PRIORITY RESEARCH AREA OF THE
WARSAW UNIVERSITY OF TECHNOLOGY

ENERGY CONVERSION AND STORAGE

COOPERATION PROPOSAL

EXCELLENCE INITIATIVE
RESEARCH
UNIVERSITY

Warsaw University of Technology

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FOREWORD BY HEAD OF THE PRIORITY RESEARCH AREA

Professor Bartłomiej Ufnalski, Ph.D., D.Sc.
Head of the Priority Research Area: Energy Conversion and Storage

Nowadays, people still meet most of their energy needs with fossil fuels. This means that we make use of the very end of the energy conversion chain, which, of course, makes energy extraction not very efficient, and additionally has a negative environmental impact. An increasingly large proportion of the costs incurred in connection with fossil fuels are those related to human health, as smog is responsible for many of the health problems experienced by city dwellers. Fossil fuels are also problematic for security reasons – they make us dependent on countries that are rich in natural resources, such as oil, natural gas and coal. We should change it by switching as quickly as possible to renewable and/or zero-carbon energy sources, including nuclear power. At the same time, hydrogen could become one of the green energy carriers, alongside electricity.

Engineers are dreamers who make their dreams come true. We are constantly striving to achieve ambitious goals in terms of energy production at the earliest possible stages of natural conversion chains. Optimally, the greatest achievement would be nuclear fusion carried out on Earth, in power plants of the future. We are keeping our fingers crossed for ITER! Nevertheless, we already have a number of advanced technologies that enable us to convert energy into useful forms before photosynthesis takes place. These include nuclear power plants, photovoltaics and wind power plants. Farewell oil, coal and natural gas! The end of your era is coming.

Another set of technological breakthroughs needed to make the transition to renewables fully feasible addresses the problem of energy storage. Harnessing unstable energy sources should be accompanied by an increase in its storage capacity. Our transport systems also need mobile storage facilities with high energy density, efficient generation and sufficient durability to electrify at least the entire road and, in part, maritime and air transport system. We have already achieved many of these breakthroughs, with lithium-ion batteries as one of examples. However, more effort is needed to switch to such materials and chemical technologies for energy storage systems, which are abundant and available with little or almost no harm to humans and the environment.

Having said that, I would also like to highlight one key element of most (if not all) modern systems that rely primarily on electricity as a convenient means of energy transfer. Forgive my bias, which may be due to the fact that my previous academic work has been related to control systems in power electronics and drives. As you can guess, I believe that special preference should be given to power electronics. Modern civilisation is becoming dependent, in a good sense, on power electronic converters. Welcome, power electronics! A new era has begun.

Regardless whether you are an electrical engineer, a specialist in electromobility, a chemist, a physicist, a materials scientist, a specialist in control automation, an entrepreneur or any other individual involved in the development of more optimised energy conversion and storage systems, you should know that the Warsaw University of Technology has made research activity in this area one of its priorities. I have the pleasure of presenting you with a catalogue of our research teams who focus their efforts and put all their energy in the field of energy conversion and storage technologies. We are open to your business ideas and invite you to cooperate with us!

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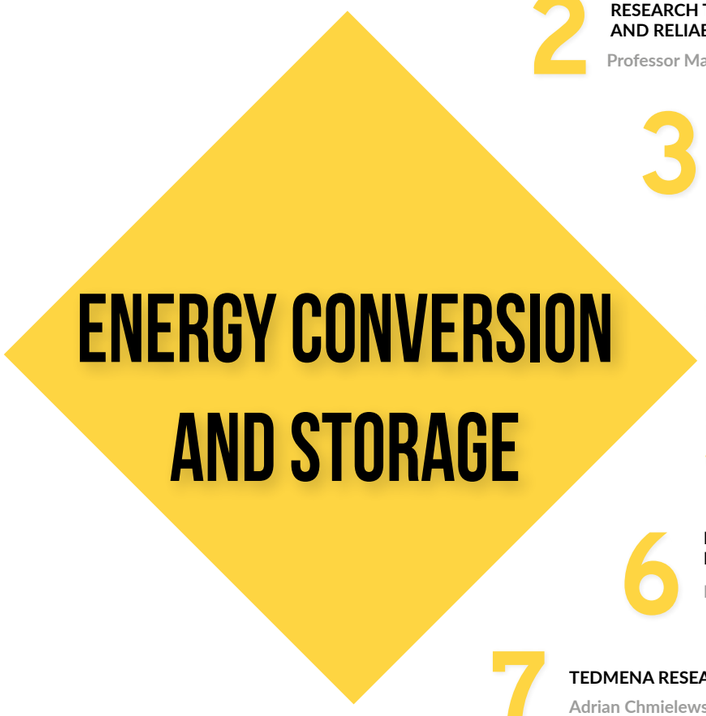

