure. It significantly reduces the risk of errors in prototype development. The key issue for WISTA was to manage abrasion with respect to the actual operational functioning of the plant. This approach enabled the measured data to be abstracted into methodologies and specific designs for the detailed technical solution of the equipment under development.

PARTNER'S NOTE | **Jiří Neuwirth** | WISTA s.r.o.

„The cooperation with the Bulk Materials research group has helped us a lot in the development of the new production equipment. The representation of the flow of abrasive bulk material in the proposed 3D model of the plant before the prototype was produced allowed us to identify bottlenecks in the process in advance, to modify them and to increase the efficiency of the design. Consulting with this research group and using their state-of--the-art measurement and diagnostic equipment, as well as their experience in applying computer simulation using the DEM method, helped us to reduce the occurrence of a number of potential problems and failures. This, of course, also reduced the financial costs of prototype development and field testing.“

DEVELOPMENT OF A MOBILE LINE FOR ASPHALT RECYCLATE PROCESSING

Partner **MOBIKO plus, a.s.**
Field **Construction**
Recycling

The availability of primary resources is now a growing global issue. And it's not just in the construction and energy sectors. With a view to the long-term sustainability of production, the focus is therefore on reducing the need for primary energy and raw materials, increasing recycling rates and finding alternative options. The laying of new asphalt and special surfaces for junctions and motorways places considerable demands on their quality, particularly their durability and longevity in the given environment. The shortage of aggregates is one of the main and pressing problems affecting not only our country, but also neighbouring countries, and it also comes up against environmentally friendly EU legislation.

One of the results of the joint and successful project called „R-mat", submitted and solved in cooperation between MOBIKO plus and the research group of Thermochemical and hydrogen conversion of the CEET-CENET, is a prototype for a new generation of processing line for recycling construction waste. It has been developed for the processing of abrasive and waste materials from construction and civil engineering, especially asphalt recyclate. The aim of the joint research and development was, among other things, to find optimal mixtures for increasing the recycling rate beyond the values and normative procedures that have been achieved so far.

The new line is capable of processing not only different types of road surface materials, but also base plates, various types of construction waste such as rubble, milled pavement, concrete edging and more. The input material to be recycled can be fed into the hopper in the form of millings, quarry bushes or bulk mix. The line includes a series of vibratory drives and crushing equipment where, thanks to the designed geometry and surface of the active part, the required removal of old material and separation of the different aggregate fractions for further use takes place. The line has been supplemented with central control and operates in automatic mode. As part of the project solution, the technological process was also designed and the parameters of the resulting recyclate were determined so that the recoverability of otherwise non-recyclable asphalt residues was significantly increased. The project also resulted in the design of a new recipe, including several suitable options for the individual binder and recyclate components and defining their percentages in the overall proposed mix. Laboratory tests and analyses of the components and binders were carried out for this purpose in the CEET-CENET laboratories at VSB-TUO.

The project also resulted in the design of an alternative modification of the line, which became a mobile facility with the addition of a mobile power source. This represents a significant advantage, as the existing processing lines are now designed as stationary. However, our new line can now be dismantled and transported directly to the recyclate processing site.

PARTNER'S NOTE | **Petr Zima** | Mobiko plus, a.s.

„The prototype is a third-generation mobile processing line with a capacity of up to 20 tonnes/hour. Based on the evaluation of the prototype's trial operation, series production can be started. Experimental measurements, laboratory tests and stress tests then show that the plant can be successfully operated with an increased proportion of recycled input even for new surfaces while maintaining the required quality parameters. The results have demonstrated the possibility to increase the recycled content of new asphalt mixes and surfaces to close to 100%. Existing technologies use only 15-60 % of this material. The result of the solution is a protected recycled asphalt mix with R-material, registered with the relevant industrial property office. It is now a competitive advantage for our company and the basis for further planned developments. And also, a source of prestige, valuable data and experience for the CEET research group of the Thermochemical and hydrogen conversion.

The proposed solution mitigates the impacts of mining, declining raw material stocks and the overall ecological burden. At the same time, it also anticipates the planned changes in legislation at the national and EU level. It will therefore also have an international impact on the wider construction market."

ECOLOGICAL DISPOSAL AND ENERGY RECOVERY OF SEWAGE SLUDGE

Partner **EKOMVO, s.r.o.**
Field **Environment**
Energy

Wastewater treatment produces sewage sludge as a waste material. The quantity of this sludge can be reduced by appropriate choice of treatment and disposal technology. The production of sludge in absolute dry matter in the Czech Republic is approximately 200,000 tonnes/year. The aim of wastewater treatment is primarily to remove unwanted components from the water into the sludge by-product and thus increase the calorific value. It can be assumed that, with increasing demands on the quality of treated wastewater, the quantity of sludge produced in the Czech Republic will further increase to 220-340,000 tonnes/year.

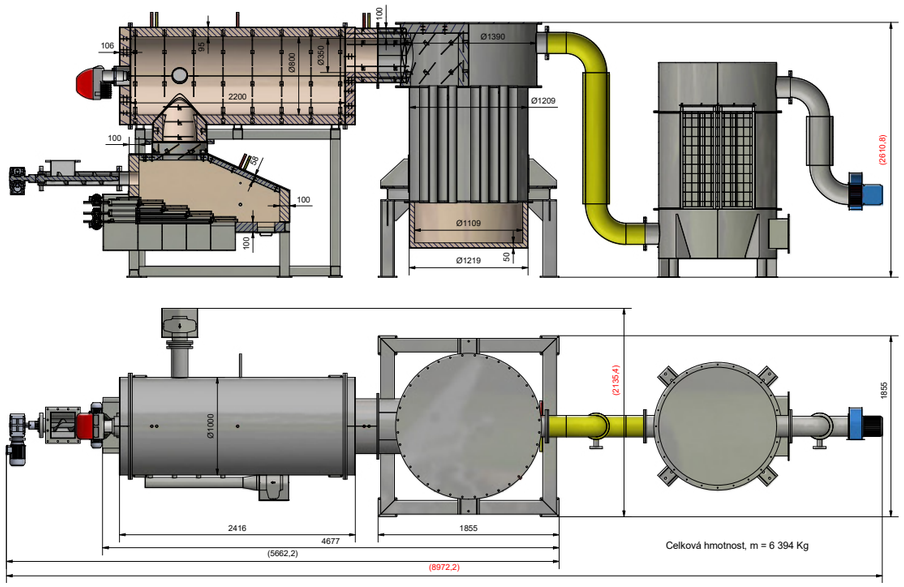
Raw sludge, which contains around 50 to 70 % of organic matter on a dry basis, is classified as hazardous waste under the Waste Act due to the possible presence of pathogenic microorganisms, with all the resulting consequences. The aim of sludge treatment is therefore to prevent adverse effects on human health and the environment and, where appropriate, to exploit its energy potential.

