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NSS 1. HEALTHY SOCIETY

SECTION I – NEW PRODUCTS AND TECHNOLOGIES

I. RESEARCH AND DEVELOPMENT OF MEDICINAL PRODUCTS

1. Methods, tools and processes leading to medicinal products: chemical medicines (innovative and generic), biologicals and biosimilars.
2. New active substances, new applications of known active substances and combination thereof.
3. New forms of medicines, both single and multicomponent.
4. Development of innovative formulations, nanostructures, carriers for medicines.
5. Technologies aimed at achieving controlled result, extended administration, release or delivery of drug substances.
6. Bio-catalysis in processes of manufacturing of medicinal products (new cell models, expressive systems, methods for clone selection, culture media and processes).
7. Methods aimed at improvement of drug pharmacodynamics (dose reduction with reaching analogical therapeutic effect) and pharmacokinetics.
8. Technologies aimed at reducing costs or enhancing efficiency, safety and effectiveness of the therapy, new technologies increasing the likelihood of patients compliance with physician instructions.
9. Application of new cell models with better properties, in vitro and in vivo models, purification methods and assessment of the effectiveness and safety of biological and biosimilar medicines - compared to the ones used in reference products.
10. Synthetic biology in medicine - use of the biological synthetic systems (including e.g. modified microorganisms, cell lines) to produce new drugs, vaccines and therapeutic solutions (e.g. cell and gene therapies).

The area includes development of medicinal products from the discovery stage, through the pre-clinical to the clinical stage and registration.

II. ADVANCED THERAPIES MEDICINAL PRODUCTS (ATMP) AND BIOLOGICALS

Work on novel use of stem and/or progenitor cells and/or other cells/tissues transplanted both as autologous and allogeneic transplants. Research and development projects can be fundamental, pre-clinical as well as clinical in nature.

1. ATMP medicinal products based on the use of stem, progenitor and other cells (e.g. mature cell from specific organs, immune system cells, etc.) delivered directly to the organism or with the use of carriers [e.g. encapsulation, biodegradable membranes, scaffold with active substance or human or animal material, or covered with cells from tissue establishment – stem cells and others; other scaffolds, patches, stents and implants, etc.
2. Biological products including innovative use of protein products (e.g. cytokines, chemokines, hormones, antibodies, genetic vector, viruses; products with xenogeneic cells).
3. Isolated human cells for the purposes of alternative therapies.
4. Tissue establishments of medicinal products necessary for the manufacturing and/or storage process which meet the requirements needed for pre-clinical and clinical researches: GMP/GLP/GCP.

III. RESEARCH AND DEVELOPMENT OF INNOVATIVE FOOD SUPPLEMENTS AND FOODS FOR PARTICULAR NUTRITIONAL USES

1. Methods, tools and processes leading to innovative food supplements and foods for particular nutritional uses.
2. New bioactive substances of better bioavailability and tolerance used for prevention, including diseases of affluence, and for the purpose of enhancing efficiency of the proper therapy.
3. New technological solutions allowing improvement of assimilability of substances contained in food supplements and foods for particular nutritional uses.
4. Technologies aimed at achieving controlled result, administration, release or delivery of substances contained in food supplements and foods for particular nutritional uses.

IV. BIOINFORMATICS

Models, algorithms and software to search for molecular targets of therapy, molecular modelling of structures, drug design and disease diagnostics.

V. MEDICAL APPLIANCES AND DEVICES

1. Development, design, implementation and production of innovative medical, including dental, appliances, instruments and devices, used for conducting or assisting therapy or medical diagnostics, aimed at: realisation of new forms of therapy or diagnostics, improvement of therapy or diagnostics effectiveness, mitigation of therapy side effects, reduction of therapy or diagnostics costs, decrease of functional limitations.
2. Development and implementation of technological solutions allowing realisation of new methods: of treatment, compensation of functionality limitations, including mobility and perception disability, rehabilitation, prevention or improvement of efficiency of methods existing in these disciplines.

The area includes diagnostic, therapeutic, rehabilitation and compensation apparatus.

VI. HEALTH TECHNOLOGIES

1. Technologies of regenerative medicine.
 - a. Developing and implementing of new techniques of tissue engineering and regenerative medicine.
 - b. Development of technologies and tools aimed at the process of organs, tissues and cells regeneration.
 - c. Creation of new biomaterials for the repair of damaged cells and tissues.
2. Artificial organs.

Innovative appliances, instruments, medical devices, including implants intended for the replacement or support of impaired organ functions for therapeutic purposes covering the use of technical device (prosthesis) as temporary support of failing organ for the time of treatment for regeneration and return of efficient function and/or as long term or permanent support/replacement of the function of failing organ.

The area includes, apart from medical devices and instruments which are direct elements of artificial organs, technical support devices, including monitoring the work of artificial organs, necessary for improving safety, effectiveness, efficiency and comfort of the life of patient being treated with the use of artificial organs, in particular implantable sensor monitoring the work of supported organs and other biological functions of the patient and the work of artificial organs; systems allowing remote monitoring of artificial and supported organ work and patient monitoring, leading to increasing safety and effectiveness of patient with artificial organ at home and in work environment.

3. Material technologies in medicine

Development of new materials which will be used for production of implants, artificial organs or for other medical uses, or new technologies for material production. This area includes also tissue and genetic engineering allowing to produce hybrid implants.

VII. IT MEDICAL TOOLS

1. Design and development of IT solutions used for collecting and analysing medical data for the diagnostic and therapeutic purposes, in particular IT systems for collecting, processing and analysing medical data and information by text, sound, picture analysis or other forms necessary for diagnosing, treating and monitoring of patients.
2. Design and development of IT solutions allowing integration of different IT systems used in the healthcare system, facilitating safe collection and storage of medical data, including sensitive personal data, development of algorithms supporting medical decisions, assisting personalisation, coordination and optimisation of healthcare.
3. Design and development of IT solutions assisting disease diagnosing, in particular systems based on artificial intelligence, complex inference systems or systems based on computer simulations at different levels of complexity (from simulations at molecular or cellular level, through organ level simulations to simulation of the organism as a whole).
4. Design and development of IT solutions allowing treatment assistance based on computer simulations at the planning stage and stage of conducting therapy.

Proposed activities in this discipline should use and create innovative IT solutions, software advanced methods of calculation and simulation, including machine learning algorithms and algorithms of Big Data analysis, developed jointly with healthcare professionals and payers.

The area DOES NOT INCLUDE IT systems for the needs of accounting medical services or collecting data under the law and not connected directly with diagnostics and treatments.

SECTION II – DISEASE DIAGNOSTICS AND THERAPY

I. DIAGNOSTIC IMAGING AND DIAGNOSTICS BASED ON OTHER DETECTION TECHNIQUES

Modern and efficient disease diagnostics based on imaging techniques and novel detection techniques is:

1. Identification, validation, development and implementation of new biomarkers of diseases of affluence on the basis of diagnostic imaging methods in groups of well characterised people (e.g. with disease predisposition, at an early stage of disease).
2. Development and use of modern methods of diagnostic imaging and diagnostics based on other techniques, allowing early identification of structural lesions within systems and organs during the course of diseases of affluence and dynamic functional assessment connected to it.
3. Validation of already identified diagnostic markers/tests based on diagnostic imaging methods of diseases of affluence in big populations of risk groups and/or general population.

The results of designing and implementing activities in place should be introduction to the market (or preparation for such introduction) of new clinical diagnostics methods and markers/tests (or validation of already existing) based on diagnostic imaging or based on other techniques, or more efficient diagnostic algorithms.

II. MARKERS/TESTS

Design of innovative and efficient methods for diagnostics of diseases of affluence:

1. Markers/tests of early detections of predispositions to diseases of affluence allowing prevention of disease development or delaying its occurrence or slowing/mitigating its progress.

2. Markers/tests of early detections of diseases of affluence allowing to start treatment sufficiently in advance.
3. Markers/tests allowing conducting personalised therapies of diseases of affluence.

A pre-condition for the design of new diagnostic tests is identification of novel markers of diseases of affluence on the basis of tests conducted in groups of well characterised people (e.g. with disease predisposition, at an early stage of disease). Research and development projects aimed at design for the needs of implementation in the area of 'Diagnostics' include new sensitive and specific markers, validation of already identified markers related to diseases of affluence in big populations of risk groups and/or general population. Progress in development of new methods for diagnosing diseases of affluence is based on new research models of diseases of affluence and on innovative technologies, especially of multi-scale nature, based on genomics, transcriptomics, epigenomics, proteomics, metabolomics. The results of activities in place should be introduction to the market or preparation for such introduction of new diagnostic markers/tests, medical devices, more efficient diagnostic algorithms or validation of already existing methods and tests.

III. TELEMEDICINE

1. Creating solutions, technologies, products, tools, applications, algorithms which by using modern information and communication technologies will improve already existing ones but above all will create new methods of acquisition, analysis, archiving and safe exchange of information about patient's health condition both between the patient and medical professional and groups of medical professionals which are in a geographically distant places. The direct goal of solutions being created in this model should be support connected to transmission of safe data and medical information for diagnostic and therapeutic processes for collecting, processing and analysing medical data and information by text, sound, picture analysis or other forms necessary for diagnosing, treating, monitoring patients and information exchange between medical professionals and groups of medical professionals.
2. Design of innovative solutions based on information and communication technologies (ICT) used as methods for remote, non-invasive and safe collection and exchange of information about health condition between healthcare system and ill or healthy person. Proposed solutions should be applicable to: diagnostics; therapy, including invasive treatments performed at a distance; prevention; medical rehabilitation; coordinated care; health condition monitoring with the use of devices, detectors and accessories; registration and analysis of biological signals of significant importance for health; improvement of following instructions, including keeping up to the therapeutic plan; postoperative and posttraumatic rehabilitation; recreational physical activity; education of ill and healthy people with promoting healthy behaviours; improvement of the quality of life of ill people and people being diagnosed; professional education of healthcare staff; creation of large medical data databases; integration and unification of dispersed medical data systems with systems of Electronic Medical Records. An important goal of innovative activities in the field of telemedicine should be design and use of ICT solutions and medical devices which help to lower the costs of healthcare and/or improve the quality of provided services and/or facilitate and shorten the time of access to healthcare system and/or ensure health safety for elderly people with chronic diseases and disabilities, and its comfort and simple use for end users.

IV. COORDINATED HEALTH CARE

Coordinated health care includes activities covering such stages of healthcare as: health promotion and prevention, risk and disease progression assessment, therapies and rehabilitation which may be integrating, comprehensive and continuous in nature, as well as coordinated education in relation to coordinated healthcare on different levels of education and addressed to different groups of recipients.

The area includes:

1. Early detection of somatic genome changes (e.g. in the DNA) and biochemical (e.g. concentration of microelements) useful in identification of high risk groups of falling ill of genetic disorders (including in particular tumors) as well as in detection of genetic disorders at early stages.

2. Development and implementation of population-based screening programmes and prevention programmes allowing diagnosis and start of treatment at the earliest stage possible.
3. Identifying risk factors of distress related to disadvantages of civilisation which directly or indirectly increase the number of mental disorders.
4. Healthy diet in health and illness, and shaping of healthy behaviours in different aspects of life with the use of universal design concept.
5. Development and implementation of technological solutions allowing realisation of new methods: of compensation of functionality limitations, including the ones resulting from mobility and perception disability, prevention or improvement of efficiency of methods existing in these disciplines.
6. Assessment of risk and/or disease progression covering aspects of clinical, social, psychological evaluation, genetic history, way of life, including dietary and lifestyle patterns.
7. Activities ensuring preservation and promotion of work-life balance, especially by dissemination of mental hygiene and activities lowering stress, allowing to stay mentally and physically healthy and reducing or slowing progression of diseases which have already occurred.
8. Methodology for risk assessment in terms of: activity decreasing or increasing risk of diseases; individualised cognitive and mental training allowing early detection of risk of mental disease or disorder occurrence; socio-economic determinants directly affecting disease risk and integration of these factors with medical and clinical factors of disease process.
9. Assessment of risk and/or rare, chronic, civilisation diseases progression in which the possibilities of improving effectiveness and/or safety of pharmacovigilance are limited, including multi-specialist and innovative care, allowing extension and improvement of the quality of life taking into account economic results.
10. Coordinated programmes and therapies taking into account all significant elements of treatment process with the aim of its optimization, integration and adaptation with personalised needs of patients by connecting to interventional and conservative treatment in the form of, among other things, and pharmacovigilance, psychotherapy, physical activation methods, supporting mental condition and hygiene, as well as change or modification of dietary pattern taking into account the personalised enteral and parenteral nutrition and correct diet.
11. Joint activities and programmes of partners such as medical and psychological centres; physiotherapy, psychology and/or psychotherapy, dietetics specialists; social workers; employers; leading to education for changes of lifestyle, speed of life, life hygiene (including psychological), covering also the generation of services and/or products of healthy qualities and psychologically healthy behaviours needed in this area.
12. Research on new civilisation disease therapies based on innovative technologies of personalised medicine (from the discipline of genomics, transcriptomics, epigenomics, proteomics, metabolomics) and personalised therapy based on biopsychosocial model (consisting of methods for work with patient taking into account psychological-psychotherapeutic profile, life conditions, available material and intangible support, and other).
13. Treatment of chronic, rare diseases and people with disabilities and physical and intellectual indispositions covers multi-specialist, coordinated care for patient together with their family.
14. Development of ICT tools which aim at information exchange of patient's health condition, coordination of activities between medical specialists at different treatment centres and education of specific professional groups of medical staff and patient's social environment. It also covers telecommunications engineering solutions causing increase of patient's involvement in treatment process by self-evaluation of health condition, evaluation of treatment process and cooperation with medical team taking coordinated care of the patient.
15. Implementation of integrated rehabilitation activities and programmes ensuring recovery and return to social and professional activity within the framework of cooperation of specialists from different disciplines, including medicine, telemedicine, medical engineering and compensation technologies, physiotherapy, psychology, dietetics, occupational counselling, law (constituting interdisciplinary teams).

V. NEW PREVENTIVE AND/OR THERAPEUTIC OBJECTIVES

Therapy of civilisation diseases should be based on design and implementation of:

1. New therapies for civilisation diseases based on medicinal products (chemical, biological, biosimilar, innovative and generic medicines).
2. Algorithms for dealing with patients on the basis of personalised diagnostics results.
3. Mechanisms of conducting selection and validation of effectiveness of therapeutic chemical units.
4. Protocols of monitoring and assessment of therapeutic activity effectiveness, e.g. on models of patient's cell lines.

The condition for proposing and preparing for implementation of targeted (personalised) therapy is conceivably complete identification of disease origin, e.g. genetic, metabolic origin, etc. as well as possibilities of prediction and assessment of the effectiveness of proposed therapy on cell line, bacteria or in silico models with simultaneous possibility to assess the effectiveness and stability of the proposed therapy. Development and implementation of new targeted therapies of unique importance, as well as combined therapies giving the possibility to improve the quality of patient's life in comorbidities with simultaneous assessment of its effectiveness, monitoring and change during conducting the therapy.

Progress and development is closely related to the development of DIAGNOSTICS and uses its results, introducing new, unique models for therapy effectiveness assessment which eliminate negative effects for the patient.

VI. CLINICAL RESEARCH

Clinical research includes:

1. Prospective clinical research including randomised research involving patients and/or healthy people, being conducted for the assessment of effectiveness and/or safety of new, innovative therapeutic methods with the use of medicines and/or medical devices. Projects in the field of clinical research may take into account biopsychosocial models, also without the use of pharmacovigilance, being therapeutic, diagnostic, screening, preventive, prognostic or epidemiological in nature.
 - a. Clinical research of early stages, aimed at the safety assessment of pharmacokinetics and pharmacodynamics, determining optimal dosage, etc. new medicines and treatment methods, and assessment of new diagnostic methods. This concerns especially innovative, personalised, targeted therapies and identification and verification of the proper prognostic biomarkers.
 - b. Clinical research of later stages, aimed at the effectiveness assessment of medical intervention and/or other therapeutic, or diagnostic method and observational and epidemiological studies.
 - c. Studies related to biopsychosocial factors; rehabilitation and/or physiotherapy; psychotherapy (including especially cognitive and behavioural methods); quality of life determined by health condition, social support, motor activation, healthy diet, cost efficiency of non-pharmacological therapy and studies on models of coordinated care of ill people.
 - d. Studies on technology of clinical research. Design of innovative technological solutions (models, processes and devices) used to increase safety of patients, lower costs, optimize number of participants, increase assessment precision and reduce time of clinical research realisation.