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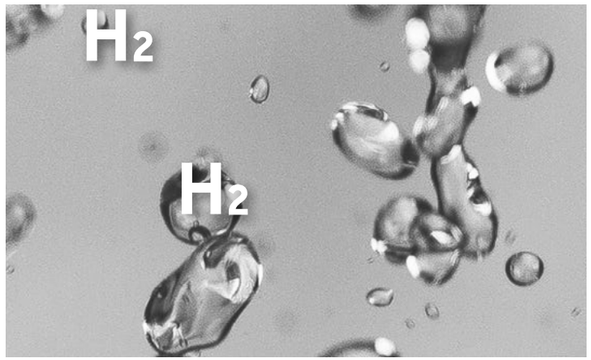
RESEARCH TEAM FOR

HYDROGEN AND FUEL CELLS

The research team is composed of employees of the Faculty of Power and Aeronautical Engineering and the Faculty of Materials Science and Engineering at the Warsaw University of Technology. In addition, our industrial partner is a spin-off company of the Warsaw University of Technology, Fuel Cell Poland.
Currently, the team is involved in several research projects and has the expertise to develop expert opinions and patent the solutions developed. Examples of the Team's clients include companies such as Orlen or Tauron, etc.



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AREAS OF COOPERATION WITH OTHER TEAMS

- Certification of fuel cells
- Certification of photovoltaic cells
- Certification of batteries
- Impedance measurements
- Gas composition measurements

#ELECTROLYSIS #SYNTHETIC FUELS #POWER-TO-GAS #CERAMIC FUEL CELLS #HYDROGEN CONVERSION
#MOLTEN CARBONATE FUEL CELLS #HYDROGEN STORAGE #FUEL CELLS #CO-ELECTROLYSIS #HYDROGEN

SELECTED PROJECTS

- Modular system based on Molten Carbonate Fuel Cells with tailored composite membranes designed for specific flue gas compositions oriented into CCS integration with an industrial power plant (POLNOR CCS2019, 2020–2023)
- High performance carbonate fuel cells (Applied Research Programme, NCBR – National Centre for Research and Development, 2015–2018)
- TENNESSEE: Development of an industrial design of carbonate fuel cells and ceramic electrolysers giving the possibility of integration into power-to-gas plants (Tauron Wytwarzanie, Power Engineering Sector Research Programme, NCBR, 2018–2023)
- New proton ceramic fuel cell (SOFC) model based on reduced parameters (OPUS, NCN – National Science Centre, 2017–2020)
- Innovative carbon-ceramic composite materials as CO_2 capture and utilisation technologies for sustainable energy (Polish-Taiwanese collaboration, NCBR, 2017–2020)

MAIN RESEARCH INFRASTRUCTURE

- High temperature fuel cell test bench
- Impedance spectroscopy test bench
- Gas chromatograph
- Optical microscope for surface analysis
- Controlled atmosphere furnace
- Ball mills
- Tape caster
- Vacuum mixers

SELECTED PATENTS

- System for carbon dioxide separation and fuel recirculation for MCFC cells, PL Patent Pat.236053, 2020
- Method for regenerating the electrolyte of a molten carbonate fuel cell, PL Patent Pat.234555, 2019
- Test bench for electrochemical measurements in molten salt environment under high-temperature conditions, PL Patent P.421492, 2019

SELECTED PATENT APPLICATIONS

- Cathode with multifunctional layer for Molten Carbonate Fuel Cells, PL Patent App. P.430869
- Sealing for high temperature fuel cells, PL Patent App. P.422085

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RESEARCH TEAM FOR

INTELLIGENT CONTROL GROUP AND RELIABILITY IMPROVEMENTS

#DISPERSED ENERGY SOURCES #RENEWABLE ENERGY SOURCES #WIND ENERGY #OCEAN WAVE ENERGY #QUALITY OF ELECTRICITY #ENERGY CONVERTERS #RELIABILITY OF ENERGY CONVERTERS #ENERGY CONVERSION TECHNOLOGIES #SIC, GAN SWITCHES #AC-DC, DC-DC, DC-AC ENERGY CONVERTERS #METHODS OF CONTROL AND DSP PROGRAMMING #ELECTROMOBILITY #POWER AND CONTROL SYSTEMS #FAST CHARGERS

The team composed of employees and students of the Faculty of Electrical Engineering at the Warsaw University of Technology implemented projects on energy conversion and storage in cooperation with industry representatives (e.g. APATOR, TRUMPF, TWERD, Wave-Dragon) and foreign research centres (e.g. Aalborg, Aachen, Doha, Taiwan). The works are focused on Power Electronic Building Blocks (PEBB). Such devices are very widely used.

Thanks to intelligent control software and communication modules, such as the 5G/6G network, they are ideal for domestic photovoltaic installations and charging stations. The Department of Industrial Electronics, headed by Professor Marek Jasiński, Ph.D., D.Sc., conducts research related to the control of AC-DC, DC-DC, DC-AC power converters, using modern silicon carbide (SiC) and gallium nitride (GaN) power electronic switches. Intelligent software ensures high power quality, efficient storage and control of energy flow.