Countries with advanced sludge treatment technology are increasingly seeking to reduce methods that do not meet the established environmental and economic requirements.

It is primarily a combination of practices to eliminate sludge retention, which is the main outcome for some sludge types in Europe so far, and a focus on methods to transform sludge into an environmentally friendly product, preferably with the aim of increasing its energy value. This effort is supported by the EU Waste Policy, which aims at waste prevention, minimisation and recycling. The discharge of sludge into the sea was stopped by EU legislation as early as 1998.

Recycling and destruction methods are considered environmentally acceptable options for sludge treatment. Recycling methods work with the use of the final product as an organic fertiliser for agriculture. Destructive methods include incineration without or with the use of thermal energy, gasification or the use of sludge as a process fuel. The residual ash is subsequently recovered or landfilled.

Today, the incineration method is the most efficient form of ecological disposal of these materials. Its main advantage is the disposal of non-biodegradable organic materials or materials that are contaminated, toxic or otherwise hazardous.



PARTNER'S NOTE | **Otakar Fajkoš** | EKOMVO s.r.o.

„The project team of our company EKOMVO in close cooperation with the research group of Thermochemical and hydrogen conversion CEET--CENET developed a test unit for the disposal of sewage sludge using incineration technology with the subsequent possibility of recovering some substances. This new treatment technology reduces the volume of sludge by up to 90%, while the remaining material is inert and can be safely disposed of in a landfill or used for the recovery of certain substances from the ash. In this case, in particular phosphorus, which can be used as a valuable fertiliser in agriculture. This output is very welcome in view of the world's dwindling natural reserves of phosphorus, which is an essential component of most fertilisers."

SUN INSTEAD OF ELECTRIC FURNACES, CHEAP NANOMATERIAL INSTEAD OF GOLD

Partner **Leibniz Institute for Catalysis, Germany**

Field **Catalysts for industrial production**

The technology, which can speed up and cheapen the production of a number of drugs, chemicals, plastics or dyes, was developed by scientists from CEET-CNT in collaboration with foreign colleagues and researchers from the CATRIN Institute at Palacký University. The basis is a new nanomaterial that works with commonly available minerals instead of the precious metals used so far. Foreign investors have already expressed interest in it and the importance of the discovery is also evidenced by its publication in the journal Nature Nanotechnology.

According to Radek Zbořil, head of the Materials-Envi Lab at CEET-CNT, in the current geopolitical situation and the related energy crisis, the European Union has no choice but to look for ways to reduce the costs of industrial production and make the most of new green technologies and materials that will free us from dependence on energy and raw material sources from Russia.

A team of Czech researchers together with colleagues from the FORTH Scientific Institute in Heraklion, Greece, and the Leibniz Institute for Catalysis in Rostock, Germany, studied the chemical production processes of aniline compounds, which are widely used in the production of a wide range of pharmaceuticals, plastics, dyes and agrochemicals. According to MarketWatch, the market for aniline compounds is approximately $12 billion per year, with significant growth expected. However, their current industrial production is very costly in terms of energy and money, as it takes place under high temperatures and pressures and requires the use of precious metals such as gold, palladium or platinum to speed up the chemical reaction. The new technology, on the other hand, works with nanoparticles of chalcopyrite, a common iron, copper and sulphur-based mineral found not only in the Czech Republic but also in many other locations in Europe, America and Africa. The nanomaterial is cheap, can be easily produced on an industrial scale, and accelerates chemical reactions better than the aforementioned precious metals, using only sunlight. When comparing the efficiency of the new system with dozens of commercial materials, the researchers found excellent results. The production rate relative to the cost of the material is an order of magnitude higher than the best competing technologies.

The work of Professor Zbořil's team builds on the discovery of a catalyst that also shows high efficiency in related drug and chemical production processes. The difference lies, among other things, in the fact that it is based on iron nanoparticles. The Czech-German team published this result in the journal Nature Catalysis. „The new chalcopyrite-based material works on a different principle and, in our opinion, has greater commercial potential, including dramatic reduction in energy costs, record efficiency, easy and cheap production, and elegant technological design. Therefore, we decided to protect the technology with an international patent application prior to publication. This was the right step, and we are already in talks with the first interested parties for the industrial use of the technology and potential investors, especially in Germany," explained Zbořil.

PARTNER'S NOTE | **Matthias Beller** | Leibniz Institute for Catalysis

„Catalysis, specifically heterogeneous catalysis, is a highly interdisciplinary field of research that enables the production of all kinds of everyday products in a cost-effective and sustainable manner. For our research group at the Leibniz Institute for Catalysis in Rostock, Germany, collaboration with Professor Radek Zbořil's team in this area is very important, as the expertise of both parties is complementary. Prof. Zbořil and his colleagues have fantastic know-how in the preparation and characterization of new nanostructured materials, which we are applying to industrially important chemical transformations, including the development of processes that are necessary for the valorisation of waste, carbon dioxide, etc."