The solutions should concern:

- models and software used to analyse massive datasets (Big Data) with the purpose of profiling prediction studies (e.g. identification of units – candidates for medicines), in bioinformatics, studies related to identification of innovative medical procedures and standards (secondary data analysis) and in screening within clinical research;
- designing new devices for use in clinical research (e.g. lab-on-the-chip, in silico) and devices allowing to collect, transmit and process biosignals;
- information and communication technologies (ICT) for collecting data and monitoring participants of clinical research;

- legal and administrative solutions aimed at efficient and fast obtaining of authorisations and concluding contracts allowing effective and safe conduct of clinical research;
- facilitations in designing, documentation assessing and financing clinical research of early stages related to new therapies developed in Polish laboratories or by Polish institutions.

SECTION III – MANUFACTURE OF PRODUCTS

I. BIOLOGICAL, BIOSIMILAR, INNOVATIVE, GENERIC MEDICINAL PRODUCTS AND MEDICAL DEVICES, FOOD SUPPLEMENTS AND FOODS FOR PARTICULAR NUTRITIONAL USES

1. Methods for conducting production process, designing new methods for production of biotechnological medicines including biosimilar and biobetter medicines, i.e. products manufactured with the use of living organisms.
2. Development of manufacturing technologies of generic, biosimilar medicines and active substances not used in development and production of reference medicines.
3. New, innovative, improved technologies of: storing (biobanks) master clones and working clones, biocatalysis, fermentation, purification, filtration, packaging, storing and qualitative study of biological medicines.
4. Design of new technologies for manufacturing innovative and generic medicinal products, biological and biosimilar medicines, medical devices, food supplements and foods for particular nutritional uses.
5. Methods for implementation of modern production technologies and formulation improvement resulting in the change of pharmacodynamic and pharmacokinetic properties.
6. Preparations manufacturing based on pharmaceutical technologies.
7. New technologies of delivering active substances to patient's organism including use of modern carriers in pharmaceutical technology.
8. Technologies of modified release of active substances.
9. Manufacturing of nanostructured materials for medical purposes.
10. Technologies for manufacturing single-component and complex products with the use of modern formulation.
11. Manufacturing of products used for new indication or dosage with the use of known active substance.
12. Manufacturing of new medicine forms based on known substances or using modified or improved technologies of their administration.
13. Searching for and manufacturing of innovative and more efficient expressive systems, cell lines, culture media and methods for biocatalysis, fermentation, purification, filtration, packaging, storing and qualitative study of biological medicines.
14. Development of innovative analytical techniques, methods of synthesis and isolation of impurities of medicinal products.
15. Design and validation of new analytical methods for active substances of medicines and proprietary medicines.

II. ACTIVE SUBSTANCES OF MEDICINAL PRODUCTS (API)

Definition: substances of indicated biological activity and declared pharmaceutical usefulness, of natural or synthetic origin, in particular: secondary metabolites or their compositions, materials of biopolimeric nature manufactured with biotechnology methods and biosimilar substances, natural substances manufactured with methods of chemical synthesis, chemical conjugates and bioconjugates, synthetic substances, molecular and supramolecular complexes, nanomaterials, radiopharmaceuticals, molecular and diagnostic probes. In particular, innovative forms of active substances of generic medicines – including nanoparticles, nanoformulations and nanopreparations, new pharmaceutically acceptable salts and complexes of different degrees of dispersion or immobilisation on target surfaces or particles.

1. New technologies for manufacturing active substances, innovative, generic and biological medicines with the use of materials, solvents, catalysts and new processes.

2. New technologies for manufacturing of active substances of medicines reducing negative effect on the environment (e.g. taking into account the principles of green chemistry).
3. New technologies for manufacturing of active substances of medicines improving their quality (content and impurity profile in the context of substances and preparations stability) and/or reducing time and money.

III. MEDICINAL PRODUCTS FOR EXTERNAL APPLICATION, DERMATOLOGICAL AND COSMETIC

Process and product innovation in relation to manufacturing new active substances and novel formulations used in the cosmetic industry. In particular, technologies for manufacturing active substances which are sustainable and do not exploit the environment e.g. cell, tissue and complex cultures (including stem cell cultures, microorganisms cultures, including microalgae). Searching for new active substances of various origin, chemically or biotechnologically modified and searching for new application areas of already known active substances. Searching for new active substances used in cosmetics of high therapeutic activity and design of technologies for their manufacturing. Developing novel methods for production of active substances used in cosmetics under laboratory conditions.

1. Innovative protective cosmetics.
2. New, innovative active substances used in cosmetics of various origin, chemically and biotechnologically modified, of high biological activity in prevention and health protection.
3. New, innovative basic substances of cosmetic compositions.
4. New test methods for the assessment of safety, effectiveness and mode of action of active substance used in cosmetics and finished cosmetic product which contains the substance.

Innovative forms of delivering cosmetic active substance.

IV. NATURAL MEDICINAL PRODUCTS

Research on innovative preparations of natural origin which have therapeutic effect in the following conditions:

1. Prediabetes and prehypertension state.
2. States endangering to destabilise the plague (heart attack and stroke prevention).
3. States related to chemotherapy and radiotherapy, and immunosuppressive therapy.
4. Chronic inflammations.
5. States related to chronic hepatitis, pancreatitis and gastrointestinal diseases – of small and large intestine.
6. Research on the creation of new forms of natural medicinal products – micro- and nano-technologies.

AGRICULTURE AND FOOD BIOECONOMY, FOREST BASED AND ENVIRONMENTAL BIOECONOMY

NSS 2. INNOVATIVE TECHNOLOGIES, PROCESSES AND PRODUCTS OF THE AGRICULTURE AND FOOD AND FOREST BASED SECTOR

I. ELEMENTS COMMON TO INNOVATIONS IN THE AGRI-FOOD AND FORESTRY AND WOOD SECTORS

1. Optimisation of production, processing and storage processes in line with the idea of sustainable development.
2. Genetic research, breeding work, molecular and biotechnological methods as well as alternative lines of production allowing to obtain high quality vegetable and animal raw materials.
3. Innovative systems and intelligent methods and tools for monitoring the production process and evaluating the quality of raw materials and finished products.
4. Innovative technologies of agri-food and forestry and wood processing to reduce the energy and water consumption and improve the production quality.
5. Acquisition and processing of bioactive compounds and other raw materials from plant material (including waste biomass) and livestock material from the agri-food and forestry and wood sectors for different industries.
6. Optimisation of management of waste and by-products from the agri-food and forestry and wood industries, including for energy purposes.
7. Methods of monitoring and counteracting the effects of natural hazards, including natural disasters disrupting the sustainable development of agricultural and forestry areas and food security.
8. Methods of monitoring the social effects of technological progress disrupting the sustainable development of agricultural and forestry areas and food security.
9. Processes, materials, measures to increase the efficiency of the protection and use of materials of agricultural and forestry origin from natural disasters and the restoration of land affected by natural disasters for economic use.
10. Innovative business models for organisation of the production, processing, storage, distribution and sale of products of the agri-food and forestry and wood economy.

II. SOIL AND FARMLAND

1. Innovative efforts to improve soil fertility and productivity, such as, *inter alia*:
 - counteracting soil degradation, improving the reaction of acid soils, increasing the absorption of fertilisers,
 - nutrients for plants in soils, forms of their presence and availability to plants.
 - live organisms and organic matter in soil, humus compounds, humification processes, mineral and organic compounds.
 - physical, mechanical and aquatic properties vs three-phase soil system, soil porosity and structure in combination with the mechanisation of agriculture.
2. innovative reclamation of degraded soils and protection of farmland.
3. rationalisation of water management in the plant and animal production.
4. measures to reduce the negative impact of agriculture on groundwater and surface water.

III. BIOLOGICAL PROGRESS IN PLANT AND ANIMAL PRODUCTION

1. Creative breeding of plants, animals and fungi with improved usefulness, with a possibility of using molecular and biotechnological tools, taking into account the issues of biodiversity and resilience of climate and environmental change.
2. Innovative production of high-quality seed and nursery material, with an increased resistance to diseases and pests.

3. New sources of protein in animal nutrition, high protein plants taking into account the characteristics of these raw materials and health safety.
4. Varieties (or species) which provide the high biological value for use in the processing and formulation of final food products.
5. Methods to improve and implement breeding effects in the production of plants and animals, *inter alia*, taking into account increasing the productivity and reducing environmental nuisance.

IV. TECHNOLOGY OF PLANT AND ANIMAL PRODUCTION

1. Agricultural biologisation methods improving the soil quality and nutritional value of plant resources (*inter alia*, biopreparations, microorganisms, integrated protection of plants and fungi against diseases and pests using innovative biopreparations, biotechnological methods and agricultural treatments).
2. Solutions to increase safety and improve the quality of plant raw materials as regards the application of fertilisers and plant protection products, including the use of the principles of integrated plant protection and sustainable production.
3. Detection and identification of pathogens and pests of plants and fungi using innovative techniques.
4. Innovative methods to improve animal welfare and animal health protection.
5. Nutrition methods and animal breeding systems with a beneficial effect on the nutritional value and health values of products of animal origin, *inter alia*, increasing the productivity and reducing environmental nuisances, including animal welfare.
6. Automated milking and milking robots.
7. Increasing the efficiency of pollination using pollinating insects, including bumblebees and solitary bees.
8. Methods to improve the sanitary and health status of commercial animals and animal breeding farms.
9. Processes and systems for optimising management of various types of farms.

V. AGRICULTURAL MACHINERY AND EQUIPMENT

1. Innovative technologies and machinery for agriculture, including precision farming.
2. Developing energy-efficient, environmentally friendly technologies and machinery and equipment for tillage, sowing and fertilising, planting, care and protection of plants, harvesting, preservation and storage of agricultural crops, improving agronomic parameters and guaranteeing the high quality of agricultural products.
3. Innovative, energy-efficient, low-cost machinery and equipment working in farms, barns, pigsties and fish breeding pools.
4. Equipment and systems for monitoring, support, evaluation, improvement of the production (technological) process taking into account the latest analytical methods e.g. remote sensing (GPS), comprehensive chromatography, spectral analysis, etc. to produce raw materials of the highest biological, health and technological quality.
5. Machinery, technical and organisational implementations for production processes at all stages of the food chain in farms, centres of buying-in, processing (raw materials, products) and slaughtering of animals (including fish) taking into account the factor reducing contamination with pathogenic bacteria.

VI. ORGANIC AND MINERAL FERTILISERS, PLANT PROTECTION PRODUCTS AND GROWTH REGULATORS

1. Innovative organic and mineral fertilisers and biological preparations with dedicated application or controlled release of components.
2. Innovative biologically active substances (natural and synthetic) intended for the production of plant protection products and veterinary medicines.

3. Modern formulations of plant protection products and biocides, reducing their negative impact on humans and the environment, compatible with the principles of integrated plant protection.
4. Innovative organic and organic-mineral fertilisers and microbiological vaccines to enrich soils with biomass and restore their proper microflora.

VII. PRODUCTION AND STORAGE

1. Technologies and equipment for the harvesting and storage of agricultural and agri-food products, reducing storage and transport losses or increasing the durability of these products in the food chain.
2. Intelligent warehouses, pigsties, barns, farms, fish-breeding pools using renewable energy sources to complement the energy needs of livestock buildings and structures.
3. New technologies for the production, packaging and storage prolonging the durability of food products, enabling the preservation of high quality, including food safety.
4. New packaging and storage technologies to monitor the food quality *inter alia*, using active and smart packagings.

VIII. PROCESSING OF AGRICULTURAL CROPS AND ANIMAL PRODUCTS

1. High-quality food production including:
 - product innovation in terms of the composition, nutritional value and bioavailability of ingredients,
 - reformulation of existing products aimed at improving their quality,
 - improvement of existing and introducing new innovative food production and processing technologies,
 - measures to minimise the food processing level and to maintain, to the greatest possible extent, nutrients and beneficial bioactive substances,
 - measures to maximise the share of natural raw materials and to reduce the use of food additives,
 - measures allowing to limit the content of or eliminate the antinutrients and allergens in food.
2. Production and evaluation of the quality of foodstuffs for special nutritional uses and other products with dedicated nutritional and health characteristics adapted to various groups of consumers.
3. New processing methods and technologies for meat products with the increased dietary value.
4. Innovative processing of agricultural products, including vegetables and milk, promoting the quality and increased consumer awareness for health nutritional values.
5. Innovative food preservatives, allowing fresh products to be distributed to the consumer.
6. Production and evaluation of the quality of organic, traditional and regional food.
7. Research, characteristics and implementation of solutions (including technological ones) for raw materials of agricultural and agri-food origin taking into account their usefulness, use and health and food safety in the feed industry.
8. Innovative production and evaluation of the quality of feed and petfood.

IX. FOOD AND CONSUMERS

1. Creating innovative communication and education tools allowing consumers to make informed food choices.
2. Use of innovative technologies to develop tools supporting better nutrition planning and evaluation of the diet at the individual and collective level.
3. Innovative methods to increase the recognisability of high quality food.
4. Creating innovative tools to detect food adulteration.
5. Developing tools and modern research techniques and food quality markers (including bioavailability of ingredients) for the purposes of assessing the impact of food products on human health.
6. Developing methods of analysis and selection of food dedicated at the population and individual level.

X. MODERN FORESTRY

1. Processes of obtaining woody plants with increased immune properties and/or taking into account climate, soil, aquatic and other conditions of biocenoses as well as systems to manufacture and acquire raw materials of plant origin using remote sensing to determine forest characteristics.
2. Environmental management using LCA techniques in forestry and tree farming.
3. Research on biodiversity to improve the quality of treestands and the quality of raw material for the wood industry.
4. Modern methods of acquiring, selecting, taking care and implementing selected species of trees and shrubs, taking into account selected tree genotypes, so as to select the desired wood performance parameters for the selected branches of the wood sector and for the cultivation, sustainable use and processing of plantation wood, developing processes of using the DNA methods in forestry.
5. Modern systems for monitoring, early warning (e.g. satellite observations) and organisation of the reduction in fires and losses they cause.
6. Development of energy crops with the large increase in mass, resistance and high dryness for the production of fuels.
7. Innovative means and methods of protecting treestands against biological pests.

XI. INNOVATIVE WOOD AND WOOD-BASED PRODUCTS

1. Use of wood and forestry biomass to produce substitutes for other non-renewable raw materials.
2. Development of technologies, applications of engineering wood, use and offer of glued construction, building elements of wood, construction of wooden houses for residential purposes and other utility purposes.
3. Searching for new innovative applications of wood and wood-based materials as consumables, wood biocomposites, including those from recycled materials.
4. Products, processes and technologies for obtaining wood and wood-based materials with the extended durability in the conditions of internal and external use, increased resistance to destructive factors, *inter alia*, biotic factors, fire, atmospheric factors, photolytic aging, intended for: furniture, woodwork, flooring materials, boat-building products, wooden garden architecture.
5. Modern means for the protection of wood and wood-based materials as well as means protecting against erosion and stabilising biologically active substances, including ecological wood preservatives, *inter alia*, based on natural biocides, plant extracts and synthetic products imitating natural ones.
6. High-efficient and energy- and material-saving machinery and lines for milling, processing and treatment of wood and wood-based materials, including cellulose, paper and cardboard.
7. Studies on wood drying technologies combined with technologies to reduce wood swelling and shrinkage.
8. Innovative adhesives to join wood with wood and wood with non-wood materials, varnishes/oils/wood stains and fillers, which take into account the needs of woodwork, industry of floors, wood-based panels and furniture.
9. Modern woodwork with the increased durability, including the use of microcoatings, nanotechnology, mimetics.
10. Large wood and wood-based structures where wood is the main building element.
11. Technologies for the modern wood construction industry based on renewable materials, especially wood.
12. Development of wood-based materials for modern construction applications: new generation materials that would demonstrate better properties, less emissions, biodegradability, but also, during normal operation, resistance to biological agents (fungi, insects, rodents).
13. Technologies for extraction of bioactive compounds from forest goods, wood industry waste, including coniferous trees, to be used in the economy.
14. Modern, biodegradable, reusable, demountable wood and wood-based, paper, cardboard packagings.
15. Products, processes and technologies for management of waste from the wood-based industries, optimisation of management of post-production residues of solid wood processing, for value added products.