SELECTED ACHIEVEMENTS

- Grade II Award of Rector of the Warsaw University of Technology, for Habilitation, 2020
- IEEE Young Professionals Hall of Fame Award for Industrial Electronics Society, 2019
- The first prize for scientific and technical achievements of the Prime Minister (Poland) in 2017 for modern power electronic converters for renewable energy sources and the mining industry, 2017

MAIN RESEARCH INFRASTRUCTURE

- Power electronics laboratories specialising in cutting-edge technologies for the conversion and storage of electrical energy
- Specialised power supplies emulating AC and DC renewable energy sources, e.g. PV, wind turbines, hydro turbines
- High-quality measurement equipment, e.g. oscilloscopes, power analysers, calorimetric chamber, current and voltage probes
- Simulation environments, e.g. SABER, Matlab, Plecs
- Systems for rapid prototyping and HiL testing, e.g. dSPACE

SELECTED PROJECTS

- Power converter module for a universal (AC-DC, DC-AC, DC-DC) fully modular power conversion system using cutting-edge wide--bandgap power switch (SiC/GaN) and communication (5G/6G) technologies (ENERGYTECH-1, Warsaw University of Technology, 2020–2022)
- Smart Integrated Modular Energy System – power electronic building blocks for DC microgrids with renewable generation and energy storage – SIMES (Mazovian Track, NCBR, 2020–2023)
- High efficiency and high-power density bidirectional DC-DC converters – HPBCEV (7TH bilateral Polish-Taiwanese bilateral conquest 2019, NCBR, 2020–2023)
- Smart multilevel Power conditioning for AeRonautical elecTricAl uNits – SPARTAN (H2020 EU, 2019–2022)

SELECTED PUBLICATIONS

- Baba S., Bachman S., Jasinski M., Li H., Evaluation of Modular Power Converter Integrated with 5G Network (2021), Energies, 14, 7355, DOI: https://doi.org/10.3390/en14217355
- Piasecki S., Zaleski J., Jasinski M., Bachman S., Turzyński M. (2021), Analysis of AC/DC/DC Converter Modules for Direct Current Fast-Charging Applications, Energies, 14(19), 6369, DOI: https://doi.org/10.3390/en14196369
- Baba S., Gieraltowski A., Jasinski M. T., Blaabjerg F., Bahman A. S., Zelechowski M. (2020), Active Power Cycling Test Bench for SiC Power MOSFETs – Principles, Design and Implementation. In: IEEE Transactions on Power Electronics, DOI: 10.1109/TPEL.2020.3018535

SELECTED PATENTS

- AC-DC Grid converter control method with bidirectional energy flow, PAT.226667, 2016
- Control circuit of AC-DC-AC converter, PAT.223775, 2014

AREAS OF COOPERATION WITH OTHER TEAMS

- Advanced control methods for power converters
- Compensation of the impact of grid voltage collapses on power converter operation
- Minimisation of the negative impact of power electronic equipment on the power system
- Modelling the reliability of power electronic equipment
- Control of AC-DC, DC-DC, DC-AC power converters
- Conducting interdisciplinary research and didactic projects in the field of energy generation from RES (e.g. PV, off-shore wind and wave farms)
- Integration of dispersed energy sources into the system

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RESEARCH TEAM FOR

DETONATIVE PROPULSION SYSTEMS

Members of the Team conduct research related to gas detonation and its application in aerospace propulsion design and other stationary applications. The research carried out has been documented by numerous publications in this area over the last 15 years.
These have been mainly related to basic research on rotating detonation, as well as its application to aerospace and rocket propulsion systems. Numerous projects related to this subject-matter have been carried out during this time.

AREAS OF COOPERATION WITH OTHER TEAMS

- Combustion and detonation
- Application of rotating detonation to propulsion systems
- Application of rotating detonation for the construction of green hydrogen-based generators

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#DETONATIVE PROPULSION #BASIC DETONATION RESEARCH #ROTATING DETONATION #METHANE #HYDROGEN #BIOGAS #GAS DETONATION

SELECTED PROJECTS

- Experimental study of a combustion chamber with rotating detonation to drive a gas turbine (SONATA, NCN, 2013–2016)
- Turbine engine with detonation combustion chamber (Innovative Economy Operational Programme, Ministry of Regional Development, Institute of Aviation, 2010–2014)
- Experimental research on rotating detonation in a hybrid mixture-fuelled chamber (own project, NCN, 2009–2012)
- Numerical simulations of the detonation process in a rotating detonation engine (Poland-Singapore bilateral cooperation, NCBR, 2006–2009)
- Model tests of a jet engine with continuous detonation combustion (own project, Ministry of Science and Computerisation, 2005–2008)

MAIN RESEARCH INFRASTRUCTURE

- Detonation tubes
- Kistler high-speed sensor kit, PCB
- NI measurement modules (USB, PXI)
- Proprietary software for data acquisition