COOPERATION WITH EUROPEAN LEADERS IN THE FIELD OF GREEN ENERGY

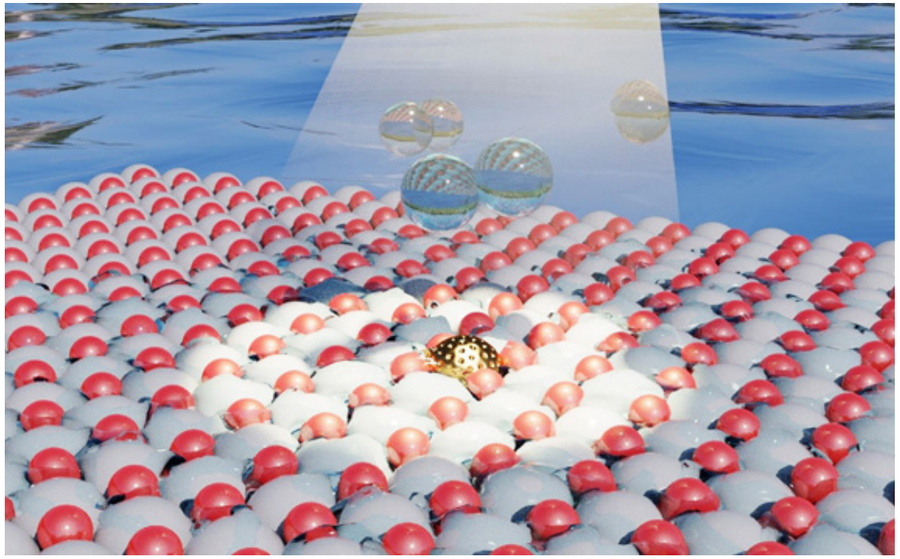
Partner **University of Trieste**
Field **Electrochemistry**

The need to end our dependence on fossil fuels and contribute to solving other environmental problems, including the impacts of climate change, is forcing scientists to come up with new solutions to these global challenges. A ground-breaking approach is the use of atomic engineering to develop new materials for green energy or to reduce atmospheric carbon dioxide emissions. This is precisely the aim of the prestigious European project SAN4FUEL (Single atom based nanohybrid photocatalysts for green fuels) from the Twinning call, in which VSB-Technical University Ostrava cooperates with colleagues from CATRIN Palacký University in Olomouc, Friedrich Alexander University in Erlangen, Germany, and the University of Trieste, Italy.

In the scientific part of the project, the main role will be played by the production of hydrogen by solar water splitting and the electrochemical conversion of waste carbon dioxide using new materials modified by atomic engineering. These technologies will allow the control of material properties down to the level of individual atoms and allow to significantly increase the production of green hydrogen or to advance the possibilities of transforming carbon dioxide into useful chemicals with high added value.

Prof. Radek Zbořil, the head of the research team Materials-Envi Lab of CEET-CNT, explains the objectives of the project as follows: „Our task is to develop technologies that enable the anchoring of individual atoms on the surface of suitable semiconductors and to control the chemical and electronic properties of these atoms. The results show that this new approach, based on so-called atomic engineering, allows, for example, to increase several times the efficiency of materials used for photocatalytic and photoelectrochemical conversion of solar energy into hydrogen, which is crucial for the implementation of green fuel production technology. Using computational chemistry approaches, we aim to understand the mechanism by which individual atoms increase the efficiency of key photochemical and photoelectrochemical processes and, based on this knowledge, to optimise a new generation of materials for energy. In the experimental part, we are exploring the potential of atomic engineering for photochemical conversion and removal of carbon dioxide, whose worldwide production is a major contributor to global climate change.“

The research team also focuses on computer-aided design of materials and understanding how they work. To model the processes, it uses the support of the National supercomputing centre IT4Innovations at VSB-TUO.



PARTNER'S NOTE | **Paolo Fornasiero** | University of Trieste

„Carbon dioxide can be converted electrochemically into useful chemicals or energy sources such as formic acid, carbon monoxide, ethylene, ethanol or methane using suitable nanomaterials. We will focus on graphene-based nanomaterials enriched with suitable metals, which have been prepared in the past by colleagues in Ostrava and Olomouc.

Our joint effort will be to increase the conversion efficiency and to develop new monoatomic materials so that carbon dioxide valorisation technologies can find application in real practice. We can build on our long-term cooperation, which has proven itself in the past and led to a number of significant results.“

HYDROGEN – THE FUTURE OF ENERGY AND TRANSPORT

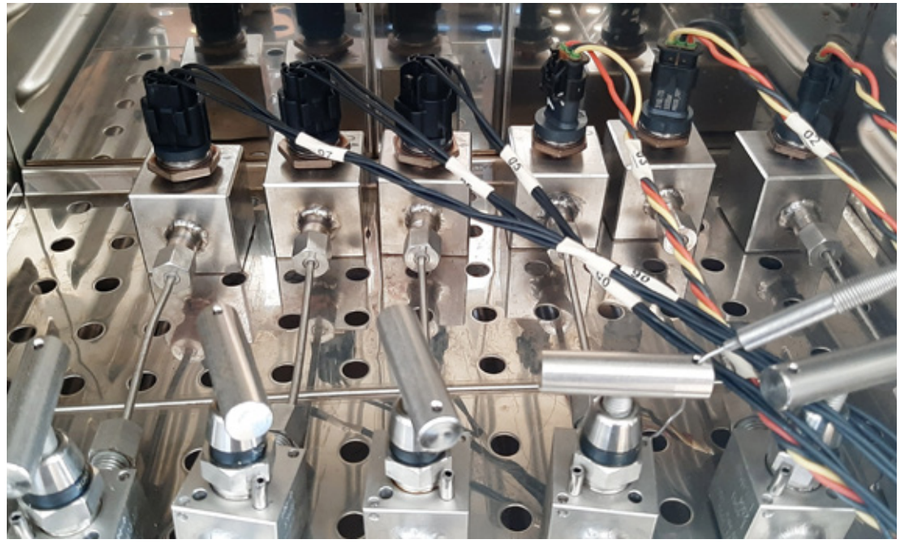
Partner **Vitesco Technologies Czech Republic s.r.o.**

Field **Mechanical engineering**

Energy and transport are extremely important sectors for modern human society. The need for cheap and environmentally friendly energy is a determining condition for the further development of contemporary civilisation. The use of hydrogen as a fuel for transport and energy is one of the possible directions that will enable sustainable and environmentally friendly development in the future. The mass use of hydrogen fuel requires a wide infrastructure including components for its production, transport, storage and safe use.