XII. INDIVIDUALISATION OF FURNITURE PRODUCTION

1. Special purpose furniture, including fixed joinery; high comfort furniture; furniture to eliminate health deficits, furniture to support the proper development and staying in good shape, eliminating adverse effects of civilisation factors, as well as integration of furniture with digital and electronic systems.
2. Process innovations in furniture design understood as the work of interdisciplinary teams (from examining needs, through design brief, prototype and its testing, improving the prototype, implementation into the production, to market verification), including the development and calibration of tools for the early evaluation of the prototype and design as well as logistic efficiency of the product.
3. Searching for and exploring the possibilities of using materials: new, alternative and with new functional properties (including micro-and nanotechnological modifications) for the furniture industry.
4. Innovative designs and manufacturing processes for furniture fittings and accessories.
5. Technical and technological innovations increasing the productivity, reducing the consumption of materials and energy for furniture production.
6. Development of modern systems for joining and assembling wood and wood-based elements and accessory materials in the furniture industry.
7. Innovative furniture production systems, including the development of processes for individualisation of the product or 3D printing techniques.

XIII. INNOVATIVE PROCESSES AND PRODUCTS IN THE CELLULOSE AND PAPER AND PACKAGING INDUSTRIES

1. Technologies and research aimed at smart tools, methods and processes leading to producing cellulose pulp, paper, cardboard, corrugated cardboard and derived products to minimise the share of basic raw material for the conservation of forest resources (*inter alia*, with the increased share of waste paper and other fibres, including synthetics), while achieving high strength parameters.
2. Technologies and processes to produce cellulose and paper products to achieve the effect of reducing the consumption of energy, water and CO₂ emissions and products with new utility functions.
3. Smart packagings, highly specialised improvements to increase the environmental friendliness, durability and safety of food, their structure and design.
4. New specialised technological solutions aimed at developing and implementing technologies to minimise waste generation in the paper and cardboard production and new forms of waste management.

NSS 3. BIOTECHNOLOGICAL AND CHEMICAL PROCESSES, BIOPRODUCTS AND PRODUCTS OF DEDICATED CHEMISTRY AND ENVIRONMENTAL ENGINEERING

I. DEVELOPMENT OF (BIO)TECHNOLOGICAL PROCESSES TO PRODUCE INNOVATIVE (BIO)PRODUCTS

Development of biological systems (including those from the field of genetic and metabolic engineering and bioinformatics), construction and modelling of effective biotechnological tools and analytical techniques for the identification and testing of properties of bioproducts.

Biomass and waste as a medium for the production of new tools for the purposes of biotechnology (including cultures of macro-and microalgae, bacteria, fungi and other organisms).

Development of new sources of biocatalysts and unique metabolites, construction and modelling of effective biocatalytic tools for the biosynthesis and bioconversion processes, biorefining and biotransformation and for the purposes of processes used in the environmental protection.

Development of bioprocesses based on the use of biomass and waste from the agri-food, forestry and wood and herbal industries, in order to obtain substrates for different industries, including chemical, cosmetic, pharmaceutical, agricultural, textile, packaging, cellulose and paper industries, and for the manufacture of other products.

Biorefining of renewable raw materials, including waste from the agri-food, forestry and wood and herbal industries (using micro-organisms, including microalgae and microscopic fungi), for their comprehensive management and use in the production of value added compounds.

Innovative technologies to obtain biofuels, feed protein and biocomponents.

Biotechnological methods of obtaining substrates for the production of polymers and products of dedicated chemistry as well as processes for their purification and processing.

Technologies using renewable natural resources for the production of plant protection products, fertilisers, biostimulators and surfactants with improved properties.

Technology for the production of bioactive materials for medical and multifunctional applications for the purposes of various branches of the economy.

Bionic engineering in the processes of modification and functionalisation of polymeric materials (including bionics of designs, structures, material characteristics, biochemical processes, biological immunity, ergonomics and other phenomena).

Biodegradation of polymeric materials for the production of biologically active oligomers and new polymer structures.

Processes for the synthesis and modification of biodegradable polymers from renewable, petrochemical and waste raw materials (including industrial, agricultural and municipal).

Development of modern processes for purification of biotechnology products and dedicated chemical products.

Modern unit operations in advanced technological processes.

Synthesis and biosynthesis technologies for dedicated intermediates used in the production processes of biologically active plant protection agents, biocidal products and veterinary medicinal products.

Technologies using renewable raw materials for the production of monomers and polymers and plastics using these polymers.

II. ADVANCED BIOMASS PROCESSING FOR DEDICATED CHEMICAL PRODUCTS

1. Production of dedicated market products from plant and animal raw materials and their derivatives through chemical, physico-chemical or biochemical processes.
2. Use of by-products from biomass processing to produce dedicated products.
3. Production of dedicated products through biotechnological and chemical biomass processing and production of intermediates to support such processing.
4. Use of renewable raw materials in the synthesis of polymers and plastics using these polymers.
5. Efficient biomass management in thermal processes

6. Efficient methods of biomass processing into biochar for the purposes of agriculture, industry and wastewater treatment plants
7. Development and use in practice of complex processing technologies of plant, animal and waste raw materials from the agri-food, chemical, energy industries, waste water treatment plants, landfills etc. to produce intermediates for further processing for the chemical, pharmaceutical, household chemical and other industries.
8. Production technologies aimed at extending the product chain, producing new or improved materials and chemical and biochemical products covering the entire lifecycle.

III. BIOPRODUCTS AND PRODUCTS OF DEDICATED CHEMISTRY

1. Dietetic and medicinal products and food additives of plant (including extracts from herbal, fibrous and oilseed plants), animal and microbiological origin.
2. Innovative, efficient technologies for the production, processing, refining and modification of natural fibres and fibres from renewable raw materials.
3. Polymer and polymer and fibrous composites, including those with plant raw materials, bionanocomposites, integrated multilayer and multifunctional composites.
4. Nano -and microfibrils, fibrous nanomaterials, bionanocoatings and multilayer compositions produced using modern processing techniques from biopolymers and thermoplastic polymers (including natural polymers, biothermoplastics and synthetic polymer equivalents).
5. Innovative (bio)polymers and (bio)plastics (including biodegradable polymers from renewable raw materials and petrochemical raw materials, microbiologically synthesised polymers, synthesised polymers with biocatalysts, natural thermoplastic polymers, polymers with bioactive and biomedical properties, natural-synthetic polymer compositions, biosensoric polymers).
6. Technologies for the processing of polymers and biopolymers for technical consumer goods (films, paper and cardboard, fibres, unwoven fabrics, injection moulds, composite products), processing techniques from polymer solutions and alloys, searching for and application of safe, efficient solvents (organic, inorganic, ionic).
7. Modern methods for the production of dedicated (bio)polymers using radiation techniques (grafting and networking) intended for dedicated products such as, *inter alia*, films, insulation, microfoams, heat-shrinkable polymers, coatings, as well as medical applications.
8. Modern functional additives in polymer materials production technologies to improve their functional properties.
9. Fibrous biomaterials and innovative polymer materials for dedicated technical, hygienic, medical, agricultural and other applications.
10. Biosensors (including polymer and polymer-fibrous sensors, textronics, biomimetic sensors, bioelectronic sensors, biocomposite sensor systems).
11. New and generic biologically active substances for the production of plant protection products, biocides and veterinary medicinal products (search for new biological activities, production and processing technologies, extraction and biotransformation technologies, formulations).
12. Development of bioformulations in terms of their applications in biosynthesis, biocatalysis, biomass and waste processing, and in the production of products.
13. Innovative auxiliary agents and additives used in the chemical, biochemical production and in downstream processing, new dedicated additives to polymer and biopolymer materials.
14. Bioagrochemicals, biofertilisers and soil improvers, plant growth-stimulating fertilisers, slow-action fertilisers, agrobiosorbents, biological preparations keeping nutrients in the root layer of crops in soil, microbiological vaccines, biopesticides, biosurfactants.
15. New technologies for the production of biocatalysts and homo-heterogeneous catalysts with the high selectivity and viability for technological processes.

IV. MODERN BIOTECHNOLOGIES IN THE ENVIRONMENTAL PROTECTION

1. Biological methods for removal of fatty and petroleum pollutants, biodegradation of organic substances of anthropogenic origin in waste streams.
2. Modern fermentation processes for processing of waste from the agri-food industry and municipal waste.
3. Biohydrometallurgical process for removal or recovery of metals from municipal waste (urban mining) and industrial waste.
4. Preventing eutrophication processes by removal of phosphorus and/or nitrogen compounds from aquatic ecosystems, municipal and industrial wastewater.
5. Development and implementation of new technologies of bio- and phytoremediation of the water-ground environment.
6. Integration of biological and physico-chemical processes in treatment of industrial wastewater, allowing to close the water circulation system/recovery of water and energy.
7. Development of deodorisation methods for municipal, industrial waste and livestock manure.
8. Technologies for cleaning waste gases emitted into the air.
9. Technologies for cleaning industrial process and waste gases for their use.
10. Biological methods of the protection against pests in agricultural and forestry crops, food storage and sanitary hygiene (pheromones, repellents, biopesticides, others).

NSS 4. HIGHLY EFFICIENT, LOW-CARBON AND INTEGRATED SYSTEMS OF GENERATION, STORAGE, TRANSMISSION AND DISTRIBUTION OF ENERGY

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 distribution 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
 - 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
 - Nickel and zinc storage technologies as technologies supporting the use of national deposits of zinc and nickel.

IV. RES

This area applies to the use of locally available renewable 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 parameters, 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 CO₂, 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 NO_x (also methods to reduce ammonia slip), SO_x, 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.

NSS 5. SMART AND ENERGY-EFFICIENT CONSTRUCTION

I. MATERIALS AND TECHNOLOGIES

10. Materials of higher parameters, especially construction and insulation qualities, with elevated resistance to aging processes, vapour-permeable, low embedded energy, high flame resistance, low emission, thermo-reflexive and manufactured from plant raw materials and technologies for their production.
11. Materials and technologies applied for renovation of buildings, including historical objects.
12. Energy renovation materials and technologies to be applied on existing thermal insulation requiring improvement of insulation qualities.
13. Materials used to accumulate heat and cold and technologies for their production.
14. Materials and technologies for the production of coatings with increased parameters, hindering the development of fungi, bacteria and algae.
15. Materials with varied physical parameters regulated with external environment qualities and/or a system of thermal management in a building, including the material of changeable thermal, spectrum, moisture and other parameters, and technologies for their production.
16. Transparent materials and technologies for their production; windows, glazing systems with varied optical parameters for solar radiation.
17. Long-lasting roof coverings and other materials characterised with high resistance to degrading factors, protecting buildings against atmospheric conditions, including materials of varied absorption properties, as well as technologies for their production.
18. Materials and technologies protecting buildings against overheating and/or limiting heat losses.
19. Studies and technologies related to heat and moist transport processes in construction partitions, in relation to applied insulation materials and the technology of energy renovation.
20. Materials and technologies for daylight utilisation systems with high efficiency and controllability.
21. Materials and technologies for passive solar systems integrated with a building shell.
22. Materials and technologies for solar heat energy (active) systems integrated with the building shell.
23. Materials and technologies for photovoltaic systems integrated with a building shell.
24. Materials and technologies for energy interactive buildings, multifunctional building shells for heating, cooling, ventilation, air conditioning, electricity production.
25. Energy-saving lighting, serviceable modular luminaires of energy-saving lighting with minimized embodied energy, luminaires increasing the cooling efficiency and durability of their elements, as well as materials and technologies for their production.

II. ENERGETIC SYSTEMS OF BUILDINGS

1. An integrated approach to building management systems.
2. Technologies and systems for a smart building, with special focus on the new algorithms which optimize utilisation of renewable energy accumulated by the building (directly) and storage of the energy; advanced systems for monitoring, control and forecast of energy availability and production, and final use.
3. Technologies and systems comprising energy systems of smart buildings with infrastructures of smart cities.
4. Systems allowing easy and full utilisation of smart buildings functions, including facilitated access and control (gesture and speech control), with the use of video camera, visual identification of threats (e.g. a fire or flood), user identification by a smart building.
5. Smart pre-payment systems for utilities supplied to a building.
6. Active façade systems protecting against overheating.
7. Systems of energy distribution in a building, regarding availability and momentary needs, preceded with development of a priority system for application of various energy sources in an integrated energy system of a building.
8. Smart lighting systems.

9. Development of algorithms and building management systems influencing users' awareness in terms of energy utilisation within the DSM (Demand-Side Management) system.

III. DEVELOPMENT OF MACHINES AND DEVICES

1. Waste-free / low-waste technologies and technological lines intended to reduce costs and/or improve effectiveness of the production of construction materials and products, as well as realisation of construction investments.
2. Technological lines, and corresponding machines and devices, which enable production (prefabrication) of modules of construction partitions with a high thermal resistance and low embedded energy.
3. Machines and devices reducing energy and labour consumption within a construction process and improving work safety.
4. Devices and systems for energy management, allowing automatic and fluent utilisation of numerous power supply sources in buildings.
5. Devices and systems for supplying building with direct current (DC).
6. BMS/HMS (Building/Home Management System) controllers installed permanently in household appliances/lightning, adjusted for cooperation with the BMS.
7. Devices and systems for conversion, storage and utilisation of renewable and waste energy.
8. Devices integrating systems for energy conversion and storage.
9. Micro or small scale devices with a high level of efficiency for transforming energy of the environment into electricity, heat, and cold for applications in construction.
10. Devices and systems of rationalisation of utilisation, obtaining, purification and treatment of water.

IV. DEVELOPMENT OF APPLICATIONS AND SOFTWARE ENVIRONMENT

1. Establishing an open Software Development Kit, which would enable creating higher-level applications in a graphic form, intended for control over operation of devices in smart buildings and interactions between particular devices in a network.
2. Integrated diagnostic applications for remote monitoring and inspection of BMS/HMS systems.
3. BMS/HMS applications/systems/interfaces improving safety, supporting buildings operations and increasing life quality of elderly persons with partial disability and disabled individuals (deaf, deafmutes, with motor disabilities).
4. Development of standards for communication and data exchange between active elements of smart buildings and local systems.
5. Designing, constructing and testing communication modules ensuring data exchange and management of active elements of smart buildings.
6. Designing, constructing and testing integrated energy management systems for autonomous local systems.
7. Designing, testing and introducing algorithms for optimisation of resources management for autonomous local systems.

V. INTEGRATED DESIGN

1. Development and standardisation of libraries supporting BIM
2. Design methods and tools leading to a Smart Design, including use of computer simulations techniques, BIM (Building Information Modelling), at all design stages (development of tools supporting the design, modelling and simulation processes for energy efficient buildings, both from the side of applied technologies and simulation of an economic result, and outlays/time for return of investment).

VI. ENERGERIC AND ENVIRONMENTAL VERIFICATION

1. Programs supporting and automatising energetic audits for the facilities that undergo modernisation and monitoring of results.
2. Development of tools for energetic and environmental verifications in terms of embedded energy consumption and the application of the Life Cycle Assessment method.
3. Validation of integrated zero-energetic construction systems in real exploitation conditions (“a network of experimental buildings” in various systems).
4. Methods and tools for quality assessment of elements of buildings (existing or under construction), allowing to determine the real characteristics of the objects.
5. Research, technologies related to impact of buildings infrastructure systems on health and work efficiency.
6. Innovative system for polygonal control of parameters of construction products influencing the final energetic effectiveness of a building.

VII. MATERIALS PROCESSING AND RE-USE

1. Development of a technology for re-use of materials and construction/insulation elements (recovery, including recycling) in the building industry.
2. New technologies and technological lines for manufacture of building materials and products using complementary raw materials, by-products and waste.

NSS 6. ENVIRONMENT FRIENDLY TRANSPORT SOLUTIONS

I. INNOVATIVE MEANS OF TRANSPORT

1. Optimisation of means of transport through reduction of their weight and dimensions, with preserving their functionality (reduction of energy consumption and emission of contaminants, materials consumption, improvement of efficiency).
2. Intermodality of means of transport, including diffusion of technical and technological solution between transport systems.
3. Infrastructure for exploitation of innovative means of transport.
4. Modular construction of means of transport, including exchange of driving units.
5. Special and specialized means of transport, including unmanned units.
6. Means of transport powered with alternative energy sources, along with infrastructure for their operation.
7. Autonomous means of transport.

II. PROECOLOGICAL CONSTRUCTION SOLUTIONS AND COMPONENTS IN MEANS OF TRANSPORT

1. Alternative drives and power sources in transport, including contactless induction systems for energy transmission to means of transport.
2. Drives employing renewable energy sources and waste and biofuel energy sources, as well as electric drives.
3. Innovative systems and components for processing, including energy recovery and storage.
4. Optimisation and improvement of structure and functionality of components in means of transport.
5. Innovative systems for recycling, recovery and utilisation.
6. Innovative systems for reduction of harmful emission.
7. Creating and development of safety systems for means of transport.
8. Innovative elements of means of transport equipment.
9. Biomechanical systems in elements of the means of transport equipment.

