Description of the specialization

I. GENERATION OF ENERGY

1. Combined generation – cogeneration, trigeneration, polygeneration
    - Technologies improving the effectiveness and flexibility of operation of combined generation installations and new methods of combined generation of energy
    - Adjustment of combined systems to the use of new fuels or fuels with worse quality parameters
    - New or combined technologies to use waste or low-temperature heat formed as a result of technological or technical processes
2. High-temperature nuclear reactors
    - Development and implementation of technologies of high-temperature nuclear reactors to produce industrial heat
    - Production of industrial heat for the industry and cogeneration using high-temperature nuclear reactors
3. Clean coal
    - New or improved technologies to produce electricity from coal, increasing the effectiveness and/or minimising emission of pollutants and a need to store combustion by-products as well as the use of coal gasification technology for the chemical production
    - Use of technologies to exploit methane from coal deposits, also at the pre-exploitation stage of the coal mine
4. Solutions improving the life of energy machinery and equipment and reducing noise
    - New technical and material solutions improving the life of energy machinery and equipment. New or improved methods to monitor, predict and analyse the technical condition of energy machinery and equipment, also using SHM (Structural Health Monitoring)
    - Reduction of noise and vibrations accompanying energy generation processes.
    - New or improved methods and systems monitoring parameters inside energy boilers.
    - New solutions improving technical possibilities of controlling the operation of energy boilers.
    - New solutions improving the quality of electricity.
5. Improving the effectiveness of energy conversion
    - New or improved methods to enhance the efficiency or flexibility of energy

generation.
    - Use of waste, low-temperature heat and other forms of dissipated energy, including the energy-related use of noise and vibrations.
    - Optimisation of energy generation and use through modern systems of control and monitoring – energy management systems.
    - Use of new energy conversion forms or methods (e.g. Energy Harvesting).
    - Increasing the use of energy-efficient drives (IE2, IE3, IE4) to reduce the energy intensity of the industry
6. Improving quality parameters of fuels
    - New or improved methods to enhance the calorific value of fuel parameters
    - Monitoring changes of quality parameters of fuel in real time.
    - New methods allowing to maintain assumed fuel parameters in real time.
    - New methods to regenerate solid and liquid fuels not meeting quality requirements.
7. Fuel cells
    - New technologies to produce electricity (also in combination) with the use of fuel cells (for mobile or stationary uses).
    - Construction of new hybrid systems with the use of fuel cells.
    - New or improved fuel cells.
8. Advanced diagnostics of power units
    - New diagnostic methods for pressure and rotary units
    - Technologies of non-destructive tests
    - Monitoring of power unit parameters using new measurement methods.
9. Energy production control systems
    - New devices and IT systems to control power units
    - New or improved technologies and systems to support the design of power installations.
    - New or improved maintenance support systems.

II. SMART GRIDS

The area includes solutions to improve the effectiveness, certainty of power supply and safety of the operation of transmission and distribution grids. It covers the issues of grid traffic, protection of individual elements and the whole grid from malfunctions, with the particular consideration given to blackouts, the issue of energy efficiency and loss reduction, proper integration and management of dissipated sources in the grid as well as other tasks related to management of demand and implementation of new methods to balance loads and regulate voltage and other quality parameters of electricity and the issues related to the IT protection of the grid (cybersecurity). Achieving the high level of grid smartness is possible through the use of smart measurement techniques, control methods and applicable IT tools, including effective

and safe solutions and ICT means.

1. Smart solutions in power grids
    - Smart protection and restitution automatic equipment in power systems
    - Smart tools used to optimise the operation and to control transmission and distribution grids
    - Smart systems to support operator decisions
    - Smart and adaptive measurement and decision-making systems for the purposes of Smart Grids
    - Systems of automation and extensive protection of transmission and distribution grids, including with the use of WAMS, FACTS, HVDC systems, etc.
    - Smart systems to identify the island operation and resynchronisation with the power system
    - Virtual power plants and their use to regulate the operation of the power system
    - Means, methods and algorithms to manage the demand for electricity (Demand Side Response, Demand Side Management)
    - Energy interfaces of many energy carriers, their feeding and metering
    - Integration of dissipated energy sources and energy storages into the power system
    - Smart management of dissipated resources
    - Methods and means to improve the energy efficiency and to reduce losses of energy in transmission and distribution grids, including products, services and engineering tools
    - Integration of power grids, ICT grids and IT systems forming smart grids
    - Development of methods and algorithms to predict insolation and windiness for the purposes of integrating RES sources into smart grids.
2. Smart metering and ICT in the energy industry
    - Digital measurement systems, including remote metering systems (Advanced Metering Infrastructure – AMI) – new constructions of AMI elements, communication technologies and smart software of AMI Central Systems, interoperability and interchangeability of AMI elements
    - Development of new techniques and technologies of data transmission for the purposes of the power industry
    - Development of protection techniques for cybersecurity of installations related to measurement and managements of Smart Grids
    - Development of new cybersecurity techniques – development of software, devices and services of IT security in the power industry
    - Integration of metering and reading systems for many utilities (electricity, water, gas, heat), including solutions for Smart Cities

- Uses of PMU systems (Phasor Measurement Units) in transmission and distrribution grids.