In cooperation with Vitesco Technologies, we focused on long-term reliability testing of pressure sensors for hydrogen pressure measurement. When developing new sensors for hydrogen handling equipment, extreme emphasis must be placed on safety and reliability under all operating conditions. As part of the solution, these sensors were subjected to long-term tests at different hydrogen pressures under various ambient conditions. The test parameters were chosen based on the real operating parameters of pressure sensors used in hydrogen environments. Tests were performed both at sub-zero temperatures and at high operating temperatures.

As part of the collaboration, measuring equipment capable of testing pressure sensors over a wide range of temperatures and pressures was designed, manufactured and verified. The sensors developed can be used not only to secure hydrogen equipment, but also other gases including hydrocarbons.



PARTNER'S NOTE

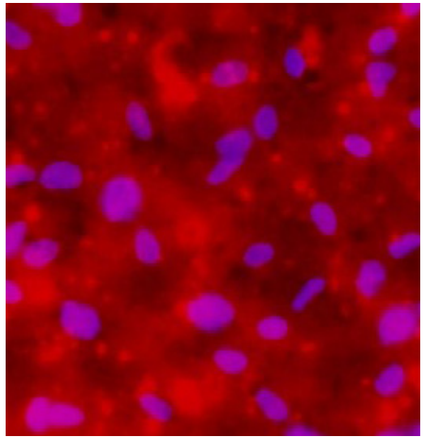
Roman Kučera

Vitesco Technologies Czech Republic s.r.o.

„By working with CEET-CNT laboratories on specific development tasks, we are increasing the level of knowledge and new experience in our company. I firmly believe that the results and benefits of our cooperation will very soon start to be seen in winning contracts in the UK market and wherever passive public transport safety plays an important role. The cooperation within the region has been highly effective and for me personally it has been, and still is, an interesting experience and also a pleasure that we have achieved many things together, even better than we originally expected."

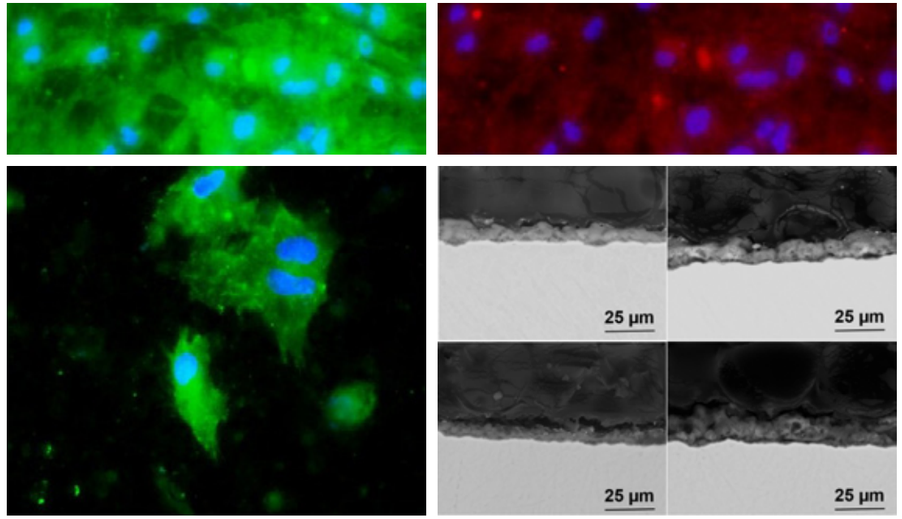
DEVELOPMENT OF CERAMIC LAYERS

Partner **VÚHŽ a.s.**
Field **Healthcare**
Mechanical engineering



Thanks to the cooperation with VÚHŽ modifications of the surfaces of β alloys and α+β titanium alloys have been developed to improve especially the tribological and corrosion properties of traumatological implants. Titanium alloy surfaces exhibit a high coefficient of friction and insufficient abrasion resistance. For these reasons, increased emphasis is placed on subsequent surface treatment to ensure sufficient tribological, corrosion and biocompatible properties. These properties have been improved by the use of a semi-operating micro-arc oxidation (MAO) unit, also known as plasma electrolytic oxidation (PEO).

The biocompatibility of the prepared coatings in terms of adhesion and cell growth, which is required for short-term/temporary implants, e.g. trauma implants such as splints, wires, screws or spikes, was also tested in the collaboration of our CEET-CNT laboratories with other academic institutions to allow easy removal of the implant after healing of the damaged bone. The use of MAO technology has also been extended to the field of Al-Si alloys, which are one of the most important foundry alloys with a wide range of applications in the automotive and aerospace industries, on the basis of our collective experience in the field of surface treatment of trauma implants. In order to achieve an effective tribological and corrosion resistant coating on Al-Si alloys, a procedure for the preparation of MAO coatings has been proposed to enable applications in areas requiring high wear and corrosion resistance.



PARTNER'S NOTE | **Vít Michenka** | VÚHŽ a.s.

„A joint solution in collaboration between CEET-CNT academia and the industrial enterprise has contributed to the use of micro-arc oxidation technology to prepare wear-resistant and corrosion-resistant oxide layers. The design, and the solution itself, was based on a long-standing collaboration in the field of surface modification of trauma and orthopaedic implants on titanium alloys. A ceramic coating on Al-Si alloys was developed for the automotive and mechanical engineering industry, meeting the mechanical and corrosion performance requirements while achieving low operating costs and environmentally friendly operation of the technology."

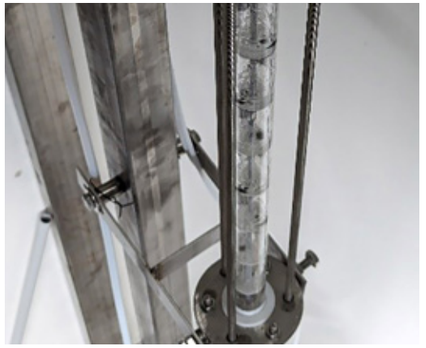
DESIGN OF A NEW TECHNOLOGY FOR THE REFINING OF CRUDE CAPROLACTAM

Partner **SPOLANA, a.s.**
Field **Chemical industry**

SPOLANA Neratovice is the only producer of caprolactam in the Czech Republic. Caprolactam is used as a basic monomer for industrial production of polyamide 6 (PA 6). This polymer, thanks to its good mechanical resistance and chemical stability, finds wide application in the field of textile fibres, technical structural elements and modern composite materials. Its world consumption is increasing. For the refining of the monomer, trichloroethylene is used as an extracting agent in large-scale production. It is classified as a category 1B carcinogen and its use is restricted by REACH legislation.