III. TRANSPORT MANAGEMENT SYSTEMS

1. Organisational and technical measures allowing realisation of preferences for mass transport.
2. Organisational and technical measures allowing realisation of preferences for ecological means of transport.
3. Organisational and technical measures allowing development of road transport of goods.
4. Development of intelligent transportation systems, including *inter alia* modal transport and optimal energy management.
5. Smart proecological management systems for the access to protected zones.
6. Smart management systems for traffic safety in transport.
7. Systems of communication between the means of transport and the environment.
8. Systems minimising impact of the means of transport on the environment, including systems and technologies for evaluation of the influence of the means of transport on health and safety.

IV. INNOVATIVE MATERIALS IN THE MEANS OF TRANSPORT

1. Innovative metal materials.
2. Innovative polymer materials.
3. Innovative composite materials.
4. Innovative coverings and coatings.
5. Innovative hybrid materials, including organic sheets or bionic structures.
6. Innovative materials based on recyclable raw materials.

7. Innovative exploitation materials, including low-emission energy carriers.

V. INNOVATIVE PRODUCTION TECHNOLOGIES FOR THE MEANS OF TRANSPORT AND THEIR PARTS

1. Modification and construction of new technological lines and production systems for means of transport, components and parts, including recycling.
2. Innovative systems for designing and assessment of the quality in terms of: methods, techniques, measuring infrastructure and procedures related to (technical) quality control at all stages of production, and finished products, including assessment of their functional qualities using modern measuring techniques.
3. Innovative systems for logistics and supply chain management.
4. Innovative systems for management of knowledge and information flow in enterprises.
5. Innovative methods for limiting the influence of production processes on the environment.
6. Innovative technologies of production, including the technologies of joining, modelling and processing.

NSS 7. CIRCULAR ECONOMY – WATER, FOSSIL RAW MATERIALS, WASTE

CE is the economic model in which – while maintaining the condition of efficiency – the following basic assumptions are fulfilled:

- a) Value added of raw materials/resources, materials and products is maximised or
- b) Amount of produced waste is minimised and waste is managed in accordance with the hierarchy of ways to handle waste (prevention of waste formation, preparation for reuse, recycling, other recovery methods, disposal).

These assumptions should be met at every stage in the lifecycle (acquisition of raw materials, ecodesign, processing and production, waste and waste water, substitution).

The National Smart Specialisation *Circular Economy* (NSS CE) – *water, fossil raw materials, waste* indicates the preferential areas of support for research, development and innovation work (R&D&I) for the transformation of the Polish economy towards the circular economy model. This change involves not only technological and product innovation, but also new solutions, including system, legislative, organisational, financial and educational, having regard to the value chain and all stakeholders.

I. ACQUISITION OF RAW MATERIALS

1. Rock raw materials
 - Technologies and processes of remediation and reclamation of post-exploitation areas of rock raw materials
 - New technological solutions allowing to improve the explosive rock working technology
 - Innovative tools and technical solutions for high-performance hard rock working in open-cast mines.
2. Metallic raw materials
3. Hard coal and lignite
 - Innovative technologies to improve the efficiency of operation of bucket ladder excavator – belt conveyor flight – dumping conveyor systems
 - Models, algorithms and software to improve the efficiency of multi-bucket wheeled excavators in conditions of exploiting low thickness beds
 - Innovative solutions and technologies for selective working of multi-bed deposits using multi-bucket wheel excavators
 - Innovative technologies to exploit hard-to-work rocks in the lignite-mining industry
 - Innovative solutions to improve the efficiency and safety of operation of basic machinery in the mining industry.
 - New solutions allowing to adapt exploitation technologies to geological and mining conditions
 - Modern methods to detect and counteract serious risks, *inter alia*, related to landslides, fires, water, etc
 - Models, algorithms and software to improve and model/forecast the energy intensity of extraction processes
 - Innovative technologies to control the extraction (extraction technology taking into account the effort of machinery, IT support for management of extraction and mine traffic)
4. Natural gas
 - a. Technologies to explore, recognise and manage natural gas deposits:
 - Modern technologies to explore and recognise unconventional gas deposits
 - Smart monitoring of deposits and decision support systems in the process of exploration and management of deposits
 - Local management of gas from deposits unfit for inclusion in gas networks
 - Innovative methods to recognise deposits of gas hydrates, including marine geophysics
 - Innovative tools dedicated to surface geophysics (apparatus, sensors, detectors)

- b. Innovative technologies to exploit deposits and intensify extraction:
 - New drilling technologies to share old and partially exploited deposits
 - Modular, container drilling systems as elements of smart gas mines
5. Crude oil
- Technologies to explore, recognise, extract and exploit conventional and unconventional crude oil deposits
- Extraction techniques and technologies to maximise the extraction of deposits
 - Integrated methods to analyse petroleum pools for hydrocarbon detection
 - Production intensification techniques (secondary and tertiary methods: injection of water, surfactants, CO₂, microbiological and chemical methods)
 - New technologies to share deposits, including tight oil
 - Automated, unmanned crude oil mines (smart oilfields)
6. Water
- Solutions for improving the ecological status of degraded rivers, water and water-dependent ecosystems (renaturalisation and revitalisation), whose objective is to reduce the grey water footprint (including combating eutrophication)
 - Techniques and methods to revitalise small reservoirs and watercourses allowing to increase water resources ecosystem
 - Biochemical remediation and storage of surface waters with hydrodynamic infiltration for the stabilisation and protection of aquiferous levels being exploited
 - Solutions for the effective protection of main groundwater reservoirs from anthropogenic threats in post-industrial and degraded areas
 - Biomonitoring and bioindication techniques of water resources
 - System solutions in building database resources and integration of distributed data sources as components of the national resource data on the state of the environment
7. Horizontal issues
- a. Minimisation of waste generation
 - Waste-free or low-waste innovative technologies to acquire raw materials
 - Methods, tools, processes and technologies limiting waste generation at the stage of acquisition of raw materials
 - Reduction in the amount of generated waste by its selective acquisition at the stage of the extraction of raw materials
 - b. Preparation for reuse
 - c. Substitution
 - New metallic and composite materials, focused on the production of substitutes for critical and dangerous metals

II. ECODESIGN

1. Creating resource-efficient and energy efficient products, new, improved, reworked or renewed
2. Creating products using raw materials recovered from waste and waste water
3. Increasing the durability and extending the life of equipment and products used
4. Providing substitutes for substances which are hazardous, complex and cumbersome in the recycling process
5. Developing substitutes for non-renewable resources and water
6. Ensuring new applications and/or reuse of products, parts thereof, materials

III. PROCESSING AND PRODUCTION

1. Rock raw materials: technological solutions to control quality of products from plants processing rock raw materials
2. Metal-bearing raw materials

- a. New technologies and devices to enrich metal-bearing mineral resources
 - Technologies for recovery of metals from ores with difficult beneficiation characteristics
 - Technologies for comprehensive recovery of useful components from anthropogenic secondary raw materials
 - Innovative technologies for enrichment of low-quality polymetallic ores
 - New designs of equipment for enrichment of mineral resources
- b. Metallurgical (pyro- and hydrometallurgical) technologies for production of non-ferrous metals from primary and secondary raw materials:
 - Innovative technologies for smelting and refining of metals.
 - New solutions in the design of energy-efficient metallurgical aggregates for smelting of ores and metal concentrates as well as for processing of products of smelting
 - Technologies for recovery of metals from waste and semi-products from metallurgical processes (slags, dusts, sludges)
 - Recovery and conserving of waste energy from technological gases from metallurgical aggregates and from solid and liquid materials
 - Development of methods for leaching, including pressure leaching, of ores and concentrates.
 - Innovative methods for selective extraction of metals from aqueous solutions (precipitation, ion exchange, electrochemical)
 - Hydrometallurgical methods for recovery of by-product metals, including critical metals
- c. Innovative technologies of deep metal processing, including:
 - Production of functional materials by liquid phase methods.
 - Development of new casting alloys of improved parameters in relation to existing alloys (new methods of controlled crystallisation and structure fragmentation, selection of new alloy additives).
 - Formation of the structure and properties using plastic working methods, heat treatment and thermo-chemical treatment.
 - Production of powder metallic and composite materials with the application and development of techniques for atomisation, high energy milling, mechanical, chemical and plasma chemical synthesis.
- d. Modification of existing and new technological lines and devices for metal processing in a continuous way, reducing the number of separate technological operations, resulting in fabrication of nanostructured products
- e. Innovative technologies for processing of metals, manufacturing and application of protective and functional layers using chemical and electrochemical methods, thermal spraying and laser-based functionalisation of surfaces:
 - Methods and materials for the protection of steel constructions against environmental factors
 - Utility coatings for the modern construction industry and new engineering applications
- f. Processing of refractory metals, with particular focus on domestic raw materials
3. Hard coal and lignite
 - Technologies of gasification, thermal decomposition using the thermolysis and pyrolysis methods, drying and production of liquid fuels by direct liquefaction of hard coal and lignite
 - Enrichment of low quality coals through the use of pyrolytic conversion
4. Natural gas
 - New technologies to produce and adapt gaseous fuels to network parameters
5. Crude oil
 - a. Crude oil processing technologies:
 - Techniques and technologies to maximise yields of white products.
 - Techniques and technologies to optimise the conversion of processed crude oil

- Techniques and technologies to optimise management of by-products and waste from crude oil processing
 - Technologies to manufacture products of improved quality and of niche products
- b. Use of new materials and technological solutions:
- Technologies and materials to optimise energy processes (possibility of functioning of processes in high temperature and pressure areas) minimising process losses, enabling better yields
 - Technologies to use natural gas in crude oil processing processes (including hydrogen production)
6. Water
- a. Improvement in quality
- Water treatment through innovative technological methods and designs of devices and the use of new generation reagents allowing to minimise the consumption of natural raw materials as well as to use secondary raw materials
 - Control of water treatment processes, tests and methods to assess the quality of water and tools and IT control systems of the state and water quality monitoring
 - Methods, processes, materials (including raw materials) aimed at keeping the biochemical stability of water and minimising the amount of by-products (and waste) formed during water disinfection processes.
 - Methods and processes to remove anthropogenic pollutants from water (pharmaceuticals, plant protection products, hormones, heavy metals), precursors of hazardous secondary pollutants and biodegradable fractions of organic pollutants
 - Methods, processes, materials and system solutions used in water treatment and recovery technologies in emergency situations
 - Methods, processes, and technologies to purify groundwater from pollution with hydrocarbons and other chemicals
 - Modelling and intensification of water treatment processes in hybrid systems
 - New measurement techniques and study methods to identify micropollutants in water.
- b. Use
- Technologies to recover and use rainwater, geothermal, saline and brackish waters, leading to the production of water intended for consumption and economic purposes
 - System solutions in the field of closing and integration of water circuits and recirculation of technological waters in municipal and industrial systems as part of industrial symbiosis
 - Technologies to limit losses in water distribution systems
 - IT monitoring systems aimed at improving the efficiency of using water resources
 - Metering and monitoring technologies to increase the efficiency of using water resources, i.e. reducing water consumption and losses in water-supply systems with the use of information and communication techniques as well as spatial information systems
 - Technologies of small retention and use of rainwater in urban and rural areas, as well as in technological circuits and for economic purposes
 - Smart systems to collect and drain rainwater that integrate the potential of natural, quasinatural and channel (infrastructure) retention
 - Engineering, spatial and organisational solutions of retention, treatment and management of rainwater in urban space and in low-urbanised areas as an alternative for “collect and drain” solutions
7. Horizontal issues – minimisation of waste generation
- Waste-free or low-waste innovative production/processing technologies
 - Methods, tools, processes and technologies limiting waste generation
 - Reduction of the amount of generated waste by its selective acquisition at the production stage
 - Minimisation of waste generation by the introduction of innovative materials
 - Minimisation of the formation of by-products of burning energy raw materials

IV. WASTE AND WASTE WATER

1. Innovative technologies for the recycling of waste

- Technologies for waste treatment by mechanical, thermal, cryogenic, biological, microbiological, physical and chemical methods
- Technologies for protection of waste treatment processes
- Waste treatment technologies, influencing the reduction of emission of CO₂ and other greenhouse gases into the atmosphere
- Technologies for recovery of scarce and critical raw materials from waste
- Technologies for processing of multi-material, multi-layer and composite waste
- Management of products from thermal processing of waste, *inter alia*, pyrolysis, thermolysis, gasification, plasma technologies, etc.
- Recovery technologies including recycling of metals from waste
- Technologies to process post-production and post-exploitation waste
- Technologies for treatment of difficult-to-process waste coming from end-of-life vehicles and WEEE
- Technologies for processing of waste from mining of energy and non-energy raw materials and mineral waste
- Devices and equipment for recovery applications, including recycling of waste
- Technologies for management of materials produced in waste treatment
- Selective technological processes for recovery of chemical compounds from highly processed waste
- Waste-based multi-material and composite products for application in different branches of economy

2. Innovative technologies of material recovery from waste water

- Technologies to recover nitrogen and phosphorus from process streams and their reuse
- Technologies to recover and biosequester non-organic carbon from process (also gaseous) streams
- Technologies to recover trace elements and metals from process streams
- Technologies to recover organic compounds (*inter alia*, cellulose, PHA) from process streams
- Solutions allowing to use industrial waste water streams carrying a load of organic compounds as substrates in processes of heterotrophic waste water treatment
- Technologies to manage raw materials formed in the sludge part of waste water treatment plants.
- Closure of water-waste water circuits, with the use of initially treated waste water, treatment of post-processing water for municipal and industrial purposes.

3. Innovative technologies to treat waste water and recover water from waste water

- Waste water treatment through innovative technological methods and designs of equipment and the use of new generation reagents and preparations
- Methods, processes, materials for removing persistent organic pollutants (POP) from waste water, including biological active substances.
- Development of methods of waste water disinfection with regard to reducing the possibility of formation of harmful by-products
- Nanotechnologies in waste water treatment
- Enhanced high-efficiency methods of anaerobic treatment of waste water, including integrated anaerobic-aerobic systems
- Water and waste water treatment technologies in the mining industry
- Methods, tools and processes to reduce the amount of nutrients introduced into surface waters, including the use of industrial water tanks as biological treatment plants of surface waters
- Technologies of individual wastewater treatment systems including removal of biogenic compounds and enhancing removal of organic pollutants, as well as leading to obtaining the technical and technological reliability and allowing to control the effects of treatment
- Increase in the efficiency of waste water treatment and sludge conditioning processes

- Smart measurement systems, IT programmes for monitoring the quality of waste water and for controlling waste water drainage systems and treatment processes
 - Modelling of treatment processes and waste water and rainwater drainage systems
 - Methods, tools, equipment and processes leading to improved waste water management of rural areas and areas with dispersed development
 - Technologies to minimise and remove substances contaminants of emerging concern
 - Reducing water consumption through the development of systems of recovery and utilisation of “grey water”
4. Use, recovery and optimisation of energy consumption in water and waste water management
- Implementation of solutions to optimise energy consumption, including the use of renewable energy sources in water and waste water management
 - Technologies to use waste water and sludges as substrates to obtain energy
 - Technologies to dispose of waste water sludges with organic co-substrates in order to increase the energy efficiency of waste water treatment plants
 - Innovative systems combining energy from renewable sources with waste water treatment processes in backyard treatment installations and other dissipated installations to store and treat waste water
 - Development and implementation of technological solutions to use energy from waste water in combined energy systems, including waste water treatment systems integrated into recovery of water and heat
5. Innovative technologies of energy recovery from waste
- Technologies of optimal generation and use of alternative fuels obtained from waste (excluding RDF)
 - Technical development of power generators, gas turbines, furnaces to safely burn fuels obtained from waste
 - Innovative solutions to recover energy from waste exclusive of burning and co-burning
 - Technologies to recover products from waste using the thermal decomposition method
6. New safe methods to dispose of waste
- Technologies to secure waste through mineralisation, solidification and stabilisation
 - Technologies to protect from emission of gases, odours and from dusting
 - Technologies to store waste impossible to use in other management processes

INNOVATIVE TECHNOLOGIES AND INDUSTRIAL PROCESSES (HORIZONTAL APPROACH)

NSS 10. MULTIFUNCTIONAL MATERIALS AND COMPOSITES WITH ADVANCED PROPERTIES, INCLUDING NANOPROCESSES AND NANOPRODUCTS

I. ADVANCED MATERIALS AND NANOTECHNOLOGIES FOR MEDICAL PURPOSES AND HEALTH CARE AND HYBRID MATERIALS INVOLVING LIVING TISSUES AND CELLS

1. New materials, including composite and nanostructural materials and innovative technologies of their production in the scope of 3D printing technologies and hybrid biodegradable polymer materials with controllable bioactivity, hybrid fibre structures for regenerative medicine applications, polymer nanocomposites and nanocomposite fibres, for medical and hygienic purposes, for innovative medical and dental equipment, instruments and products, for providing and supporting medical diagnostics, as well as treatment and methods in the area of regenerative medicine.
2. New materials, including composite and nanostructural materials used for manufacturing medical and dental products and implants, as well as stents with varied chemical and phase composition of the core and outer layers, characterised by anisotropic and biomechanical properties, biocompatibility, biodegradability, adjustable degradation time, as well as nanocomposite materials used for porous scaffolds for cell cultures and innovative technologies for their production based on 3D printing, hybrid and surface engineering methods and involving tissue engineering methods.
3. New materials, including composite, nanostructural and hybrid bio-engineered materials involving living tissues and cells, used for medical implants, including dental implants, stents, artificial organs and hybrid bio-engineered implants, and innovative technologies for their production based on 3D printing and hybrid methods.
4. New composite and nanostructural materials acceptable by the human body, used for medical nano- and microimplants, biocompatible fluorescent nanomarkers, for nanoencapsulation of pharmaceuticals, for applications in bioimaging and drug transport, for diagnostic and treatment purposes, enabling creation of smart medical and telemedical nanolaboratories, as well as development of innovative technologies for their production.
5. New smart composite and nanostructural materials for dressings, for surgical and hygienic products, enabling dosing of drugs and nanopharmaceuticals, with adjustable time of biodegradation and separation from bed, as well as innovative technologies for their production.
6. Technologies and nanotechnologies of special-purpose surface and nanostructural layers for products used for medical instrument system and medical and dental implants, as well as in food sector equipment.