SELECTED PUBLICATIONS

- Kindracki J., Wacko K., Woźniak P., Siatkowski S., Mężyk Ł. (2020), Influence of Gaseous Hydrogen Addition on Initiation of Rotating Detonation in Liquid Fuel–Air Mixtures. Energies. 13(19), 5101, DOI: https://doi.org/10.3390/en13195101
- Kindracki J., Siatkowski S., Łukasik B. (2020), Influence of Inlet Flow Parameters on Rotating Detonation. AIAAJ, 58(12), 5046–5051, DOI: doi/abs/10.2514/1.J058152
- Kindracki J. (2015), Experimental research on rotating detonation in liquid fuel–gaseous air mixtures. Aerospace Science and Technology, 43, 445–453, DOI: http://dx.doi.org/10.1016/j.ast.2015.04.006
- Kindracki J. (2014), Study of detonation initiation in kerosene–oxidizer mixtures in short tubes. Shock Waves, 24, 603–618, DOI: 10.1007/s00193-014-0519-2
- Kindracki J. (2013), Analysis of the experimental results of the initiation of detonation in short tubes with kerosene oxidizer mixtures. Journal of Loss Prevention in the Process Industries, 26, 1515–1523, DOI: 10.1016/j.jlp.2013.09.003
- Kindracki J., Wolanski P., Gut Z. (2011), Experimental research on the rotating detonation in gaseous fuels–oxygen mixtures. Shock Waves, 21, 75–84, DOI: 10.1007/s00193-011-0298-y
- Hu M., Xiaosong W., Kindracki J., Chenglong Y., Li D. (2016), Three-Dimensional Numerical Simulation of Rotating Detonation Engine with Separate Injection. Journal of Combustion Science and Technology, 22(1), 9–14 (in Chinese)

#POWER SOURCES #ENERGY SOURCES #CELLS #BATTERIES #ELECTROLYTES #ELECTRODES #ENERGY STORAGE

4

RESEARCH TEAM FOR

ENERGY STORAGE AND CONVERSION

MAIN RESEARCH INFRASTRUCTURE

- Drybox – M-Braun (purity class: < 1ppm H_2O) including crimping tool for CR2032 cells
- DSC (differential scanning calorimeter) –TA Q200 by TA Instruments – for phase transition testing
- VMP3 – multichannel potentiostat by Bio-Logic
- Spectrometers: FT-IR and Raman
- Automatic film applicator – a device for the production of thin film
- Vacuum dryer with vacuum controller – for post-drying and purification
- Cryostat (temperature range -30°C to 80°C)
- Cycler for cell testing – multi-channel equipment

The Research Team for Energy Storage and Conversion (formerly the Polymer Ionics Research Group) has been working for years on ways to store energy in lithium-, sodium-ion and Li-S cells.
The Team has extensive experience in the synthesis of new materials (salts, additives, specialised solvent mixtures, etc.). Both electrolytes and electrodes are developed and tested according to the procedures developed by the Team. Also, cell systems are developed for application under the required conditions (e.g. temperature). A wide range of materials (including those environmentally friendly ones) allows the Team members to tailor the system to specific needs. Another area of the Team's activity is the development and testing of coin cells (type CR2032). The team can be a partner in the development of new systems. Members of the Team have obtained numerous patents and have authored numerous publications in the field of energy storage.

SELECTED PROJECTS

- ASTRABAT (Horizon 2020, EU, 2020–2023)
- BIG-MAP (Horizon 2020, EU, 2020–2023)
- MOGLiS (M-ERA.NET2, NCN, since 2020)
- and others

SELECTED PATENTS

- Salts for electrolytes for galvanic cells, preferably lithium-ion and sodium-ion cells and method of obtaining them, PL232856, 2019
- Mixtures of organic solvents, in particular for galvanic cells and galvanic cells electrolytes, PL232931, 2019
- Solvent mixtures for industrial applications, especially in galvanic cells, use of solvent mixtures for making electrolytes, and electrolytes for galvanic cells, PL232679, 2019
- Salts for electrolytes for galvanic cells, preferably lithium-ion cells and method of obtaining them, PL227209, 2017
- Salts for electrolytes for galvanic cells, preferably lithium-ion cells and method of obtaining them, PL 230305, 2018
- Method of obtaining cathode material $LiNi_{0,6}Mn_{0,2}Co_{0,2}O_2$, PL238688, 2019
- Sel d'anion pentacylique et son utilisation comme electrolyte, FR2935382
- Pentacyclic anion salt and use thereof as an electrolyte, WO2010023413, CN102264926 (2014-06-25), EP2334831 (2015-01-06), JP5469668 (2015-01-06), US8927160 (2015-01-06)

AREAS OF COOPERATION WITH OTHER TEAMS

- Development of new energy sources for portable devices or implants
- Research on new materials for energy storage
- Research on the use of new cell systems for diagnostic devices, e.g. those operating at extremely low temperatures
- Research on cells made of significantly less toxic or hazardous materials aimed at protecting patients and the environment

The Team is willing to partner with all entities looking for stable and reliable power sources for their equipment.

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RESEARCH TEAM FOR

UNMANNED HELICOPTERS

#HELICOPTER #UNMANNED AERIAL VEHICLE #CONTROL #AUTOPILOT #ELECTRIC PROPULSION #ENERGY OPTIMISATION #NAVIGATION #FLIGHT MANAGEMENT SYSTEMS

AREAS OF COOPERATION WITH OTHER TEAMS

- Modelling the movement of aircrafts (both manned and unmanned)
- Navigation
- Automatic control
- Electric and hybrid propulsion system

The Research Team for Unmanned Helicopters has expertise in the dynamics, aerodynamics and modelling of aerial vehicle motion (manned and unmanned, as well as other aircrafts), automatic control, navigation, actuator systems, flight path planning and electric propulsion.