TECHEM CZ, Prague is an innovative consulting company focused on industrial applied research and solutions to toxicological and environmental issues in the chemical industry. In cooperation of SPOLANA and TECHEM CZ with CEET-IET and within the projects „Refining of raw caprolactam“ no. TH01030104, „Elimination of trichloroethylene from ammonium sulphate production“ no. TH04030008 and „Continuous refining of caprolactam“ No. FV-40040, a refining process has been developed which allows to achieve the same or better quality of the output caprolactam and ammonium sulphate as by-product without the use of carcinogenic trichloroethylene. As part of the development of a new process for the refining of crude caprolactam, laboratory facilities were built for research and simulation of refining processes. They can also be used to solve problems in the field of refining technology. The new refining process developed has been registered in RIV in the G-functional sample category. The obtained knowledge will be used for further verification on a pilot unit built at SPOLANA. The aim is to verify the safety, economics and quality of process before the new technology is put into operation.

Innovation and modernisation of the operating technologies, increasing their operational safety and protecting health and the environment are the basic strategic objectives of SPOLANA Expected benefits will include savings in operating costs and better public awareness of the company.



PARTNER'S NOTE | **Martin Čech** | SPOLANA a.s.

„We would like to highlight our long-term and successful cooperation with CEET-IET at VSB-TUO. During our aforementioned joint projects, we had an opportunity to get to know their professional approach, high level of technology and deep knowledge in the field.

CEET-IET has emerged as a leading research institute focusing on innovative and sustainable technologies for environmental protection. Their team of experts is not only well-trained, but also continuously monitors and applies the latest research and trends in the field, which have been continuously applied during the cooperation on joint projects both within the ELTRIS project and the KONTIRAK project.

During our cooperation we have focused on applied research in the field of caprolactam refining. Thanks to their expertise and technological know-how, we were able to successfully fulfil the substantive content of the projects and achieve excellent results. Their approach to solving this problem was innovative and efficient, which enabled us to make significant progress in the field of caprolactam refining.

Overall, the cooperation with CEET-IET has been very beneficial and inspiring for us.“

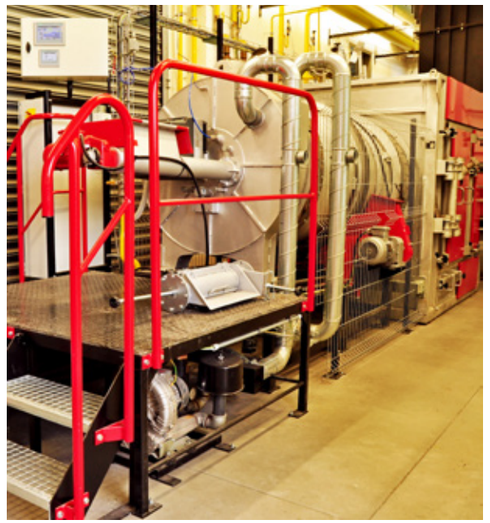
INCREASING THE EFFICIENCY OF NITROGEN OXIDE REDUCTION TECHNOLOGY

Partner **SMS CZ spol. s r.o.**
Field **Waste gas purification**

Most of the time, we all enjoy getting new things. What we don't always realise at this point is that the item will outlive its usefulness and that the question of what to do with it is still there. It is good news that our society is not indifferent to waste management issues and is trying to find effective ways to give real meaning to the concept of sustainability. The best solution is to return things to their original purpose, or to recycle the materials from which they are made efficiently. Such waste management is not possible in all cases. There are some wastes that cannot be recycled, such as hospital waste or many hazardous wastes from industrial production. We must not forget the waste that is generated during the recycling process itself and which cannot be used effectively. It is certainly not a good solution to landfill these wastes. Then there is still the option of using the waste for energy. Firstly, by doing so, we will get rid of their hazardous properties, effectively reducing their volume, in a short time and faster than the time it takes to generate them. In addition to these benefits of energy recovery technology, the process of thermal decomposition of waste releases much sought-after energy that can be used to generate electricity or heat.

SMS CZ, based in Rokycany, has been designing and manufacturing waste-to-energy equipment for several decades. Their products can be found not only in the Czech Republic, but also in many other European countries.

The company's business is highly influenced by the European Union's legislative framework in the field of environment and energy. The company must be able to respond quickly to new challenges. Cooperation with scientists from CEET-IET brings SMS CZ new solutions in the field of reducing emissions from energy recovery processes. The scientists even won a silver medal together at the patent exhibition in Katowice, Poland, for their solutions in the field of reducing the environmental burden in the energy processing of non-recyclable parts of car wrecks. The company has also been able to collaborate on projects where existing energy facilities replace fossil fuels with fuels based on waste products. A mobile waste-to-energy facility has been developed jointly, where the entire technology is housed in an easily transportable container. The plant can then be used in areas affected by natural disasters or where the infrastructure needed to build large-scale industrial complexes is not available.



PARTNER'S NOTE | **Petr Jirsa** | SMS CZ spol. s r.o.

„We have been cooperating with CEET-IET laboratories since 2013. We were very pleased that the institute's newly established laboratories chose our company as a supplier of waste-to-energy technology. From the beginning of our contact I was convinced that the cooperation would be long-term. Over a period of ten years, we have jointly tackled and successfully implemented five research projects and we have plans for the new ones. Our cooperation outputs have helped us in our business activities. We have gained new knowledge which is being applied in our production, making our new products more competitive and, above all, more environmentally friendly. At the same time, we cannot but boast that our joint outputs have won recognition from the professional community."