II. ECOMATERIALS, COMPOSITE AND NANOSTRUCTURAL BIOMIMETIC, BIONIC AND BIODEGRADABLE MATERIALS

1. New functional materials, nanomaterials and nanocomposites for natural environment protection, including protection against pollution and greenhouse gas emission, used in low emission systems and for strategic substitution of environmentally hazardous materials, with materials free from harmful substances, ensuring good environmental protection, more suitable for recycling, and innovative technologies for their production.
2. New materials, technologies and constructions for material, technological and construction conversions in view of ensuring sustainable development, reduction of manufacturing costs and energy consumption, elimination of harmful substances or their emission, reduction of consumption of scarce elements, as well as development of related engineering design methods and computer-assisted engineering design methods.
3. New cost-effective materials and nanomaterials, including alloys and structures relevant for environmental development, for water filtration, for moisture or fog absorbers, solar collectors, solar cookers, thermoelectric roof tiles using diffused solar radiation, as well as innovative technologies of their production.

4. New composite and nanostructural ecomaterials with adjustable time of degradation or resorption from natural raw materials, biopolymers reinforced with fibres of plant origin and subject to controllable biodegradation.
5. New and bio-inspired technologies, metal materials and constructions and their superhydrophobic surfaces, for vessel-shaped cooling channels, hierarchical alloys/foams/composites, and new multifunctional biomimetic and bionic materials, nanomaterials and nanocomposites and new multifunctional structural composites and nanocomposites, bionic layers and structures, as well as innovative technologies for their production.

III. ADVANCED MATERIALS AND NANOTECHNOLOGIES IN RENEWABLE ENERGY AND FOR TRANSFORMATION, STORAGE AND RATIONALISATION OF ENERGY MANAGEMENT

1. New multifunctional materials, nanomaterials and nanocomposites for production, transformation, storage and rationalisation of energy management.
2. New advanced materials, nanomaterials and nanocomposites for highly efficient photovoltaic energy production based on mono- and polycrystalline silicon, inorganic and organic materials, used for production of perovskite and dye-sensitised cells, involving conductive polymers and antireflection coatings containing particles, thin coatings, carbon nanotubes and graphene, heat transfer fluids, multiphase materials, receptors and their combinations, as well as innovative technologies for their production.
3. New advanced materials, nanomaterials and nanocomposites ensuring integration of grid energy storage technologies, as involving advanced functional particles, fibres, layers, coatings, in order to integrate mass storage equipment within an electric network, and based on using high-capacity cables and superconductors, high-voltage cables and accessories, materials for medium-voltage and electrical accessories, smart new materials for extreme conditions and surface treatment of existing materials to protect and improve performance in the context of grid energy storage and new copper-, silver or aluminium-based composites, containing various allotropic forms of carbon, including graphene, intended for applications in the power industry, for heat dispersing materials, low- and high-voltage joints, power transfer wires.
4. New advanced materials, nanomaterials and nanocomposites ensuring the choice of energy storage methods through transformation of electricity to chemical energy carriers, materials for durable high-capacity proton transfer membranes, hydrogen generators using high-pressure electrolysis, for permanent low-pressure hydrogen storage and direct hydrocarbon synthesis, for photochemical water splitting reactors using new catalysts based on advanced materials.

IV. MULTIFUNCTIONAL COMPOSITE AND NANOSTRUCTURAL, ULTRALIGHT AND ULTRADURABLE MATERIALS WITH RADICALLY IMPROVED HEAT RESISTANCE AND HEAT CREEP RESISTANCE

1. New advanced light construction materials, nanocomposites and nanocomposites, characterised by improved mechanical properties, composites with metal warp reinforced with micro- and nanostructures, containing various light components, such as Mg, Al, Ti in construction and heating applications, and as Cu, Al, with a low friction coefficient, wear-resistant, shock-resistant, for electric applications, as biocompatible materials, new low-density and high-resistance materials, very plastic steels and alloys, polymer and composite layered materials and high-resistance foams with a reduced unit mass, as well as their innovative technologies.
2. New advanced light high-resistance intermetallic materials in the scope of aluminides, silicides and ductile lanthanides and cerments, new nanocrystalline Mg, Al or Li hydrides characterised by high absorption and desorption kinetics for hydrogen storage, materials, nanomaterials and nanocomposites, as well as precipitation-hardened core-coating Al-Li-Sc, Al-Mg-Sc alloys for high-resistance specialised elements and their innovative technologies.
3. Technologies of advanced light and new solid metallic glasses based on Mg, Al, Ti, Fe and amorphous, nanocrystalline and crystalline composites and nanocomposites for applications for specialised construction, functional or biomedical wear- and corrosion-resistant elements and microelements, as well as their innovative technologies.

4. Technologies of advanced ultralight new wear-resistant cell structures with metal, polymer, ceramic and composite warping and hybrid cell structures, metal foams, micro- and nanoscaffold, grid and hybrid constructions.
5. New advanced materials, including compound metal alloys characterised by high entropy, which ensures unique structural properties and greater phase stability for hightemperature applications, heat-resistant alloys of W, Ta, Re, Hf, Nb, Mo, V and platinum-group metals for operation in the most extreme high-temperature and oxidising environments and for thermonuclear applications, as well as new metallic-ceramic composite materials with unique properties and their innovative technologies.
6. Technologies of new advanced fine-grained superplastically deformed Ti or Al alloys and of high-resistant super-bainite steels grade TRIP, TWIP and TRIPLEX, new ODS steels and bearing steels.
7. Technologies of new advanced light composites with fibre-reinforced polymer warping and hybrid composites, which improve mechanical properties and reduce the mass of the final product.

V. ADVANCED MATERIALS AND NANOTECHNOLOGIES FOR APPLICATIONS RELATED TO SAFETY

1. Technologies of new advanced polymer and hybrid materials, nanomaterials and nanocomposites with fibre reinforcement characterised by improved mechanical properties and reduced mass, using spatially formed fibre structures, with a 3D-printing formed structure, reinforced additionally with inorganic or organic fibres and integrated with sensors, for personal protective equipment and smart specialised clothing.
2. Technologies of new advanced multilayer composite and hybrid materials based on surface engineering technologies, using laser technologies, and of ceramic-metal composite materials.

VI. ADVANCED MATERIALS AND NANOTECHNOLOGIES FOR PRODUCTS WITH HIGH ADDED VALUE AND HIGH SIGNIFICANCE FOR VALUE CHAINS IN INDUSTRY

1. New methods of production of sintered and ceramic materials, including superfine-grained materials, and innovative products manufactured with those technologies, methods for powder metallurgy and productions, in the scope of atomisation, cold spraying, extrusion forming and coating, other innovative forming techniques, incremental sheet forming, blast forming or creep forming, isostatic densification, new processing technologies and increase in metal production and their forming process, near-net-shape precision processing, thermal processing, thermal-plastic and surface processing, as well as joining and recycling techniques.
2. New incremental technologies, technologies of laser selective sintering and melting as well as 3D printing, along with proper devices, new innovative solid and porous materials, including hybrid and gradient materials with properties gradient or properties transforming in a designed manner in relation to their volume, or anisotropic layer composites with continuously transforming compositions, from metal to ceramics, or with various compositions and core and surface properties, composites composed of materials differing in physical and chemical properties, melting point, heat conductivity, absorptivity, regarding heat creep resistance requirements, wear resistance, passivation abilities, corrosion resistance, innovative materials with geometrically designed internal structure, filled with grid and rod structures, or layer materials with special mechanical properties, controllable rigidity or elasticity, vibration damping or dispersing capacities, to a degree other than may be allowed by the qualities of the base material alone, hybrid materials volume- or surface-doped with powders differing in their size or composition from the base material.
3. Innovative technologies for manufacture of unit or small batch products, with new functionalities, characterised by a complex shaped, with adjustable porousness, “smart” products through integration with sensors and effectors, with short time of implementation into the production process, multi-material products and products from materials impossible to be produced with other technologies, from components with varied melting and boiling points, for application in various sectors of industry and economy, as well as in medicine and health care.
4. New innovative technologies for production and processing of nanocrystalline multifunctional alloys with methods of plastic deformation by twisting, cyclical squeezing, multiple angular channel pressing, with hybrid rolling methods, hydrostatic squeezing and alternate forging, in relation to various construction

elements, through pressure casting with infiltration, microcasting and imprinting of alloys, composites and solid metallic glasses, used for dedicated elements of microdevices, integrated electromechanical MEMS microsystems, as well as nanostructural matrices and surface hierarchic coatings, in Cu, through electrolytic settlement to be applied in boilers, heat exchangers and pipelines.

5. New advanced hybrid technologies for materials and final products related to nanostructure and nanofunction forming during the standard process for finished or semi-finished products, in crystallisation additives in nanoparticles during injection moulding of a metal layer or during forging or independent creation of hierarchical structures while coating, in order to produce non-standard finished products or semi-finished products from advanced materials, nanofoams and nanocomposites, following the provision of an increased level of reliability and repeatability of industrial processes.
6. New and developed microfluidisation devices based on polymer materials through 3D printing or injection of polymer or ceramic materials, during the production of microflow integrated electromechanical MEMS microsystems, for nozzles and filters, applied for sensors, lab-on-chip systems, printed biochemical materials, soft beds for biological micro- and nanoapplications, biomedical and biophysical sensors, biocompatible or non-toxic scaffolds for active cell growth, and also in order to reduce costs of quick production and prototyping of a new series of single-use products, where production costs have to be reduced to minimum, and in order to use them for practical applications after shifting from the laboratory or small-batch scale to industrial applications simultaneously to the growth in the level of reliability and repeatability of industrial processes.

VII. MATERIALS, NANOMATERIALS AND FUNCTIONAL COMPOSITES WITH ADVANCED PHYSICAL-CHEMICAL AND UTILITY QUALITIES

1. Technologies for production and processing of new advanced smart materials, nanomaterials and nanocomposites, integrated in 2D and 3D forms, advanced light composites in polymer, metal, organic fibre and textronic warping, as well as metal materials, involving carbon nanoparticles, in order to provide new functionalities, communicating and cooperating with the environment, archiving data on its state and reacting to external stimuli, changing their physical properties, viscosity, shape, colour due to changes in temperature, tension, electric field, solar energy, having the capacity to collect, store and transfer data, to be used for sensors in self-diagnosing elements, elements that identify damages on their own or can repair themselves during exploitations, for functional composite gradient materials with variable magnetic purposes, for vibration and sound damping, conductive polymers generating heat energy.
2. New advanced functional materials with non-standard electric and heat conductivity, intended for industries producing final products, for condensers, thermal coatings, insulation panels of energy-efficient buildings, and with application of new production devices and processes of incremental technologies and 3D printing, in order to advance integration with multifunctional nanomaterials and their utilisation in practical applications on a big scale, much bigger than the previously limited niche applications, after moving from laboratory scale to industrial applications, together with an increase of reliability and repeatability level of such industrial processes.
3. New innovative technologies for production and processing of nanostructural advanced materials with new functionalities, superhydrophobic, self-cleaning, self-repairing systems, smart biomimetic textiles and papers, with controllable shape change and memory, self-organising systems acquiring energy, intended for industrial and economic sectors relevant for industrial design, in order to obtain added value for products through application of new material and non-material functionalities, as well as designing and producing radically new products with a strong market competitive advantage.
4. New technologies that enable application of paper and textiles for functional electronic elements or devices, with promising technical, economic and environmental advantages, for smart displays for labels, packaging, biological marks, in medicine in relation to development of lab-on-chip and interconnected development of new production technologies for paper and textiles, with use of reinforcement fibres and fillers, with provision of a required level of porosity and development of new paper and textiles, with proper organic, inorganic or hybrid layers, processing and functionalisation of paper and textiles surface with use of nanocellulose, plasma or gas, and introduction of new materials, including conductive materials, insulator semiconductors, electrochromic materials, electrodes for batteries as well as print that is highly precise and

profitable, or other large-scale production technologies, with application for ink printers and in roll-to-roll processes.

5. Advanced multifunctional smart nanostructural materials to be applied in electronics, optoelectronics, sensorics, IT, photonics and communication, and their technologies.

VIII. MULTIFUNCTIONAL COMPOSITE NANOMATERIALS WITH WARP OR STRENGTHENING FROM NANOSTRUCTURAL CARBON MATERIALS AND OTHER NANOFIBRES, NANOWIRES AND NANOTUBES AND THEIR TECHNOLOGIES

1. Technologies of advanced multifunctional nanostructural and nanocomposite materials, including those in metal, polymer and ceramic warp, with strengthening from various kinds of carbon nanostructural materials, nanotubes, fullerenes, nanofibres, graphene, together with development of production scale from laboratory to industrial, with improvement of reliability and repeatability of relevant industrial processes, and other organic and inorganic natural materials, halloysite and synthesized substances, titanium dioxide, nanowires, nanofibres, nanotubes and other nanostructural objects, in order to obtain an added value of products and unexpected results in a form of improvement of mechanical and physical-chemical properties through application of new material and non-material functions, as well as design and production of radically new and significantly developmental products with a strong competitive market advantage.
2. Technologies for advanced multifunctional nanostructural and nanocomposite materials with a warp of various types of carbon nanostructural materials, nanotubes, fullerenes, nanofibres, graphene, decorated with precious metals nanocrystals, applied for nanosensors, with nanolayers of polymer complexes applied on fibres in order to embed metals into the surface and change its qualities – heat, bactericidal and catalytic, use as reactors for matrix polymerisations, together with development of a production scale, for use in nanosensorics, nanoelectronics, nanoencapsulation of medicines, in order to obtain added value of products, through use of new functionalities and production of radically new and highly developmental products.

IX. MULTIFUNCTIONAL LAYERS AND PROTECTIVE AND ANTIWEAR NANOLAYERS AND SPATIAL, LAYERED AND SELF-REPAIRING COMPOSITES AND NANOCOMPOSITES

1. New technologies for surface processing through surface shaping and applying layers, *inter alia* nanostructural layers, including applying self-assembled monolayers, immobilisation, templating, and applying diamond layers and diamond-like carbon coatings and electrophoretic and sedimentation settlement, providing good biocompatibility and corrosion resistance of coatings, and a possibility of applying them to elements of highly-complex geometries, in relation to production of innovative devices, instruments and medical and dentist products.
2. New nanotechnologies for processing of anti-bacteria surfaces through use of surface coatings or modification of surface morphology, for use in hospitals on surface layers of furniture, equipment and medical devices, surgical implants, as well as in water treatment systems, textiles, packagings, to storing food and on household appliances, and their utilisation for practical purposes after moving from laboratory scale to industrial applications, along with increasing the level of reliability and repeatability of relevant industrial processes.
3. New technologies of surface processing through shaping the surface and applying layers – *inter alia* nanostructural ones – through physical and chemical embedment of coatings from a gas phase (PVD/CVD), implantation of ions and coating with ceramics and cermets in relation to metal construction materials, and physical and chemical application of coatings from a gas phase, embedment with impulsive laser or through EUV laser and plasma sources radiation, and with a sol-gel method and through electrophoretic embedment in relation to non-metal construction elements, applied in various industrial sectors, mainly in machinery and electro-machinery, and application of powder polymer coatings, painting and lacquering with liquid polymer materials, hot dip galvanizing with additional annealing, application of layers from polymer foils and metal spraying, through laser ablation (PLD), hybrid technologies, with participation of laser processing, the method of gradient coatings application, physical and chemical application of coatings from a gas phase (PVD/CVD), in relation to materials for instruments.