III. STORAGE OF ENERGY

1. E-mobility
    - Use of batteries of electric vehicles as energy storages in optimising the operation of power grids
2. Methods and technologies to store energy using various carriers
    - Use of excessive energy to produce media allowing to store alternative fuels (including, *inter alia*, hydrogen and synthetic methane)
    - New or improved technologies to store energy
    - New technologies to improve the efficiency of pumped-storage sources
    - New or improved technologies to store energy with the use of air
    - Storage of energy with the use of phase-change materials
    - Innovative technologies to store energy with the use of chemical compounds, including heat accumulators
    - New solutions with regard to accumulators and batteries, including lithium-ion, acid and flow batteries, EDLC and LIC supercapacitors
    - Automatically/remotely controlled systems enabling smooth regulation of supply of and demand for renewable energy sources through energy storage
    - Integration of energy storages into the national power grid at various levels of voltage, including the identification of barriers and concepts for their removal necessary for dissemination of energy storage technologies
    - Integration of energy storages into RES installations
    - Mobile energy storages in a form of high-temperature heat – optimisation of heat generation in relation to the demand of local cogeneration systems
    - Use of energy storages in dissipated hybrid systems (including, *inter alia*, batteries, kinetic storages – flywheel, batteries of accumulators with internal storage, pumped hydro power plants)
    - Use of energy storages to provide systemic services (passive power compensation, reduction of power swing and voltage changes, reduction of peak load)
    - Management of charging electric vehicles
    - Terminals of quick battery charging
    - Development of methods to develop the electromobility sector in the context of operation of power grids.
3. New generation technologies to store energy
    - Nickel and zinc storage technologies as technologies supporting the use of national deposits of zinc and nickel.
    - Supercapacitors – studies on developing new devices to create possibilities

of their use in the energy industry
    - Searching for new solutions allowing to scale technologies of various energy storages and methods to increase the effectiveness and service life of storages
    - Studies and development of new type of materials and technologies used in the energy storage process to improve its safety and effectiveness

IV. RES

This area applies to the use of locally available reneweable energy sources and fuels, so as to increase the energy independence of the specific area (including autonomous energy regions) and to apply new, effective technologies with regard to production and storage of renewable energy and obtainment of liquid fuels for the purpose of reducing the demand for energy from conventional sources. Energy may be generated independently from each source, based on smart synergic modular systems combining several identical sources or various renewable energy sources composed in terms of technical paramteres, depending on the local potential and availability of selected energy sources (including, *inter alia*, synergy between RES and construction industry). The main objective of actions within this sector is to improve the effectiveness of energy generation.

1. Wind energy
    - Optimisation of construction of local wind power plants on a micro and mini scale
    - Innovative technologies to produce electricity from wind energy, aimed at improving the efficiency of the process of converting wind energy into electricity (*inter alia*, vertical axis wind turbines)
    - Development and improvement of tools to forecast energy production from wind power plants
    - New or improved technologies in the field of offshore wind energy industry, contributing to increasing the efficiency of converting wind energy into electricity or to reducing investment costs
2. Solar energy
    - Innovative solar technologies allowing to generate heat
    - Photovoltaic cells based on new materials and other new technologies allowing to generate energy from solar sources
    - New technologies allowing to improve the efficiency of energy generation and other exploitation features in conventional photovoltaic cells.
3. Water energy
    - Development of new efficient technologies allowing to use water as energy raw material with reducing their negative impact on changes in the natural

environment

4. Improved efficiency in systems converting water energy into electricity.
   Geothermal energy
   - Efficient and environment-friendly production of energy based on geothermal heat
   - New technologies to explore and exploit geothermal waters, including technologies to manage waste geothermal waters
5. Biomass, biogas, biofuels and other energy carriers from processing waste biomass of plant and animal origin and another type of plant biomass with the exclusion of excessive exploitation of forest areas
   - Innovative processes and technologies of biomass pre-treatment and obtainment of biomass raw materials
   - New technologies to improve the quality of biomass and new technologies enabling effective biomass pre-treatment using physical and/or chemical methods allowing to intensify processes of obtaining liquid (liquid and gaseous) biofuels and biofluids for stationary uses
   - New or improved technologies to produce biogas (including, *inter alia*, development and studies on process of purifying biogas to biomethane with the simultaneous development of methods to use waste CO_2, production of biofertilisers – energy agriculture)
   - New or improved technologies to gasify biomass for energy purposes (including, inter alia, innovative small-scale technologies – up to 5MW to burn biomass, exclusive of co-burning)
   - Innovative processes leading to obtainment of liquid biofuels and biocomponents, other chemical compounds from second and further generation biomass.
6. Biogas plants

- Analyses of using biowaste in rural communes
- Analyses of possibilities to cultivate energy crops on low-class soils in the context of their use in biogas plants and examination of the impact of increased quantity of energy crops on food prices in the country
- Analyses of using urban biowaste in biogas plants (analysis of possibilities of biodegradable waste segregation in urban areas)
- Technologies to obtain biofuels and biofluids, allowing to reduce the amount of waste and by-products
- Production of fuels, biopolymers, chemical substances and fertilisers based on release and/or synthesis of valuable chemical compounds in biorefining processes
- Development of the concept of constructing biomass refineries (biorefineries) in Polish conditions

7. Generation of electricity from surrounding renewable sources with the use of “energy harvesting” methods.

V. PROSUMER ENERGY INDUSTRY

This area covers user-friendly technologies and systems whose application will contribute to increasing energy efficiency and improving the quality of supplying power to customers in low-voltage distribution grids, to which prosumer installations are connected. Studies should aim at creating conditions for development and dissemination of these solutions and activating the consumer group to implement them.