NEW TECHNOLOGY FOR WASTE GAS PURIFICATION BY ADVANCED OXIDATION PROCESSES

Partner **DEKONTA a.s.**
Field **Waste gas purification**

The main focus of the technologies commercially available nowadays for the degradation of undesirable compounds in waste air are adsorption on various types of materials, catalytic combustion or the use of biofilters. However, existing processes are generally burdened with a number of drawbacks. An important alternative to the technologies for the degradation of unwanted compounds is represented by so-called advanced oxidation processes, including the photochemical oxidation method. Compared to the most commonly used methods to date, the proposed process is convenient even for low concentrations of highly nuisance or highly toxic substances, both process-wise and economically.

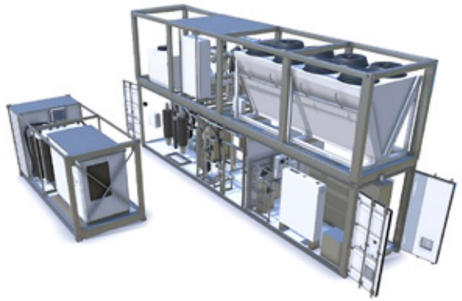
DEKONTA is one of the leading companies offering comprehensive environmental and waste management services on the Czech market, such as waste air treatment, emission elimination, waste water treatment and others.

The cooperation between CEET-IET and DEKONTA has produced remarkable outcomes. By using advanced oxidation processes, a semi-operational photochemical unit was developed and constructed, which was subsequently tested in the field of cleaning various types of waste air containing organic compounds, especially from groups of odorous substances. The device was tested in the polygraphic production plant of BN International in Česká Skalice, in the premises of Nuvia in Kralupy nad Vltavou, in the premises of Juta and in the real operation of the production of feed granules Nutrin in Dobruška. The results of the cooperation represent a significant step forward in the field of environmental protection. It also serves as an inspiration for other similar projects.

PARTNER'S NOTE | **Radim Žebrák** | Dekonta a.s.

„I would like to commend the excellent cooperation with CEET-IET in the field of waste gas treatment using advanced oxidation processes. This collaboration is a perfect example of a synergistic partnership between a scientific institute and an industrial entity to protect the environment and ensure sustainable development. I would like to express my appreciation to both parties for their efforts, expertise and commitment. Our cooperation demonstrates in practice that science and industry can work together to address key environmental challenges. I am confident that the collaboration will continue and contribute to further innovation and environmental improvement not only domestically but also globally."

USE OF HYDROGEN FOR ADVANCED ENERGY TRANSFORMATION



Partner **Veolia Energie ČR, a.s.**
Field **Energy**

Veolia Energie ČR is one of the largest producers and suppliers of heat in the Czech Republic and a major independent producer of electricity. The company offers innovative, environmentally friendly and smart energy production and supply solutions for residential buildings, industrial plants and commercial premises. They aim to optimise energy consumption and maximise the use of alternative sources to achieve cost savings.

The pilot project of the CEET-VEC and Veolia Energie ČR mutual cooperation is a proposal for a solution for the production of green hydrogen linked to a system for the production and storage of energy obtained from renewable sources (RES). The aim of the joint project is to produce green hydrogen for bus, train and freight transport using solar energy and biomass at existing sites of Veolia's heating complexes. The green hydrogen will be produced from surplus electricity produced from RES using the Power to Gas technology. The Power to Gas process is used to transform electrical energy into chemical energy bound in gases which can then be used as energy storage media or as feedstock for other industries.

The principle of this transformation process is, in the first stage, the production of hydrogen by electrolysis of water using a system of electrolyzers with a capacity of several MW. This will be followed by compression, storage and distribution. Another innovative technical solution will be the integration of a large-capacity battery storage system into the entire system. Putting these advanced technologies into practice is seen as an important step towards a transition to cleaner energy sources and help accelerate the region's energy transformation.

PARTNER'S NOTE | **Arnošt Gross** | Veolia Energie ČR, a.s.

„The cooperation with the research team at CEET-VEC in the area of preparation for the production of „green" hydrogen for energy purposes follows the focus and development strategy of our company Veolia Energie ČR, a.s. From this cooperation we expect a wider use of renewable energy sources and a positive benefit for our company. The introduction of advanced hydrogen technologies and their interconnection with thermal power plants is part of our vision for the transition to clean energy sources and the transformation of the region. There are a number of benefits to linking hydrogen production with existing district heating technologies, or supplementing it with additional renewable sources. For one thing, green hydrogen can be produced reliably all year round, but it can also provide the support services needed to balance fluctuations in the power grid."

COOPERATION ON EXPLOSION RISK ASSESSMENT

Partner **IHAS s.r.o.**
Field **Industrial safety**

Researchers at CEET-VEC have been dealing with industrial safety and fire and explosion risk assessment for more than 10 years. The main assets of our accredited workplace include high professionalism, acquired experience and especially independence. The research group involves leading experts from universities and research institutes.
IHAS has been active for more than 15 years in the field of occupational safety, especially in the field of industrial fire and explosion risk assessment. Its main attributes include high professionalism and independence backed by accreditation. It uses a top team of forensic experts, inspection bodies and university professional institutes to carry out its activities.

The concept of the CEET-VEC and IHAS cooperation usually consists of two main parts. The first takes place at the CEET-VEC laboratory and the second at the respective industrial plant. The laboratory part of the work is supervised by a technician who communicates the measured data to the company. Specially trained technicians and accredited systems have been selected to provide and enable interface with the corporate part. The primary task of any safety assessment case is to obtain adequate input data to perform a quantitative risk analysis of chemical processes. In addition, experimental measurements must be made in the laboratory tests. The aim of the collaboration is first to identify the risks of industrial technologies where flammable and explosive substances may occur and subsequently make recommendations to the public authorities and for the safe management of such operational risks. Subsequent objectives are the design of simulation models, the completion of a risks catalogue and the identification of appropriate measures to minimise them. In doing so, maximum emphasis is placed on the safety of the relevant industrial technologies, from the construction of the plant, through the storage of hazardous substances, to their operational use.

Explosion analysis of material data is used to determine or refine the risk analysis of an industrial plant and is carried out by forensic experts and inspection authorities. If a detailed data analysis is required, such as the method of determination depending on different conditions (e.g. to prepare the material for a specific use in the plant), this is a rather lengthy process. It requires the utmost attention and is often carried out wholly or largely by one person. Therefore, tools that allow the automation of blast tests, the quality of which increases with each additional case analysed, are currently in high demand. Especially in the last thirty years, since the need to improve working conditions for employees has become a priority for the European Commission.