The Team is composed of employees of the Department of Automation and Aeronautical Systems of the Faculty of Power and Aeronautical Engineering of the Warsaw University of Technology (WUT) and the Department of Electrical Propulsion of the Faculty of Electrical Engineering (WUT). The Team has been constantly expanding knowledge and skills during the implementation of numerous successful research projects.

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SELECTED PROJECTS

- Optimisation of energy consumption of an unmanned electric helicopter during take-off, en-route and during landing (HELINERGY) (ENERGYTECH-2, Warsaw University of Technology, 2021–2022)
- Modification of an optionally piloted helicopter for maritime mission performance (HELIMARIS) (NCBR, INNOLOT, 2017–2020)
- Affordable Digital Fly-By-Wire Control System for Small Commercial Aircraft (ADFCS II) (5th Framework Programme, EU, 2002–2004)
- New Aircraft Concepts Research (NACRE) (6th Framework Programme, EU, 2005–2009)
- New Track Integrated Electrical Single Flap Drive System (NEFS) (6th Framework Programme, EU, 2007–2011)
- Novel Innovative Competitive Effective Tilt Rotor Integrated Project (NICE-TRIP) (6the Framework Programme EU, 2006–2013)
- Advanced Cockpit for Reduction of Stress and Workload (ACROSS) (7th Framework Programme, EU, 2013–2016)
- Methodology for the synthesis of an aircraft control system taking into account high-risk situations (MYSTERY) (PBS, NCBR, 2013–2016)
- Optimization of Unmanned System of Systems (OpUSS) (Lockheed Martin, 2013–2015)
- Fuel cell hybrid propulsion of light aircraft (PBS, NCBR, 2015–2018)

MAIN RESEARCH INFRASTRUCTURE

- Complete unmanned helicopters
- Navigation sensors (GPS/INS, magnetometers)
- Control computers, autopilots
- Special software for helicopter movement simulation: FLIGHTLAB
- Matlab/ Simulink software
- Access to airport in Przasnysz (Mazowieckie Voivodeship)
- Access to wind tunnels
- Access to electric propulsion research laboratories

6

RESEARCH TEAM FOR

ADVANCED CONTROL METHODS FOR ELECTRIC DRIVE SYSTEMS

#ELECTRIC DRIVE #POWER ELECTRONICS #ELECTRIC VEHICLES #DRIVE CONTROL #ELECTRIC MOTOR #GENERATOR #HYBRID VEHICLES #VECTOR CONTROL #SERVO DRIVE

MAIN RESEARCH INFRASTRUCTURE

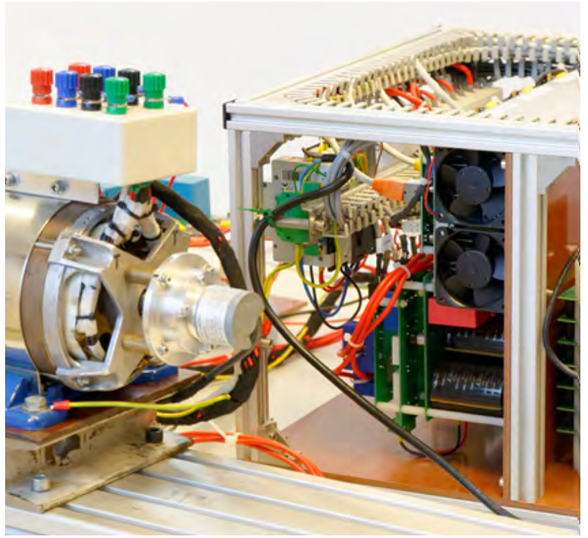
- Electrical propulsion laboratory of the Faculty of Electrical Engineering at the Warsaw University of Technology
- Hardware-in-the-loop platform for the analysis of converter systems
- Digital oscilloscopes with current probes up to 150 A and 1 kV insulated voltage probes

The Team is carrying out research and development works on specialised drive systems. It boasts achievements in the design of advanced control methods for drive systems, including state vector coupling controllers, neural controllers, fuzzy controllers or non-linear controllers. In addition, it has extensive experience in the design of specialised electric motor drive systems, including electric machines, power electronic converters, measurement systems and microprocessor controllers. The Team's particular area of interest entails electric vehicle drive systems.

In recent years, the members of the Team have carried out R&D projects related to the development of the propulsion systems of urban electric vehicles and missile control surfaces.

SELECTED PROJECTS

- ECO-Mobilność [ECO Mobility] (Innovative Economy Operational Programme, NCBR, 2009–2014)
- Development of control actuation system technology for missiles (Programme for national defence and security, NCBR, Mesko, 2017–2019)



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AREAS OF COOPERATION WITH OTHER TEAMS

- Development of propulsion systems for electric vehicles
- Development of control algorithms for multi-motor electric and hybrid vehicles (e.g. torque distribution management, control of braking forces, control of drive wheel slip)
- Development of specialised drive systems for special applications (e.g. unusual component sizes required, special operating conditions, etc.)
- Development of control systems for non-standard drive motors (e.g. 2/6-phase machines, linear motors, reluctance motors, etc.)
- Development of drive systems with required high control precision or high control dynamics (e.g. positioning heads, aerodynamic rudders, numerical control machine tools, electric actuators)

The Team would like to establish cooperation with companies in the private and military sectors looking for support in own product development, as well as the development of new solutions.