1. Prosumer energy sources
    - Innovative, highly-efficient devices and microgeneration systems of heat and/or electricity, using any sources of primary energy
    - Integrated systems to generate various energy carriers: electricity, heat, cold
    - Highly-efficient systems to convert and use energy on a small scale, situated near or directly at the user
    - New, innovative low power renewable sources integrated into energy storages
    - Innovative, energy efficient prosumer energy microsystems, with the defined and measurable effectiveness, cheap and easy to operate
    - Use of innovative technological solutions in microsources: photovoltaic (including new materials to be used in photovoltaics), fuel, biological and microbiological cells, using thermoelectric, piezoelectric and other phenomena to generate electricity and heat
    - New mobile sources of electricity (means of land and water transport) in

relation to storage of electricity and improving the reliability of supplying power to prosumer systems.
    - New systems allowing to use post-process energy on a microscale
    - Innovative systems using watercourses, water currents etc. to generate electricity for the purposes of customers and local systems.
2. Prosumer installation and low-voltage distribution grids with dissipated generation
    - New methods to integrate sources and storages of electricity and heat in microinstallations, small installations and energy clusters/autonomous energy regions
    - New systems to manage and control the operation of low-voltage grids with energy sources and storages
    - Use of microsources for the purposes of regulation of voltage in the grid
    - New means and solutions to improve the effectiveness of supplying power for various energy carriers, including regulation of voltage and flows of active and passive power in grids with the great share of microsources
    - Use of energy storages, including mobile storages, to support management of energy and to provide auxiliary services related to the improved quality of supplying power
    - Development of new services (including engineering tools) to design new technologies for prosumer energy industry.
3. IT technologies in prosumer energy industry
    - New IT technologies in determining the conditions of connection and forecasts of operation of power grids with prosumer energy industry
    - New GIS technologies in low voltage grids
    - New systems to support prosumer energy industry
    - Smart systems of prosumer service with home computer networks of HAN type
    - Development of open protocols and data exchange standards in power grids and installations.

VI. ENERGY FROM WASTE, ALTERNATIVE FUELS AND ENVIRONMENTAL PROTECTION

1. Management of post-extraction, industrial and municipal waste
    - Development of technologies of energy management of waste in WtE processes (also in combination)
    - Development of technologies to clean gases formed in the process of energy management of waste with regard to optimisation of production costs and possibilities of its management
    - Development of energy-efficient installations to dry and manage biodegradable fractions for their further use as raw material
    - Studies on preparing new mixtures of waste allowing to increase its calorific

value and thus to be able to use it in practice
    - Development, studies and support of composting infrastructure; introduction of selection of wet biodegradable waste and implementation of technologies of process to obtain full-value compost
    - Innovative systems to generate electricity (also in combination) with the use of waste hydrocarbons and by-product hydrogen in technological processes (e.g. production of hydrochloric acid, fertilisers, refineries)
    - Development of technologies of energy management of post-extraction waste – mainly coal silts
    - New and improved technologies to use waste in a form of flyashes, slags, ash and slag mixture and post-reaction products from installations in the construction industry
    - Methods to use anthropogenic in the process of reclamation of post-extraction areas.
2. Fuel gasification
    - Development of technologies of pyrolysis and gasification towards energy and towards acquiring a number of fuels obtained using various methods
    - Development of gas purification technologies after the process of gasification, enabling the direct use of generation units (including fuel cells and gas turbines) to produce energy
    - Development of gasification technologies enabling the use of various fuels in the same device e.g. biomass and waste (including, *inter alia*, gasification with fluidised bed)
    - Innovative systems using processes of biological and thermal gasification with the use of solutions related to purification and refining of generated gas.
3. Reducing and management of harmful compounds from emissions and by-products in the energy generation process
    - New technologies reducing harmful gases in the energy generation process, using chemical and physical processes
    - New or improved technologies related to minimisation of production and usable management of combustion by-products
    - New or improved technologies to reduce/manage harmful compounds from emissions, including NOx (also methods to reduce ammonia slip), SOx, dust, heavy metals, carbon dioxide (CCU).
4. Alternative fuels
    - New or improved processes to convert biomass or waste into fuels with parameters enabling safe use in currently produced generation units
    - New or improved processes to produce liquid (liquid and gaseous, including biohydrogen) alternative fuels for energy purposes from selected waste (or other unmanaged materials) as raw material – WtL (waste to liquid)

processes
- New or improved technologies related to the use of compressed natural gas and liquefied natural gas.