PARTNER'S NOTE | **Ing. Tadeáš Podstawka, Ph.D.** | IHAS s.r.o.

„The use of specialised instruments for the study of explosion phenomena and flammability of materials is beneficial for the industrial sector as well as for forensic experts and inspection authorities. Cooperation with the laboratory at CEET-VEC which is the only facility in the Czech Republic allows to obtain key explosion parameters. Moreover, the explosion process can be applied to specific industry requirements that companies are concerned about and the result parameters can be further used to plan safety measures tailored to a specific customer.“

REDUCING MERCURY EMISSIONS

Partner **ČEZ, a.s.**
Field **Energy**

Laboratory at CEET-VEC is one of the leading laboratories in the Czech Republic dealing with emissions measurement. In recent years, in connection with the new European legislation, other flue gas components such as NH_3, HCl, HF, heavy metals and especially mercury have also been monitored. For these components, CEET-VEC staff have verified, accredited and applied continuous measurement methodologies to help optimise emission reduction technologies. In the field of mercury emission reduction solutions, the main industrial partner is the ČEZ Group.

The basic principle of CEET-VEC's successful cooperation with industry is the systematic building of partnerships with companies and the implementation of research activities for the needs of operational practice. The laboratories are equipped with modern infrastructure and instrumentation for the implementation of quality research and development with applicable results.

CEET-VEC in cooperation with ČEZ was the first entity in the Czech Republic to accredit a methodology for continuous measurement of mercury, which significantly helped to improve the monitoring of their emissions in flue gases. After the validation of the methodology, the research teams jointly verified other ones for reduction of mercury emissions in cooperation with ČVUT on test stands and in the existing ČEZ plants burning lignite coal. The comprehensively tested and recommended sorbents, both solid and liquid, based on our long-term tests and their results, help to significantly reduce mercury emissions and thus prepare plants for the stricter emission limits applicable from 2021 for newly built or reconstructed capacities.

ČEZ Group is the largest producer and supplier of electricity in the Czech Republic. It produces, distributes and sells energy to end customers. At present, ČEZ is working intensively with CEET-VEC to select and verify new and available technologies in order to meet new limits for emission components of heavy metals, especially mercury.

At the same time, ČEZ Group is preparing intensively for a shift away from coal and decarbonization as part of its Clean Energy of Tomorrow strategy. CEET-VEC is one of the partners cooperating with ČEZ prepare the construction of low-emission sources. These include steam-gas cycles, gas-fired boilers, biomass boilers, heat pumps, photovoltaic plants or electrolytic hydrogen production.

PARTNER'S NOTE | **Luděk Dušek** | ČEZ a.s.

„The cooperation with CEET-VEC has contributed significantly to address the issue of reducing the newly monitored harmful components in emissions from the thermal use of fossil fuels, in particular mercury emissions. Thanks to the long-term measurements carried out, the importance of introducing efficient DeHg technologies, tested on real ČEZ plants, was confirmed. The measures taken will contribute to achieve a higher degree of greening of our heat generation technologies by operating nowadays still extremely important energy units. An essential part of solving the emission reduction issue in cooperation with CEET-VEC are research projects focused on fossil and alternative fuel combustion processes. As an example of our successful cooperation, I would mention two joint projects: experimental tests of solid sorbents designed to reduce the concentration of Hg, HCl and HF in flue gases (2018-2020), TA CR THETA and Implementation of measures to achieve BAT in the energy sector (2019-2022), National centre for energy."

DEVELOPMENT OF MODERN BIOMASS BOILERS AND STOVES FOR HOME HEATING

Partner **ROMOTOP spol. s r.o.**
Field **Energy**
Environment

"If you can not measure it, you can not improve it." That is a famous quote from Lord Kelvin. At the CEET-VEC testing centre of combustion equipment we are professionally involved in the accredited measurement and evaluation of the heat sources. We dispose of measuring equipment with a high level of accuracy and experienced personnel. These are the basic prerequisites for successful research and development of new heat sources for home heating. The primary goal of our efforts is to develop equipment that delivers the same amount of heat energy with less pollutant production.

The CEET-VEC operates four dilution tunnels and measuring loops that allow testing of combustion plants with power ranging from units up to 500 kW. The unique calorimetric chamber allows to determine the heat output transferred to the space and is ideal for testing heavy duty storage stoves. Analyzer arrays allow us to measure pollutant emissions in both the basic (CO, TOC, PM) and extended ranges (PAHs, heavy metals, PCDD/F, PM10, PM2.5, PM1, particle number and size). The fuel analysis carried out in an accredited laboratory allows to determine the input parameters needed to optimise the combustion process. The test facility operates the combustion equipment at standardised conditions as well as at conditions close to real household operation depending on the need and the research objective.

Biomass is an imaginary accumulator of stored solar energy, which can be successfully converted into heat for heating our homes in winter. However, as the heat loss of heated homes decreases, the rated output of the household heat sources used (e.g. stoves and fireplace inserts) gradually decreases. This presents a technical problem that is almost reaching the limits of its solution. The way forward is therefore towards heat storage and optimisation of the combustion chamber, including combustion air distribution. It is not a problem to burn dry wood well, but it is not so easy to burn it slowly and with a lower heat output. If the primary measures described above are not sufficient, secondary measures are another possible solution. In this respect, we are intensively working on the development of electrostatic precipitators to reduce dust emissions as well as on the development of catalysts to reduce CO and NO_x emissions.

As a result of our research and development, we design better heat sources that consume less fuel while producing fewer pollutant emissions. We also systematically address another important element, which is the influence of the operator. Here too, we are working on permanent education and training for the operators of these heat sources.

PARTNER'S NOTE | **Dušan Smilek** | ROMOTOP, spol. s r.o.