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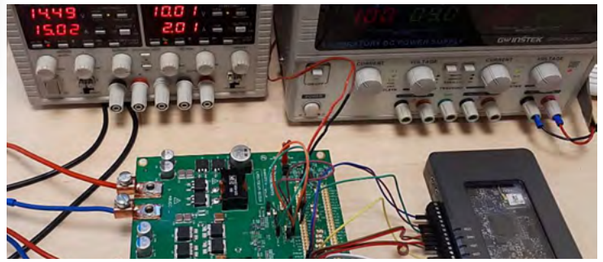
RESEARCH TEAM

TEDMENA – RESEARCH TEAM FOR DATA MINING TECHNIQUES IN ENERGY STORAGE AND ALTERNATIVE DRIVES

#HYBRID ENERGY STORAGE #DUAL CONVERTERS #AUTOMATED TESTING AND VALIDATION SYSTEMS #DATA MINING #EXPLOITATION RESEARCH #TESTING AND VALIDATION #MACHINE LEARNING #ALTERNATIVE DRIVES #ALTERNATIVE ENERGY SOURCES



The Team is composed of employees of the Faculty of Automotive and Construction Machinery Engineering and the Faculty of Mechatronics at the Warsaw University of Technology. A strategic partner of the Team is the Polish Alternative Fuels Association. As regards energy storage and conversion techniques, the team also cooperates with the Faculty of Power and Aeronautical Engineering at the Warsaw University of Technology, the Institute of Energy in Warsaw, the Centre of New Technologies at Warsaw University and the WWF Poland Foundation.

The Team's main areas of research interest include: data mining techniques in energy storage and alternative drives, automatic data acquisition, processing and aggregation systems, and alternative, zero-emission sources of electricity.

Currently, the team is implementing a project as part of the ENERGYTECH-1 POB competition at the Warsaw University of Technology, entitled "Experimental research and modelling of hybrid energy storage for vehicle powertrain and distributed generation systems using adaptive, analytical and learning methods". The researchers involved in the project include: Adrian Chmielewski, Ph.D., Krzysztof Bogdziński, M.Sc., Jakub Możaryn, Ph.D. (Institute of Automatic Control and Robotics, Warsaw University of Technology) and Professor Piotr Piórkowski, Ph.D. The methodologies used in projects include Agile and PRINCE2.

MAIN RESEARCH INFRASTRUCTURE

- Proprietary test benches for energy storage components and alternative propulsion systems
- Climatic chamber with a volume over 1.5 m^3
- NI equipment (cDAQ, measuring modules, etc.)
- Texas Instruments, Siemens controllers, SCADA etc.
- Specialised software: Matlab, R, C/C++, JAVA, JavaScript, LabVIEW, ANSYS, LS DYNA, Python, CATIA, SolidWorks

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SELECTED PUBLICATIONS

- Chmielewski A. et al. (2016), Aspects of balanced development of RES and distributed micro cogeneration use in Poland: case study of a μCHP with Stirling engine. Elsevier Renewable & Sustainable Energy Reviews, 60, 930–952
- Chmielewski A., Możaryn J., Piórkowski P., Dybała J. (2021), Comparison of hybrid recurrent neural networks and dual-polarization models of valve regulated lead acid battery. International Journal of Energy Research, 45/2, 2560–2580
- Piórkowski P., Chmielewski A., Bogdziński K., Możaryn J., Mydłowski T. (2018), Research on Ultracapacitors in Hybrid systems: Case Study. Energies, 2018, 11, 2551
- Chmielewski A., Możaryn J., Piórkowski P., Bogdziński K. (2018), Comparison of NARX and Dual Polarization models for estimation of the VRLA battery charging/discharging dynamics in pulse cycle. Energies, 2018, 11(11), 3160
- Chmielewski A., Gumiński R., Bogdziński K., Szulim P., Mączak J., Możaryn J., Piórkowski P. (2019), Model based research on electrochemical battery connected with 3 diodes model of PV module – selected properties. International Journal of Structural Stability and Dynamics, 19/5, 1941005
- Chmielewski A., Gumiński R., Mączak J. (2017), Selected properties of the dynamic model of the piston–crankshaft assembly in Stirling engine combined with the thermodynamic submodel. International Journal of Structural Stability and Dynamics, 17/5, 1740009 (25 pages), DOI: http://dx.doi.org/10.1142/S0219455417400090

SELECTED ACHIEVEMENTS

- Implementation in Prosperita's in-house operations of modular systems based on phase change materials in Camper electric vehicles, 2018

AREAS OF COOPERATION WITH OTHER TEAMS

- Hybrid energy storage systems for alternative propulsion and distributed generation systems

SELECTED PROJECTS

- Preparation of a publication on available and future forms of energy storage (WWF Poland Foundation, 2019–2020)
- Experimental research and modelling of hybrid energy storage for applications in vehicle propulsion and distributed generation systems using adaptive, analytical and learning methods (POB ENERGYTECH-1, Warsaw University of Technology, 2020–2021)
- An original system of social housing (Regional Operational Programme of the Małopolska Voivodeship, EU, 2016–2018)