4. New nanotechnologies for surface processing through application of nanostructure coatings or nanotexturisation of surface, in order to provide increased resistance to scratch and abrasion, high hardness, resistance to wear and corrosion, colour or gloss, for self-cleaning surface of buildings, for technical textiles coatings with increased resistance and mechanical properties, for construction elements of machinery, structures and means of transport, in various sectors, including packagings, sea, water treatment, electronics, building industry, motor industry, energetics, in textiles and leather products, and their practical application together with an increase in the level of reliability and repeatability of relevant industrial processes.
5. New technologies for glass surface processing, micro- and optoelectronic and photovoltaic elements, and functional products manufactured from those materials, through shaping a surface and applying layers, *inter alia* nanostructural, through chemical and physical embedment from a gas phase (PVD/CVD), a sol-gel method, laser texturing, production of hybrid coatings – organic and inorganic, and new technologies for processing of surfaces of polymer and fibre materials, through creation of gradient and self-development coatings, polymerisation in situ, physical and chemical embedment of coatings from a gas phase (PVD/CVD), a sol-gel method, EPD and ALD, and surface laser processing, along with broader use of those technologies on an industrial scale.
6. New and developed nanotechnologies for processing flame retardant and anti-electrostatic surfaces through the use of surface coatings or modification of surface morphology, in order to eliminate or significantly reduce the accumulated charge in connection with flame retardant qualities, applied in places exposed to volatile substances explosion, in warehouses, mines and on landfills, and packagings, when storing volatile substances and their practical application after moving from the laboratory scale to industrial applications, along with an increase in the level of reliability and repeatability of relevant industrial processes.
7. The InnovativeNew multifunctional advanced structural, spatial, shell, layered composites and nanocomposites, with a gradient of qualities, with qualities transforming in a designed manner in their volumes or anisotropic materials and foams, with warp and/or strengthening of metal, polymers or ceramics, shaped with laser selective sintering and melting, and 3D printing technique, or through infiltration and impregnation, with innovative internal 3D geometrical structure, with both micro- and nanostructural strengthening, or strengthened with organic or inorganic fibres, carbon nanomaterials and natural nanotubes, with use of spatially formed fibre structures, thin textiles, or such filled with grid and rod structures, with structures of layers and bionic structures, honeycombed structure, with special mechanical and physical-chemical qualities, with elevated resistance, thermal and acoustic insulation, resistance to environmental impact, strikes and cracks, with low density, and innovative technologies for their production.

X. STRUCTURE MODELLING AND QUALITIES OF MULTIFUNCTIONAL MATERIALS AND COMPOSITES, INCLUDING NANOSTRUCTURAL ONES WITH ADVANCED QUALITIES

1. Computer aided design of materials, especially the newly introduced advanced materials, nanomaterials and nanocomposites, along with modelling in an atom scale and in a large scale, with simulation of microstructure and micro-mechanical properties, with use of virtual reality tools and artificial intelligence as well as data exploration methods, with a purpose of virtual designing, virtual processing and virtual testing of advanced materials for technical applications.
2. Modelling and simulating phenomena of degradation and damage to materials in exploitation conditions, in order to predict in conditions of virtual testing the behaviour of advanced materials in technical application.

NSS 11. SENSORS (INCLUDING BIOSENSORS) AND SMART SENSOR NETWORKS

I. PHYSICAL SENSORS

1. Spot and distributed optic fibre sensors, in particular employing microstructural optical fibres, for measuring physical quantities, in particular shape, deformation, temperature and others.
2. Technology and construction of sensors and detectors of electromagnetic and/or ionizing radiation.
3. Technology and construction of sensors employing ultrasounds.
4. Technology and construction of sensors and microsensors (MEMS/NEMS/MOEMS), including those for mechanical quantities (force, stress, deformation, acceleration, vibrations, position and others).
5. Development of flexible and/or printed sensors.
6. Technology and construction of sensors of electric and magnetic quantities.
7. Sensors for diagnostics of materials , including non-destructive tests.
8. Navigation systems in closed spaces.
9. Physical sensors for autodiagnosics of machines and equipment in M2M or M2H systems.
10. Sensors for weight and force measurements, including dynamic measurements.

II. CHEMICAL SENSORS

1. Development of new construction solutions and a technologies for producing chemical sensors, including the electrochemical, semiconductor, thermometric, mass, optic and optical fibre, lab-on-chip, spectrometer, resonance (MEMS/NEMS) and others.
2. Matrices of chemical sensors.
3. Chemical sensors for gases (photonic, conductometric and others).
4. Techniques and materials for functionalisation of chemical sensors
5. Chemical sensors, detectors and sensor networks for monitoring chemical and radiological safety and security.

III. BIOSENSORS

1. Sensors for measurements of bioelectrical parameters of the living organisms and biological structures.
2. Sensors for measurements of biomechanical parameters of the biological structures.
3. Techniques and materials for biosensors functionalisation.
4. Technology and construction of biosensors employing MEMS and NEMS structures.
5. Biosensors matrices.
6. Optoelectronic sensors employing biological structures (enzymes, proteins, nucleic acids and others).
7. Sensors for monitoring the vital functions of people operating in extreme conditions (firefighters, rescuers, policemen, athletes and others).
8. Sensors and sensor networks for telemedicine, including monitoring of human health.
9. Sensors for biomedical implants.
10. Sensors of biomedical signals for device and equipment control.

IV. SENSOR NETWORKS

1. Techniques of management, optimisation and self-organisation of sensor networks.
2. Security of sensors and sensor networks as well as security systems for data transmission and collection.
3. Localisation in sensor networks (localisation algorithms, techniques for localisation and creation of maps, in particular dedicated to areas of high risk and/or difficult propagation conditions).
4. Techniques for processing and collecting data for sensors and sensor networks.
5. Artificial intelligence techniques supporting the functioning and use of intelligent sensor networks.

6. Smart sensors and sensor networks employing acoustic, seismic, spectral and/or imaging techniques.
7. Development of sensors and sensor networks of Body Area Network type (BAN).
8. Development of new solutions for autonomising the functioning of sensor networks.
9. Sensor networks for monitoring the condition of the human environment.
10. Sensor networks for monitoring land, air and water traffic, including radars with a controlled beam.
11. Smart sensor networks supporting trade, in particular electronic, and systems integrating electronic sale channels with traditional channels.

V. HORIZONTAL (CROSS-SECTION) NOTIONS IN SENSOR TECHNOLOGIES

1. Electronic and IT technologies for sensor systems.
2. Innovative materials for sensor technology.
3. Techniques and systems for efficient energy consumption for autonomous sensors and sensor networks.
4. Instruments and systems for energy harvesting for sensors and sensor networks.
5. Sensor operating within harsh environmental conditions.
6. High resolution and high accuracy sensors.
7. Packaging and microassembling technologies for sensor and detector technology.
8. Integration and miniaturisation of heterogeneous and smart sensor systems.
9. Methods for improving reliability of sensors and sensor systems.
10. Sensors of physical and chemical quantities as well as electronic support systems working in harsh environment, including space conditions.
11. Utilisation of data fusion collected by various types of sensors.
12. Microelectronic systems, including specialised ASIC integrated circuits for sensors and sensor networks.
13. Sensors and sensor networks for biomedical diagnostics.
14. Sensors and sensor networks for prevention in situations of public safety and/or epidemiological threat.
15. Sensor networks for managing the security of critical infrastructure and public facilities.
16. Sensors and smart sensor networks for the needs of disabled persons and for rehabilitation.
17. Sensors and sensor networks for monitoring technical condition of engineering structures and/or prediction of the period of their safe exploitation (SHM and PHM).
18. Functional sensors and sensor networks for technical devices.
19. Sensors and sensor networks for smart buildings and cities.
20. Sensors for monitoring of natural environment.
21. Sensors and sensor networks for modelling of people, their behaviour and environment (work ergonomics, creation of virtual environments and others).
22. Sensors and sensor networks supporting agriculture, forestry and agri-food industry.
23. Sensors and sensor networks for modelling, simulating, controlling and/or operating of the technological processes in industry.
24. Sensors and sensor networks for monitoring storage conditions in the supply chain and tracking products for identification purposes.
25. Sensors and sensory networks for advanced systems of perimeteric protection.
26. Sensors and sensory networks for gestures and speechcontrol of machines.
27. Sensors and smart sensor networks for locating people and things in a dynamically changing environment in a limited area.
28. Sensors and sensor networks for adaptive anti-collision and anti-crash systems in transport and industry.

Dictionary:

MEMS (*MicroElectroMechanical Systems*) – a microsystem that is most often produced using semiconductor technology, consisting of mechanical and electrical components.

NEMS (*NanoElectroMechanical Systems*) – a microsystem that is most often produced using semiconductor technology, consisting of mechanical and electrical components, including elements in nanometric sizes.

MOEMS (*MicroOptoElectroMechanical Systems*) – a microsystem that is most often produced using semiconductor technology, consisting of mechanical, optical and electrical components.

Body Area Network – a sensor network, the elements of which are located on or inside living organisms.

SHM (*Structural Health Monitoring*) – monitoring technical condition of a structure.

PHM (*Prognostics Health Monitoring*) – management and prediction of the lifetime of the structure.

M2M (*Machine to Machine*) – Communication between machines.

M2H (*Machine to Human*) – Communication between a human and a machine.

Harsh environment – difficult environmental conditions (e.g. outer space conditions, mining, metallurgy etc.).

NSS 12. SMART NETWORKS, INFORMATION AND COMMUNICATION TECHNOLOGIES AND GEOINFORMATION TECHNOLOGIES

Specialisation covers problems of smart networks, information and communication technologies and geoinformation technologies, both as independent and interconnected elements. However, attention should be paid to the potential resulting from combination of both the scope of research and development .

The notion of “smart networks” means teleinformation technologies and systems¹ used in various infrastructures (e.g. energy, transportation, telecommunication, health, factories, houses, cities, vehicles), in order to provide, *inter alia*, optimisation of operation, savings of resources, including energy, environmental protection, ergonomics of use, advantages arising from mutual communication and information exchange. Smart networks and systems are characterized with the following features²: autonomous character, ability of self-organisation, adaptation and decision making, resistance to errors and faults, scalability, predictability of quality assurance, architectural openness, teleinformation safety.

“Information and communication technologies” (ICT), interchangeably referred to as information and telecommunication technologies or information technologies, are a family of technologies that process, collect and send information in electronic form³.

The notion of “geoinformation technologies” covers technologies related to acquisition, storage, processing, analysing, providing access to and visualisation of geoinformation, i.e. information, for which location is specified in an agreed reference system, and defines, reads out and visualises relationships between the objects and phenomena occurring in that geographical space. First of all, geoinformation (geographic information) is usually related to the Earth’s surface , but geoinformation technologies can be also applied for modelling of other spaces. Geoinformation technologies usually use information and communication technologies, in particular geo-ICT and teleinformation solutions and methods. “Geoinformation technologies” fall into the field of research called geomatics (or GIScience), and are especially related to the discipline of “geodesy and cartography”.

¹ Teleinformation system – a set of cooperating IT devices and software, ensuring processing and storage, as well as sending and receiving data through telecommunication networks using a final device relevant for a given type of network (definition as stipulated in the Act of 16 July 2004 – Telecommunications Act).

² R&D works should cover one or more of the listed features.

³ Based on the definition in: “Społeczeństwo informacyjne w Polsce. Wyniki badań statystycznych z lat 2006-2019”, Informacje i opracowania statystyczne, GUS, 2010

I. TECHNOLOGIES OF THE INTERNET OF FUTURE, TECHNOLOGIES OF THE INTERNET OF THINGS, EMBEDDED SYSTEMS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Smart network components
2. Solutions enabling development of services for a new generation network (*inter alia* 5G)
3. Infrastructure for prototyping, testing and experiments, serving for implementations
4. Optical, wireless network technologies
5. Solutions of the Internet of Things
6. Semantic Web components, Linked Data
7. Wearable devices

II. SMART NETWORKS IN INFRASTRUCTURES

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, in the following infrastructures:

1. Smart cities
2. Smart homes and buildings
3. Smart factories and enterprises
4. Intelligent Transportation Systems
5. Smart vehicles
6. Smart transmission networks, such as electrical, heat, fuel, water, sewage, communication, telecommunication network (including smart networks management systems)

III. ARCHITECTURES, SYSTEMS AND APPLICATIONS IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Integration of smart systems
2. Communication in critical situations
3. Optimisation of the use of communication network resources
4. Preserving communication continuity
5. Ensuring communication availability
6. Self-organising communication networks
7. Smart services for residents, *inter alia* health and education (smart healthcare, smart education), support for persons with disabilities
8. Simulators and “serious games” solutions
9. Supporting decisions
10. Managing the degree of load and energy consumption in data centres

IV. INFORMATION MANAGEMENT IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Analysis of data collected in clouds
2. Optimisation of effectiveness and rate of Cloud Computing
3. Dispersed systems and parallel processing

4. Machine learning
5. Artificial intelligence
6. Virtualisation
7. Processing of complex, large, changeable and diversified data collections (big data, data mining)
8. Compression and reduction of data sizes
9. Effective verification, archiving and storage of data
10. Knowledge management in organisations
11. Utilisation of social networks in data acquisition and analysis as well as information distribution
12. Video content analysis for automatic detection of objects and events, optimisation of visual information analysis
13. Hardware infrastructure and software enabling foundation of network systems and applications of large-scale data

V. HUMAN-MACHINE AND MACHINE-MACHINE INTERFACES IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Smart machine-machine interfaces
2. Smart human-machine interfaces (HMI), in particular:
 - Biometric systems and solutions
 - Recognition of emotions, behaviours and gestures
 - Augmented reality
 - Imaging and visual information analyses, adapting to available communication and visual resources
 - Acoustic and voice communication

VI. STANDARDISATION, SAFETY AND MODELLING OF SMART NETWORKS

Development of innovative (new or improved) cross-cutting solutions for establishment and development of smart networks

1. Teleinformation security in smart networks and systems
2. Cyber security
3. Privacy protection
4. Smart security systems
5. Support for development of methodologies, standardisation processes and their implementation
6. Methods for modelling and automatic testing (software development quality improvement – creating applications)
7. Utilisation of geoinformation in development of smart networks and systems

VII. POSITIONING AND NAVIGATION

Development of innovative products, technologies, processes, methods (or significant improvement of the existing ones) intended for determination of an object's position in defined space, its navigation or monitoring (with the necessary level of security), in the following scope:

1. Improvement of quality of satellite and other spatial positioning systems (in particular their accuracy and integrity).
2. Multimodal determination of objects' positions.
3. Indoor navigation and positioning systems.
4. Navigation and location-based applications using information from many sources in real time.

5. Navigation and location-based applications with innovative methods of information transmission (including cartographic), in particular with innovative presentation methods.
6. Network centric navigation systems.
7. Remote monitoring of moving objects.
8. GNSS systems protection against intentional and unintentional interferences, and safe GNSS systems for authorised users.
9. Development of components for positioning and navigation systems (*inter alia* for satellite navigation) for ground and on-board segments, including embedded software.
10. Utilisation of smart networks in development of location and navigation systems.

VIII. COLLECTING GEOINFORMATION

Development of innovative products, technologies, processes and methods (or significant improvement of the existing ones) for obtaining spatial information, to the following extent:

1. Non-invasive measurement systems (e.g. remote sensing and aerial, satellite and short-range photogrammetry, aerial and terrestrial laser scanning, ground-penetrating radars, radar observations, hyperspectral observations, thermovision).
2. Solutions in teledetection, photogrammetry and other fields allowing automated identification of objects and their features, as well as spatial changes, on the basis of signal, data and imaging analysis.
3. Mobile data acquisition (including mapping) and mobile GIS systems.
4. Instruments, sensors, systems for obtaining and displaying spatial data or new ways to integrate instruments, sensors and systems (including manned and unmanned mobile platforms).
5. Land surveying control and control-measurement systems.
6. Utilisation of smart networks in geoinformation acquisition systems.