„ROMOTOP began cooperating with the CEET-VEC researchers in the 1990s. Our founder has always placed great emphasis on the continuous development of new products with better parameters for the customer and with higher added value. Supporting research and development is one of the most essential and profitable investments in the prosperity and competitiveness of any successful company. In our case, we see that it also contributes significantly to supporting the material and energy sustainability of our country's economy. We are convinced that creative cooperation between production and research is mutually beneficial. The cooperation with CEET-VEC fully confirms this conviction. Its upward trend is illustrated by the successful results of two selected joint research projects, which I present as an example of exemplary cooperation: Low-emission local biomass-burning heater technology for nearly zero-energy homes (2021-2022), TREND - Subprogram 1 and TAP transport technology and catalysts for pollutant emission reduction (2023-2026), National centre for energy II.

DEVELOPMENT OF A SMART HYBRID HEAT SOURCE

Partner **BENEKOVterm s.r.o.**
Field **Energy**

CEET-VEC employees have been cooperating with BENEKOVterm on a long-term basis. This Czech company is now one of the leading European manufacturers of boilers for burning pellets, wood chips, shavings and wood industry offcuts. Its boilers with a heat output in the order of several units to hundreds of kW are used for heating family homes, schools and company buildings in more than 30 countries around the world.

A successful example of their mutual research cooperation was aimed at improving boiler efficiency parameters and reducing the amount of pollutant emissions in flue gases. The research agenda in a joint project „FV40307- Development of an intelligent hybrid heat source“ was implemented in the period 7/2019-12/2022 with the financial support of the Ministry of Industry and Trade of the Czech Republic under the TRIO programme. The innovative solution combines a heat pump and a pellet boiler. The uniqueness of this solution is to maximise the use of the strengths of both heat sources. The source control unit automatically selects either the independent operation of the heat pump or the pellet boiler, or their concurrence in relation to the input parameters which are the current prices of electricity (CZK/kWh) and wood pellets (CZK/t). The operation of this hybrid heat source is therefore automatically controlled so that the required heat (kWh) is produced at the possible lowest price while complying with all required emission limits.

In three and a half years CEET-VEC and BENEKOVterm teams have developed and tested three prototypes of the smart hybrid heat source with an output of 10, 25 and 90 kW. As the products are unique on the market and there is no methodology for the approval of hybrid sources yet, the individual sources have to be certified separately. Therefore, in parallel with the solution development, draft legislation for hybrid sources is being prepared in relation to the planned changes to the European Commission (Ecodesign) regulation.

By using this type of hybrid heat source, the operators can optimise and save annual operating costs, which is a crucial result for most of them. The CEET-VEC test facility is equipped with state-of-the-art measurement technology to determine the parameters needed to monitor and understand the processes taking place and allows to suggest improvements and thus optimise the cost of the heat produced.

PARTNER'S NOTE | **Leopold Benda** | BENEKOVterm s.r.o.

„We have been cooperating with CEET-VEC at VSB-TUO for more than 20 years. As customer demand changes, we have to adapt to new trends. Our constant investment in research and development and cooperation with technical and testing facilities of CEET-VEC has helped us to stay on the market for 30 years. The development of the hybrid heat source was very much in the right direction.

At the time we started developing the equipment, we had no idea that this solution would become a very popular trend for heat technology throughout the EU. As far as I know there are only two other European companies having developed a similar technology to ours. Currently we would like to follow up the project and further develop the know-how.“

PUBLIC EDUCATION ON HOME HEATING

Partner **Ministry of the Environment**
Field **Energy**
Environment

According to the data on the balance of pollutant emissions in the Czech Republic, approximately 20% of Czech households still heated with solid fuels produce more than 50% of all dust emissions and 95% of all carcinogenic benzo[a]pyrene emissions. According to dispersion conditions, these pollutant emissions can significantly deteriorate the quality of the air we breathe in winter. This is the main reason why many of CEET-VEC research activities focus on the area of pollution sources.

The official national inventory of pollutant emissions prepared for the Ministry of the Environment by the CHMI uses emission factors based on measurements of boiler emissions carried out in the CEET-VEC laboratories. Within the ARAMIS project we prepare emission factors for local heating systems (stoves, fireplace inserts, cookers and other local heating systems) based on our measurements. A good knowledge of real heating emissions enables us to prepare the basis for new and more effective remedial measures for the government.

When comparing the results of the emission parameters of the certification combustion tests of boilers and stoves carried out in our test room with the emissions measured on similar devices under real conditions (thousands of tests), it turns out that the parameters in real operation are significantly worse. Our primary goal is to reduce this difference. We strive to do this by actively participating in national and international projects in the following areas:

- modifications to the test house's measurement procedures (certification, new methods for dust determination - primary and secondary particles, product labelling procedures - beReal method);
- the design and implementation of new methodologies for measuring actual operational parameters in households;
- the use of tools to demonstrate the combustion of unsuitable fuels in an operating combustion device. Our proposed SEMAFOR methodology is part of the official methodology for state control authorities;
- education and training of operators and the general public (educational show SMOKEMAN hits the Ten Points of a Good Boilerman, according to the signed licensing agreement new videos will also be shown on CTedu Channel);
- education of public administration staff in the framework of the accredited training programme (AK/PV-276/2020) and preparation of the Ecological Heating Course.

A basic summary of SMOKEMAN's message is contained in the individual videos that have been created for each point of SMOKEMAN's Ten Points of a Good Boilerman and are available online:

PARTNER'S NOTE

Kurt Dědič

Ministry of the Environment of the Czech Republic

„Having succeeded in significantly reducing emissions from the large energy and industrial sectors, local heating with solid fuels in boilers and stoves is becoming a more monitored area worldwide. Their operation emits large amounts of hazardous substances into the air that cause serious illnesses and therefore needs to be minimised. High-quality science and research outputs are essential for effective policy setting and subsidy programmes. Over the years, CEET-VEC has built a reputation as a research facility that can deliver new knowledge in this field, and its work is valued abroad. In addition to research activities, it is not afraid to devote time and energy to education, which, although not as valued as measurable scientific outputs, is undeniably very necessary and effective. Since the influence of the operator on the emissions from wood or coal boilers and stoves is crucial, it is also important to convey this information in a way that people can understand, which is not always an easy task. It also requires a certain amount of creativity and playfulness, which the SMOKEMAN team certainly has.“

PORTFOLIO CEET

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