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RESEARCH TEAM FOR

ELECTRICAL ENERGY CONVERSION AND MANAGEMENT

#ELECTRICITY CONVERSION #POWER ELECTRONIC CONVERTER #POWER QUALITY
#RENEWABLE ENERGY SOURCES #ELECTRICITY STORAGE #PROSUMER APPLICATIONS
#SMART GRID #DC MICROGRID #POWER ELECTRONIC/HYBRID TRANSFORMERS

The Team is composed of employees of the Department of Industrial Electronics of the Institute of Control and Industrial Electronics at the Faculty of Electrical Engineering of the Warsaw University of Technology. The Team focuses on control and modulation in multilevel power electronic converters single- and multi--phase, resistance of power electronic systems to disturbances in the power grid, power electronic couplings between renewable energy sources, energy storage and fuel cells and the power grid, power quality improvement systems and power electronic/hybrid transformers.

Over the past 10 years, the Team has carried out more than a dozen research projects, including projects conducted in collaboration with international entities. The subject matter and scope of the basic research conducted is related to the current problems and challenges posed by the development of civilisation and technology on the one hand, and the growing environmental awareness of society on the other. The Team's aim is to ensure that the developed solutions meet market needs and respond to the problems faced by entrepreneurs.

The fact that, in the vast majority of cases, the solutions find application in industry, helping companies grow, is a good measure of their success. These solutions, developed by the Team and implemented in production, have been repeatedly recognised and awarded by independent entities and institutions. These have included the Team's own solutions as well as R&D work commissioned by companies. The Team can provide solutions that meet specific standards and are ready to be implemented in the production process. It can also help raise funds to finance R&D work.

In addition to conducting cutting-edge research, the Team's aim is to provide high-quality education at all levels. Each diploma dissertation concerns research currently conducted or is prepared as part of an ongoing project. As a result, students acquire the knowledge and competences currently required on the labour market. More than 90% of graduates take up employment within three months of completing their studies, and their skills are highly valued by employers. An additional measure of the Team's success in the field of education is that the authors of supervised dissertations frequently win competitions for the best dissertations organised by such companies as ABB or Siemens.

SELECTED PROJECTS

- SMARTGYsum – Smart and Green Energy Systems and Business Models (Horizon 2020, EU, 2021–2025)
- SPARTAN: Smart multilevel Power conditioning for AeRonauTicAl electrical uNits (Horizon 2020, EU, 2019–2022)
- Universal current control algorithms for power electronic AC/DC grid converters resistant to intrinsic and grid voltage disturbances (OPUS, NCN, 2019 –2022)
- Highly efficient and fault tolerant SiC-based smart transformer in distributed energy systems (TEAM--TECH, FNP- Foundation for Polish Science, 2016 –2020)

SELECTED IMPLEMENTATIONS

- Comprehensive power quality conditioning system with energy storage for low-voltage distribution grids and electric vehicle charging stations (NCBR, Fast Track, 2020–2022)
- Modular power electronics system for sustainable renewable energy management with storage function for household and industrial applications (NCBR, Fast Track, 2017–2020)
- A series of high-frequency bipolar power supplies based on silicon carbide elements with increased resistance to grid faults and a regulated output voltage waveform (NCBR, INNOTECH III, 2014–2017)
- Series of 3-level, bidirectional 3.3 kV medium-voltage AC-DC-AC converters of 0.5-2 MVA capacity for applications in the mining industry (NCBR, INNOTECH III, 2014–2016)

AREAS OF COOPERATION WITH OTHER TEAMS

- Energy storage: mechanical, electrochemical and chemical energy storage and its integration into the power grid
- Power electronics systems for hydrogen generation technology and electricity production from hydrogen
- Power quality conditioning systems
- Prosumer functionalities for RES and energy storage
- Integration of fuel cells into the electricity grid
- Distributed generation of electricity including smart grid
- Management of power flow in power electronics systems integrating RES, energy storage and fuel cells with the power grid, including DC microgrids

The team would like to establish cooperation with companies in the private and military sectors looking for support in own product development, as well as the development of new solutions.

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#ELECTRICITY CONVERSION #POWER ELECTRONIC CONVERTER #POWER QUALITY
#RENEWABLE ENERGY SOURCES #ELECTRICITY STORAGE #PROSUMER APPLICATIONS
#SMART GRID #DC MICROGRID #POWER ELECTRONIC/HYBRID TRANSFORMERS

MAIN RESEARCH INFRASTRUCTURE

State-of-the-art converter theory laboratory, equipped with:

- bi-directional power grid simulators up to 45 kVA
- controllable direct current sources (max: 800 V, 54 kW, 300 A) with the possibility of simulating energy storage and RES
- multi-channel current and voltage parameter analysers (Fluke, Yokogawa, etc.)
- thermal imaging cameras
- precision high-frequency probes (up to 150 A, up to 1000 V)