IX. PROCESSING, ANALYSING, PUBLISHING AND VISUALISING GEOINFORMATION

Development of innovative products, technologies, processes and methods (or significant improvement of the existing ones), for processing, analysing, storing, publishing and cartographic visualisation of spatial information, in the following scope:

1. Development of spatial knowledge bases.
2. Utilisation of computational intelligence and semantic webs for geobusiness intelligence.
3. Spatial data mining.
4. Spatial data harmonisation.
5. Fusions of various spatial data and automation of geoinformation processing.
6. Solutions for effective geoinformation exchange in environments exploited by numerous users, including those exploited in real time.
7. Modelling (including cartographic), preparation of scenarios and prognoses for spatial changes.
8. Monitoring spatial changes (e.g. based on Copernicus data, based on data from laser scanning) and resulting spatial data update.
9. Cartographic data visualisation, e.g. visualisations of spatial data using augmented reality techniques, holography, contextual visualisations, visualisations taking into account the time aspect, infographics, 2D/3D visualisations.
10. Utilisation of solutions in the field of smart networks in the processing, analysis and publishing of geoinformation.

X. GEOINFORMATICS

Development of innovative systems, applications, algorithms, functions, models, standards (or significant improvement of the existing ones), with utilisation of modern ICT techniques, in order to guarantee effective acquisition, storage, processing, analysing, publishing, visualisation of spatial information, in the following scope:

1. Models and structures of spatial data, standards and forms of recording, compressing and exchanging data.
2. Spatial cloud computing.
3. Hardware infrastructure and software for effective processing of large-scale geospatial data.
4. Spatial big data management.
5. Spatial data harmonisation.
6. Effective filtration, aggregation and generalisation of spatial information.
7. Ensuring the security of spatial data resources.
8. Geoinformation real-time applications, and those taking into account the time dimension (e.g. multitemporal).
9. Optimisation of moving objects routing.
10. Integration of geoinformation systems with other IT systems, e.g. ERP, CRM, SCADA, BIM⁴.
11. Automation of the process of integration of state registers with spatial databases.

XI. INNOVATIVE APPLICATIONS OF GEOINFORMATION

Development of innovative products, technologies, processes, methods (in particular in connection with technologies of smart networks), which will significantly improve already existing or create new ways of using geoinformation technologies in:

1. Smart cities systems.
2. Intelligent Transportation Systems, logistics, transport and forwarding, and vehicle control.
3. National security systems, public security systems, forensics, crisis management, rescue services, health care.
4. Navigation and land, sea and air safety systems.
5. Smart management systems for transmission networks.
6. Vehicle simulators, simulators of situations and phenomena (e.g. flight simulators and simulators for crew training, tactical simulators and "serious games" solutions).
7. Advanced planning systems, spatial management, real estate management, systems for social geoparticipation supporting spatial management.
8. Advanced systems for livestock and crops production (e.g. precision agriculture, smart forestry).
9. Advanced systems used in geomarketing.
10. Advanced information systems supporting the implementation of EU directives, the implementation of which requires geoinformation.
11. Advanced systems used in the study Science (e.g. in geology, geophysics, archeology, mining).
12. Systems for environmental monitoring and assessment, and systems aimed at preventing the effects of climate variability and extreme hydrometeorological phenomena.
13. Systems for identification and optimisation of natural resources exploitations, and systems intended for counteracting the negative effects of human activity (engineering, industrial, economic) and minimise the effects of such activity.

⁴ ERP – enterprise resource planning, CRM – customer relationship management, SCADA – supervisory control and data acquisition, BIM – building information modelling

NSS 13. PRINTED, ORGANIC AND FLEXIBLE ELECTRONICS

I PHOTOVOLTAICS AND OTHER ALTERNATIVE SOURCES OF ENERGY

The implementation of the state energy policy, improvement of the environmental conditions, and international agreements requires effective application of alternative sources of energy as well as development of more secure rational energy management systems, inclusive of energy harvesting. *Energy Harvesting*). The development and implementation of technological solutions mainly leaning on polymer-based materials and nanomaterials will enable development or emergence of new methods of electric power generation from renewable sources or waste energy, as well as energy storage. In order to ensure full functionality of electronic systems their proper assembly and hermetisation will also be required.

The wireless power systems for autonomous devices, products, and systems ready for application to many sectors, for example medicine, packaging or the Internet of things, shall be a final result in the area. *Internet of Things*).

Studies within this area include:

1. Large-format organic photovoltaic cells, characterized with low costs of production, simplicity of the technological process, possibility of fast printing on large surface, small weight and flexibility.
2. Technologies for production of flexible thermal generators, piezo-electric transducers, supercondensers, polymer batteries.
3. Conducting polymers and composite conducting polymers as materials for flex electrodes in the thin-film photovoltaic technology and in the technologies based on new photovoltaic material - the perovskites.
4. Organic semiconductors for printing application techniques and other low-cost methods.
5. Conducting polymers and composite conducting polymers intended for integration with optical fibres with the aim to obtain new active components of optical fibres, such as for example polarization controllers, polarization switches or modulators.
6. Development of technology, innovative products, algorithms, enabling effective energy management in autonomous power supply systems.
7. Development and implementation of technologies, innovative instruments and systems employing alternative sources of energy improving the comfort and safety of users and their validation in real conditions.

II. FLEXIBLE SENSORS

The sensory components are an extremely important part of contemporary electronics as they ensure necessary interface between the physical world and electronic systems that operate within such networks as the *Internet of Things*) and M2M (Machine-to-Machine). They are considered to be vital components of smart objects. *Smart Objects*). The printed electronics technology enables to print the majority of smart object components, such as sensory elements, signal lines, communication system antennas, in a single process. The components responsible for more complex computational operations are attached to the printed components with a flip-chip type assembly. Such a hybrid approach enables significant reduction in costs of electronic circuits manufacturing. The thematic area covers innovation in the development of new sensory polymer-based materials, technology of production of reproducible materials on a large-scale, and target products, systems and algorithms for real-time data analysis in real time. Furthermore, it will be necessary to provide sensors with adequate level of hermetisation to protect them from adverse effects of the external environment.

Studies within this area include:

1. Transparent and flexible conducting materials which are an alternative for fragile metallic oxides, such as e.g. ITO *Indium Tin Oxide*).
2. Force and pressure sensors e.g. for touch screens or load monitoring.

3. Temperature sensors intended for use in monitoring of food products – for instance for verification of whether a deep-frozen product has not been defrosted during transportation or storage.
4. Gas sensors such as CO, O₃, HS, NO, NO₂ sensors
5. Chemical sensors, such as pH and heavy metals sensors, to be applied in trace analysis used in food control and environmental protection.
6. Biosensors for applications in medical diagnostics (single-use sensors, glucose sensors, pregnancy tests, HIV, HVC and other antibodies tests, DNA tests, etc.),
7. Photodetectors.
8. Technology for large-scale production of inexpensive sensor layers.
9. New conducting polymers and composite conducting polymers for application as active coatings of microstructural optical fibres.
10. Integrated organic and non-organic systems.
11. Flexible sensors to be integrated into structural materials, e.g. composite materials, laminated or cast materials.
12. Flexible and printed antennas on various substrates for integration in e.g. laminated, injected or welded materials.
13. New polymer-based materials, nanomaterials, and production technologies for monitoring of parameter variability in environments of special importance or hard to access.
14. Sensors, in particular for monitoring production processes, condition of natural environment, human life parameters, threats, strength of a structure.
15. Intelligent sensor networks, data transmission methods, and algorithms enabling monitoring and signalling of threats for applications in the telemedicine, environmental protection, personal protective measures of an employee, transport, and various industrial branches.
16. Innovative fibre optic devices for application in new types of sensors, e.g. sensors utilizing the effect of surface plasma resonance.

III. LIGHTING

The area includes the development and implementation of advanced manufacturing technologies of innovative light sources, such as organic light emitting diodes (OLED) and electroluminescent displays (EL), and their applications characterized by low production costs, low energy consumption, and the ability to manufacture on large, flexible and profiled surfaces. Furthermore, an important task within this thematic area is research on developed technologies and products in real conditions ensuring proper durability and reliability of a product. The tests shall take into account the encapsulation and components assembly issues, since a lack of appropriate protection or circuit leads will make it impossible to integrate products.

Studies within this area include:

1. Transparent and flexible conducting materials, posing an alternative for fragile metallic oxides, such as ITO, e.g. paints based on carbon nanopipes and graphene flakes
2. Development of organic electroluminescent materials of high chemical stability: polymers, low molecular-weight particles and their compositions prepared for the printing technology.
3. Flexible organic light-emitting diodes (OLEDs) made with the use of printing techniques and other low-costs solutions.
4. Printed and flexible large-surface EL displays.
5. Smart and energy-efficient lighting systems and algorithm for controlling the lighting based on printed sources of light.

IV. PERSONAL ELECTRONICS AND SMART TEXTILES

Year by year the electronic devices are becoming more and more present and personalized being introduced into various spheres of life related to sport, health, entertainment or personal safety. Due to the increasing requirements of

users, the electronics are becoming more and more personal (as the, so called, wearable electronics) being used as accessories (e.g. smart watches) or an integral part of clothing. New applications require of the electronics to be flexible, light, with wireless communication and power systems. Furthermore, a low price of product is an indispensable condition, as this translates into product availability. The printed electronics facilitate production of flexible printed circuits on various substrates, such as textiles or polymer films. In addition, it is possible to produce, for example, flexible displays (e.g. to illuminate clothing after dark), flexible photovoltaic cells supplying power to portable devices, and antennas that increase the coverage of, for example, mobile phone systems. The textronic elements of clothing can be used, among others, to monitor the physiological processes and vital functions of human body, such as: heart rate, respiration rate, pulse, assessment of climate between fabric and human body, etc. The textronic elements must be appropriately hermetised and adapted for assembling so as to facilitate their cooperation with existing electronic systems.

Studies within this area include:

1. Smart textiles that change such parameters as: dimension, change of resistance, under the influence of various factors: temperature, humidity, UV radiation, chemicals, etc.
2. Conductive fibre-polymer materials obtained with the following methods: magnetron sputtering of metals, metal oxides or metal alloys; extrusion (e.g. by melt-blown method) of polymer blends containing electrically conductive metal nanoparticles and carbon allotropes.
3. Textile materials (fabrics, nonwovens) with surface coated with thin electro-conductive layers for use as barrier materials for protection of persons and sensitive electronic devices from strong electromagnetic fields in various frequency ranges (generated by electric power transmission lines, medical diagnostic and physical therapy equipment, radio and television broadcasting devices, or high-frequency digital telecommunication devices).
4. Textronic screening elements of special clothing, such as, for example, nonwovens, tapes or threads for individual protection of employees protecting from radiation in various spectral areas, such as intensive infrared radiation.
5. Textronic antennas, sensor and heating elements in form of tapes and threads to be integrated into textiles.
6. Flexible photovoltaic cells and other alternative sources of energy which supply power to personal electronics.
7. Flexible sources of light to be integrated into textiles for safety or design.

V. PACKAGING, LOGISTICS AND SECURITY

The dynamics of contemporary world development is highly challenging also in such disciplines as logistics and safety and security. Challenges related to security are associated not only with the safeguarding of goods but also above all, people, their personal data and material goods. Consumers' needs become increasingly more sophisticated, and the time to meet them is getting shorter, which is why an answer can be smart warehouses with highly-automated logistic processes, such as automatic product recognition or autonomous quality control. The radio-frequency identification (RFID) and, first of all, integration of printed antennas, printed sensory surfaces, and printed energy collection systems with micro-processor systems enable to create new products that can support entrepreneurs in logistics and security, as well as design. The developed solutions must also consider the subject of hermetisation.

Studies within this area include:

1. Smart collective and unitary packaging, which enable to monitor the quality of content and of the environment
 - Smart collective and unitary packaging will be equipped with printed heating and cooling elements absorbing humidity and other adverse vapours or gases.
 - Smart unitary packaging with printed batteries, OLEDs and photovoltaic cells, enabling readouts of various parameters of packaging content, with simultaneous creation of new attractive visual effects.

2. Smart shelves and warehouses cooperating with printed identification systems

- Smart shelves and warehouses cooperating with smart packaging with printed identification systems to speed up picking products in a warehouse and their transportation to a desired place.
- Smart warehouses adjusting the sequence of dispatching goods from a warehouse adjusting it to, for example, product expiration date encoded within the identification system.
- Smart warehouses preventing overloading, e.g. by monitoring goods with printed identification systems.

3. Flexible security materials.

- Absorbers of electromagnetic field for shielding contactless documents and payment cards to prevent unwanted access.
- Conductive sealing materials for tight housing of electronic devices protecting electronic systems from interference to/from external systems and electromagnetic pulses.
- Conductive materials for production of the electronic systems' housings that protect them from interference to/from external circuits and electromagnetic pulses.

NSS 14. AUTOMATION AND ROBOTICS OF TECHNOLOGICAL PROCESSES

I. DESIGN AND OPTIMISATION OF PROCESSES

1. Smart security systems for automated systems and robots
2. Designing the advanced human-machine, human-system, machine-machine, and system-system interfaces.
3. Virtual prototyping of solutions in process automation and robotics of processes.
4. Development and design of IT solutions for data collection and analysis to support production processes, including systems based on artificial intelligence, expert systems, extensive inference systems, systems based on computer simulations of various levels of complexity, multi-agent systems.
5. Optimisation systems for auxiliary processes of automated and robotised processes.
6. Designing, optimisation, automation, robotisation of production processes.

II PROCESS AUTOMATION AND ROBOTISATION TECHNOLOGIES

1. Technologies of intelligent control of devices and machines as well as robots in production systems.
2. Mobile technologies in devices, machines, robots, as well as manufacturing and logistic processes.
3. Sensor techniques, drives, power supply in processes, machines, devices, and robots.
4. Production and assembly technologies in outer space conditions.
5. Methods, tools, instrumentation, materials and processes related to incremental technology.

III. DIAGNOSTICS AND MONITORING

1. Advanced diagnostics and monitoring systems designed for processes, machines, devices, robots and their systems using artificial intelligence methods and techniques, expert systems.
2. Smart systems for measurement and quality control, including those designed for processes and products of manufacturing systems.

CONTROL SYSTEMS

1. Innovative control systems for machines and devices, robots, and innovative distributed and/or multi-agent systems improving the efficiency of manufacturing processes, including those resistant to interferences and errors occurring during autonomous operation of machines and devices.
2. Computational software and systems for simulation, modelling and optimisation of control systems.
3. Control systems for robots, vehicles and other mobile devices, including the unmanned ones.
4. Vision and tomography systems in automation and robotics.

V MACHINES AND DEVICES FOR AUTOMATION AND ROBOTIZATION OF PROCESSES

1. Unmanned systems and robots operating in special conditions.
2. Mobile robots and exoskeletons.
3. Manipulators and grippers

NSS 15. PHOTONICS

I. TECHNOLOGIES, MATERIALS AND DEVICES FOR PHOTOVOLTAICS

1. Technology of photovoltaic cells using the crystalline silicon with radically novel, non-standard architecture, e.g. thin crystalline substrate technologies, alternative (e.g. liquid) methods of passivation, alternative methods of current collection, hybrid structures, etc.
2. Technologies of highefficiency thin-film PV cells based on perspective materials, such as CIGS alloys, kesterites, perovskites, and other new materials.
3. Third-generation solar cells, based on quantum dots, plasmons, transferintermediate bands, charge carrier multiplication, organic and dye-sensitized structures (stable cells, cells on flexible substrates), light spectrum manipulation (luminescence, up-and-down conversion), and others.
4. Technology of transparent conductive layers and transparent n- and p-type semiconductors for applications in photovoltaics and displays.
5. Thin photo , thermo and electro-chrome layers and structures.
6. Technology, manufacturing and testing of photovoltaic modules for building integrated PV systems with improved glass parameters, and cheaper encapsulants.