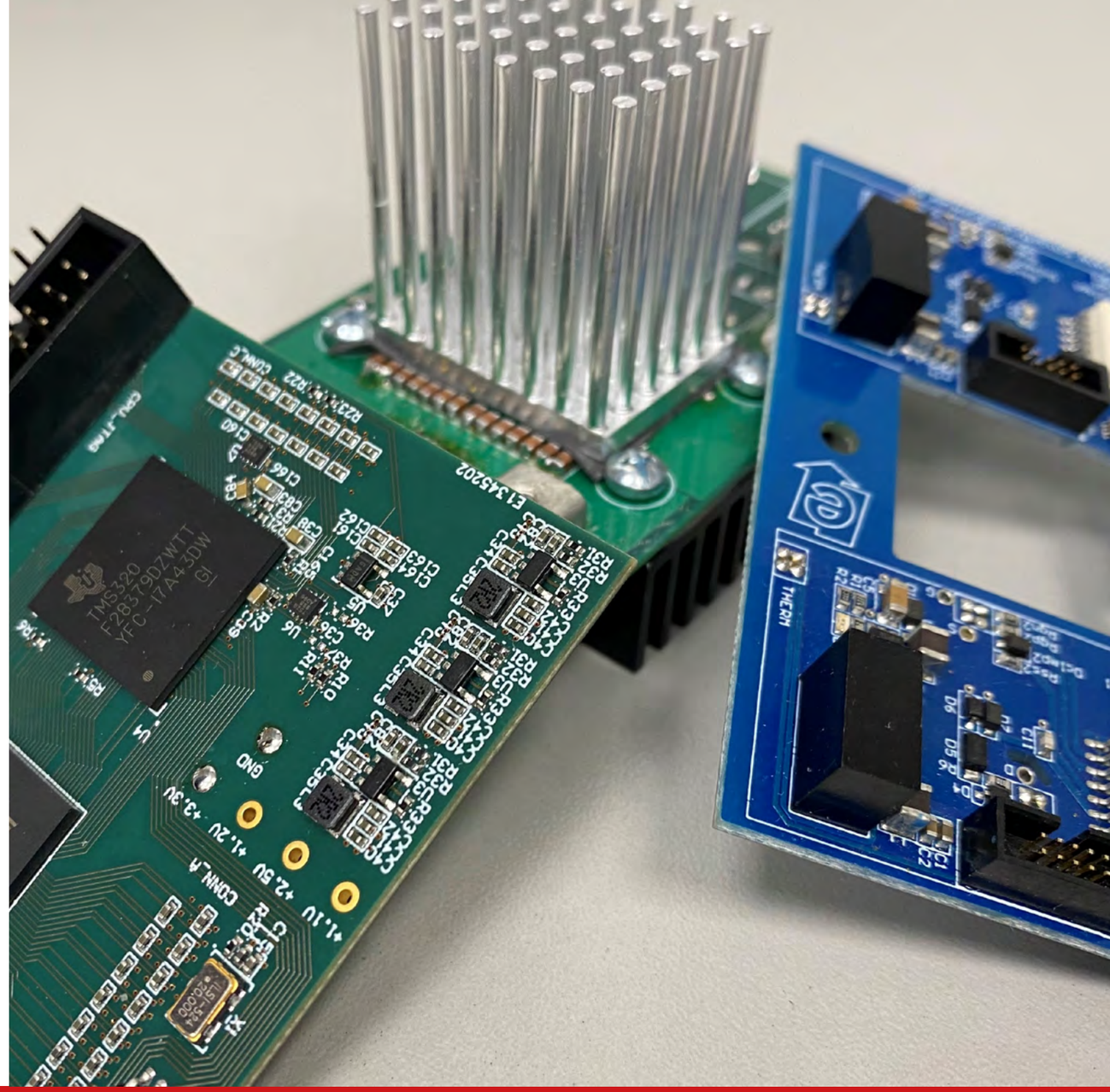
INDIVIDUAL AWARDS

- Istvan Nagy Award outstanding contribution to the development of issues related to control in power electronics, Professor Mariusz Malinowski, Ph.D., D.Sc., 2020
- IEEE IES David Bimal Bose Award for Industrial Electronics Applications in Energy Systems, Professor Mariusz Malinowski, Ph.D., D.Sc., 2015
- 3-year scholarship (2014–2017) of the Minister of Science and Higher Education for outstanding young scientists, Sebastian Styński, Ph.D., 2014

SELECTED ACHIEVEMENTS

Implementation of original methods of modulation and control of power electronic converters in industry, awarded with:

- 1st Team Prize of the Prime Minister for a scientific and technical achievement, 2017
- Team Scientific Award of the Warsaw University of Technology for outstanding achievements resulting in the transfer of scientific and technical research results to the economy, 2015
- Special Award in the 18th edition of the Polish Product of the Future Competition, 2015
- Special award of the Minister of Economy “eCO_2 innovation”, 2015
- Nomination for the Polish Promotional Emblem “Teraz Polska”, 2013
- Special Award of the Polish Agency for Enterprise Development in the 15th edition of the “Polish Product of the Future” competition, 2012



Priority Research Area of the Warsaw University of Technology
ENERGY CONVERSION AND STORAGE
Cooperation Proposal

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