II. FIBRE OPTIC TECHNOLOGIES, MATERIALS AND DEVICES

1. Technologies and diagnostics of passive and active optical fibres, both glass and polymer, and optical fibre components based on new optical fibre types (i.e. those having significant improvements in comparison with standard fibres as specified in the ITU-T recommendations, the G.65x series) for the next-generation fibre optic telecommunications .
2. Technologies and diagnostics of active optical fibres for applications in amplifiers and fibre lasers (both CW and pulsed).
3. Technologies and diagnostics of microstructured and nanostructured optical fibres with adjustable transmission properties, optical fibres made of functionalized polymers with new properties, as well as optical fibres containing composite materials.
4. Technologies and diagnostics of specialized optical fibres designed for non-standard functionalities, including supercontinuum generation and other non-linear effects, for transmission of high optical power, for non-standard spectral ranges, and optical fibres with unconventional modal or dispersion characteristics.
5. Optical fibre devices - new generation fibre lasers and amplifiers, including devices designed for standard spectral ranges, such as visible (VIS) and mid-infrared (MIR).
6. Technologies and diagnostics of optical fibre sensors and auxiliary optical fibre elements and optical components for sensory applications.
7. Technologies and diagnostics of optical fibre coatings for industrial applications, as well as coatings of high resistance to aggressive environment and exposure, including exposure to chemical, biological, and radiation agents , or to mechanical effects; also technologies enabling connecting and processing of optical fibres in such conditions.

III. TECHNOLOGIES AND MATERIALS FOR PRODUCTION OF OPTICAL RADIATION SOURCES AND DETECTORS

1. Technologies and materials of laser radiation sources and radiation detectors based on materials with wide energy gap. Lasers and detectors in the visible (VIS) and ultraviolet (UV) wavelength range.
2. Technologies and materials for lasers and radiation detectors for the infrared (IR) range. Lasers and detectors within IR spectrum range.
3. Technologies and materials for generation and detection of radiation within the terahertz (THz) range and related imaging systems.
4. Laser devices and systems generating broadband radiation with high spatial coherence.

5. Technologies, materials and systems of solid-state lasers (microlasers) operating in continuous or pulse (nanosecond, picosecond, and femtosecond) regime, nonlinear optical frequency conversion systems
6. Laser devices and systems for industrial applications, including industrial micromachining and diagnostics
7. Laser devices and systems for information transmission and processing.
8. Laser devices and systems for medical diagnostics and therapy.
9. Systems supporting laser and detection systems.

IV. OPTOELECTRONIC DEVICES AND SYSTEMS

1. Optoelectronic solutions in manufacturing and control processes:
 - devices and systems for spatial and surface machining of materials and production of components, including supporting devices and technologies;
 - devices and systems for monitoring and production processes controlling and quality check of components, subassemblies and products, including supporting tools and technologies;
 - devices for recording images in various spectral ranges, their formation, transformation, comparison and analysis, including the night vision and thermal devices, used in “artificial vision” applications for robotics and navigation which enable imaging under very low light intensity regime, including supporting tools and technologies.
2. Optoelectronic control and measurement instruments
 - Devices for measurement of electromagnetic radiation parameters in various spectral ranges (e.g. spectrometers, ellipsometers, energy meters).
 - Light microscopy.
 - Control and measurement devices based on imaging in various spectral ranges, as well as image formation, transformation, comparison and analysis; sensors used for conversion of various physical quantities into equivalent parameters of light beams and control and measurement systems built according to this approach.
 - Specialized measuring devices designed for optical metrology and ultra-precise optical and atomic measurements.
 - Control and measuring devices employing specific properties of laser radiation.
3. Optoelectronic diagnostic, therapeutic, and analytical devices utilizing specific properties of various light sources, often based on lasers or combined with optical fibres and capacity to render, process, and analyse images for medical applications.
4. Optoelectronic devices in security systems: smart sensors, sensor networks and lines that collect flood, atmospheric, fire, radiological and transport hazards data and send them to decision centres enabling the ongoing control of safety and security within particular aspects of life and economy sectors.

V. OPTICAL TELECOMMUNICATION AND INFORMATION SYSTEMS

1. Optical transceivers, processing devices and active and passive components of optical fibre networks within the Next Generation Networks (NGN) area.
2. Optical devices and systems ensuring security of data transmission and/or processing at the physical layer level.
3. Techniques of modulation and demodulation of optical signals with increased resistance to interference and distortion of transmission.
4. Increase of data throughput rate of optical lines and networks through complex coding methods and advanced detection techniques.

5. Optical transceivers, processing devices for transport networks including long-distance transmission, effective optical power amplifiers, technologies related to optimisation of a band used, also beyond C and L bands, and reduction in energy consumption.
6. Development of FSO (Free-Space Optical communication) technology for 100 Gbps bandwidth level and distances of at least 10 km.
7. Development of optical signal processing technology

VI. INTEGRATED OPTOELECTRONIC SYSTEMS

1. Technologies and materials for integrated optoelectronics - including the technologies based on semiconductor and dielectric platforms.
2. Prototyping and manufacturing of MOEMS / NOEMS systems for application in the sensor, telecommunication, medical and information processing systems
3. Prototyping and manufacturing of components and application specific photonic integrated circuits (ASPICs) for application in the sensor, telecommunication, medical and information processing systems.
4. Photonic electronic integration technologies (ASPIC + ASIC).
5. Packaging technologies for integrated optoelectronics systems.

NSS 16. INTELLIGENT CREATION TECHNOLOGIES

I. DESIGN

1. Design development

Development of products, services, visual communication, interfaces, with the following considerations:

- Form - design works on complete novelty in shape, modernization of shape - thorough or superficial.
- Function - utility notions arising from functional and ergonomic analyses, observation of users' needs and preferences, as well as new usage and operational concepts.
- Technology - resulting from emergence of new technical capabilities, in the field of construction as well as material and production technologies.
- Creation of new consumer and social needs.
- Setting up information structures.
- Setting up functional structures.
- Design of interactions.
- User experience (UX).

2. Tools supporting the design development process

- Innovative design methods improving the effectiveness of design works.
- Innovative design methods employing advanced IT systems.
- Methods of testing design concepts leading to creation of new tools supporting a design process, employing i.a. IT technologies.
- Methods of development of operational models used in a design process in particular those based on IT technologies.
- Innovative tools for recording, communicating and presenting effects of design works aimed at improving decision-making process in designing, in particular those based on IT technologies.
- Innovative tools for managing work and communication of an interdisciplinary design team, including those based on IT technologies.
- Innovative tools for testing design concepts in pre-prototype phase.
- Innovative tools for prototyping of design concepts, resulting in the development of material and non-material solutions (system, process, organization, service), including those within UX and IT field.

II. GAMES

1. Development and design of video games

Works within this area pertain to the whole process of game production and relate to prototyping, designing, and development of game components, including:

- Innovative concepts of games addressed to current demand and expectations of the market and players.
- Base gameplay model, a set of main and side elements of game's functionality and their connections and relations.
- Model of communication with a player, visual code and visual style, including a unique artistic layer intended to have an anticipated effect on the player.
- Sets of animations, models and textures, behavioural models of living creatures and mechanical devices.
- Sound systems for games based on real-time analysis of game situations.

- Levels, interfaces, communities, characters, icons, objects, vehicles, special effects, plants and vegetation models, weather conditions with simulation of weather conditions impact, day and night cycles.
- Innovative and more efficient production methods, production tools and business models.

2. Platforms, engines, and processing techniques

This point covers technologies on which the game production process and operation of any video game are based, i.e. mainly the processing techniques and middleware (the, so-called, engines):

- Devising and development of innovative engines for game graphics and physics and their adaptation to requirements of various platforms and devices (mobile, consoles, etc.).
- Motion and performance capture techniques.
- Innovative techniques of image and 3D object digitalization.
- New and improved techniques and tools for data optimisation.

3. Application of artificial intelligence to:

- improve algorithms solving basic problems related to artificial intelligence and methods of their implementation in games;
- develop algorithms and simulation models of credible behaviour of characters, groups of characters and environment;
- mechanisms for automatic generation of content;
- create systems for collecting, storing and processing data resources of high complexity, variability and size (the, so-called, „Big data”).

4. New tools and mechanisms of interaction

Interaction between user and video game is a key aspect of game playability and operation, and at the same time significantly affects the user's interest in a particular product and user's engagement in a game. That is why research in the following fields is crucial for sector development:

- modern tools for using innovative interfaces and mechanisms of interaction with the game and environment, their adaptation to new hardware platforms and adjustment to the needs of persons with disabilities;
- application of data coming from controllers and sensors in modern mechanisms of interaction with a game or in game mechanics;
- methods and solutions which allow to create and apply new models of narration and games with non-linear plot.

5. Digital distribution and multiplayer online games

Development of modern methods of sales and distribution of games, and provision of support for the development of technologies and infrastructure necessary for the multiplayer online games, including:

- solutions, technologies and infrastructure for sharing and servicing of games in a cloud, including digital distribution, real-time data streaming, handling of external distribution systems, unification of message display;
- creation of platforms and functionalities for advanced multiplayer games and interactions between users inside and outside the games with the use of various platforms and networks (e.g. Internet, LAN) and anti-fraud protection technologies and systems;
- development of distributed infrastructure facilitating multiplayer games and creation of the persistent state world for such games;
- development of innovative economic models for digital distribution and online games;
- development of platforms providing content related to mobile and network games.

6. Tools and knowledge supporting the game creation process.
 - Tools and methods employing advanced methods of assessment of reaction and psychological and emotional condition of a player.
 - Tools for automation and facilitation of game testing and error detection processes, including tests of elements created in a procedural (automatic) manner
 - Tools supporting communication and data exchange within a game developing team.
 - Tools supporting the process of development of video games for various platforms and devices.
7. Application of video games in other areas
 - Development of simulation, creation of virtual models of real systems and processes, simulation studies on performance, capacity and behaviour of systems.
 - Creation of games for therapeutic and medical purposes.
 - Creation of games for research and educational purposes.

III. MULTIMEDIA

1. Support to and optimisation of processes
 - Developing innovative methods and models of supporting, optimisation, and controlling the content production and dissemination processes.
 - Tools and methods employing advanced methods of assessment of response and psychological and emotional state of content recipients.
 - Tools for automation and facilitation of error detection, tests generated with the use of algorithms and procedures of content production processes.
 - Tools supporting communication, data exchange and transmission within teams creating content.
2. Shaping the market of creators and consumers.
 - Models and tools for remote and direct measurements, analysis and evaluation of recipients' preferences aimed at improving effectiveness of creative projects fulfilling the high-ranking needs of citizens: measurements employing the subjective and objective indicators.
 - Models and tools used to personalize the audio-visual communication based on preferences and behaviour of recipients.
 - Development of innovative business models enabling co-financing and engagement of recipients in the process of creation and implementation of audiovisual content and interactive solutions.
 - Tools and applications for creation of innovative educational and presentational models employing multimedia and interaction.
 - Technologies and solutions supporting innovative forms of dissemination of content among various social groups.
3. Knowledge and tools supporting production and revitalization.
 - Models, technologies, devices, design applications, management and production of visual, auidial and audio-visual content, including: network technologies, mobile hardware embedded systems, stationary systems for automation of production and post-production processes, innovative interfaces, interactive systems, and multimedia engines generated in real-time or automatically, systems employing image and sound analysis and processing in multidimensional modelling.
 - Technologies, devices, applications and algorithms for processing and digital reconstruction of copies recorded on analog or digital media, including: technologies aimed at improving and automating the processes of digitalization, revitalization, and adaptation of content to modern distribution channels

- Technologies and solutions supporting the processes of modelling, prototyping, and testing the functionality and usability of content, products, and audio-visual and interactive services, including the creation and application of new narration models and content of non-linear stories.
- All creation technologies for the development and automation of pre-production, production and post-production processes of image and sound, image and sound sharing and storage, including the techniques of digitization and processing of images and multi-dimensional objects, and the motion and performance capture techniques, and visual code, visual style, animations, models and textures, simulations, special effects, behavioural models of living organisms, and mechanical devices.

4. Distribution and management of content

- Creation of innovative distribution channels of content dedicated to various social groups (including the groups excluded due to health, economic, geographical, social condition), including: intelligent streaming of content, real-time delivery of content.
- Models, tools, technologies, applications, interfaces for intelligent dissemination and distribution, among others by ensuring permanent identification and effective protection of copies against illegal access or dissemination.
- Tools, methods and technologies for measuring and control the maintaining of correct content distribution parameters.
- Data management systems for data of considerable complexity, variability, or size.
- Solutions facilitating inter-system exchange of multi-element digital data.
- Creation of platforms and functionalities for multiplayer and interactive participation of users in content communication with the use of various distribution channels.
- Development of platforms related to content distribution via mobile means or networks.

5. Archiving and smart access to content

- Models, technologies, devices and applications for secure long-term storage of content recorded in analog or digital format.
- Technologies of searching and accessing content, including semantic analysers of image and sound, and systems of smart indexation of multimedia content.
- Complex digital data management systems and solutions compliant with international standards allowing data exchange between systems.

NSS 17. INNOVATIVE MARITIME TECHNOLOGIES FOR SPECIALIZED VESSELS, MARITIME AND OFFSHORE STRUCTURES AND LOGISTICS BASED ON THE SEA AND INLAND WATERWAY TRANSPORT

I. DESIGNING, CONSTRUCTION AND CONVERSION OF SPECIALIZED VESSELS AND THEIR SPECIALIZED EQUIPMENT

1. Designing vessels and their modules, systems, and devices, including hardware and software solutions for the modelling and simulation of performance of structures, systems, and complete vessels.
2. Construction and conversion of vessels and their blocks and sections, including the vessels of reduced impact on the environment, exploration and fish-processing vessels, off-shore service vessels, ecological passenger-vehicle ferries, ships and ship sections made of aluminium, vessels for navigation in arctic conditions, search and rescue vessels, research vessels, shallow-draft barges and pushers, yachts and motor boats, cranes and floating tanks, as well as other dedicated vessels
3. Unmanned / autonomous vessels, including those designed for the monitoring, inspecting and handling off-shore facilities, marine hydro-engineering facilities, ships, seaport infrastructure, environmental condition, and assessment and exploitation of sea resources.
4. Technological and technical solutions reducing adverse impact of vessels on the environment, including those with electric and hybrid propulsion system, powered by LNG, and other alternative fuels, systems for storage, distribution and refuelling of the low-carbon fuels and LNG, as well as infrastructure and solutions reducing emission of pollutants into the water and air.
5. Technologies, systems and devices for vessels, including the marine power engineering, automation and hydraulics, remote monitoring of operation and use of a ship, economic efficiency and energy efficiency, operation in compliance with the environmental protection standards and remote control in critical states, navigation and communication systems, system for control and assessment of technical condition of on-board devices, ventilation and air conditioning systems, propulsion devices and systems, as well as energy storage and conversion systems.

II. DESIGNING, CONSTRUCTION AND MODIFICATION OF MARINE AND COASTAL STRUCTURES

1. Multifunctional, modular research and measurement platforms for field testing of innovative technical solutions in the exploitation of sea resources in real conditions, as well as simulators and trainers of objects.
2. Unmanned mobile platforms for diagnostics and monitoring of condition of marine structures as well as equipment, techniques and measurement systems for acquisition and processing of the marine environment data.
3. Floating and stationary structures of marine equipment for conversion of energy from renewable sources (including the off-shore wind farms and converters of tidal wave and water current energy) and platforms and distributed systems for exploration, extraction, and processing.
4. Components and equipment of offshore facilities (including specialized cranes, grippers, overhead cranes, compensating and tensioning systems, specialized hoist systems and hydraulic systems).
5. Marine structures for development of aquaculture and technologies, devices and methods of marine organisms breeding.
6. Recreational, residential, educational and training facilities at sea.
7. Devices and means for transport and handling of large-size marine supporting structures.
8. Technologies and devices of enhanced efficiency and energy effectiveness used for the purposes of the off-shore production and water transport.
9. Development of hyperbaric technologies.
10. Designing, technology, devices, systems and methods for exploration, estimation and acquisition of marine and seabed resources.

11. Designing, technology, devices, systems of marine and offshore fuel terminals of alternative fuels, including LNG.

III. PROCESSES AND DEVICES APPLIED FOR LOGISTICS BASED ON SEA AND INLAND WATERWAY TRANSPORT

1. ICT systems and technologies for monitoring, integration, control and management of water transport modes and transport infrastructure.
2. Systems of organization, supervision, navigation, e-navigation, decision support, risk management, and safety of shipping and cargo transport.
3. Passive and active protection systems for marine facilities and infrastructure.
4. Energy-efficient cargo handling technologies in seaports (e.g. defrosting of bulk cargo containers).
5. Development of intermodal transport technologies on routes to / from the seaports.
6. Simulation systems and environments using the mixed or augmented reality as a method of controlling the water transport modes.