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SCIENCE AND INDUSTRY IN A COUNTRY OF CHANGES

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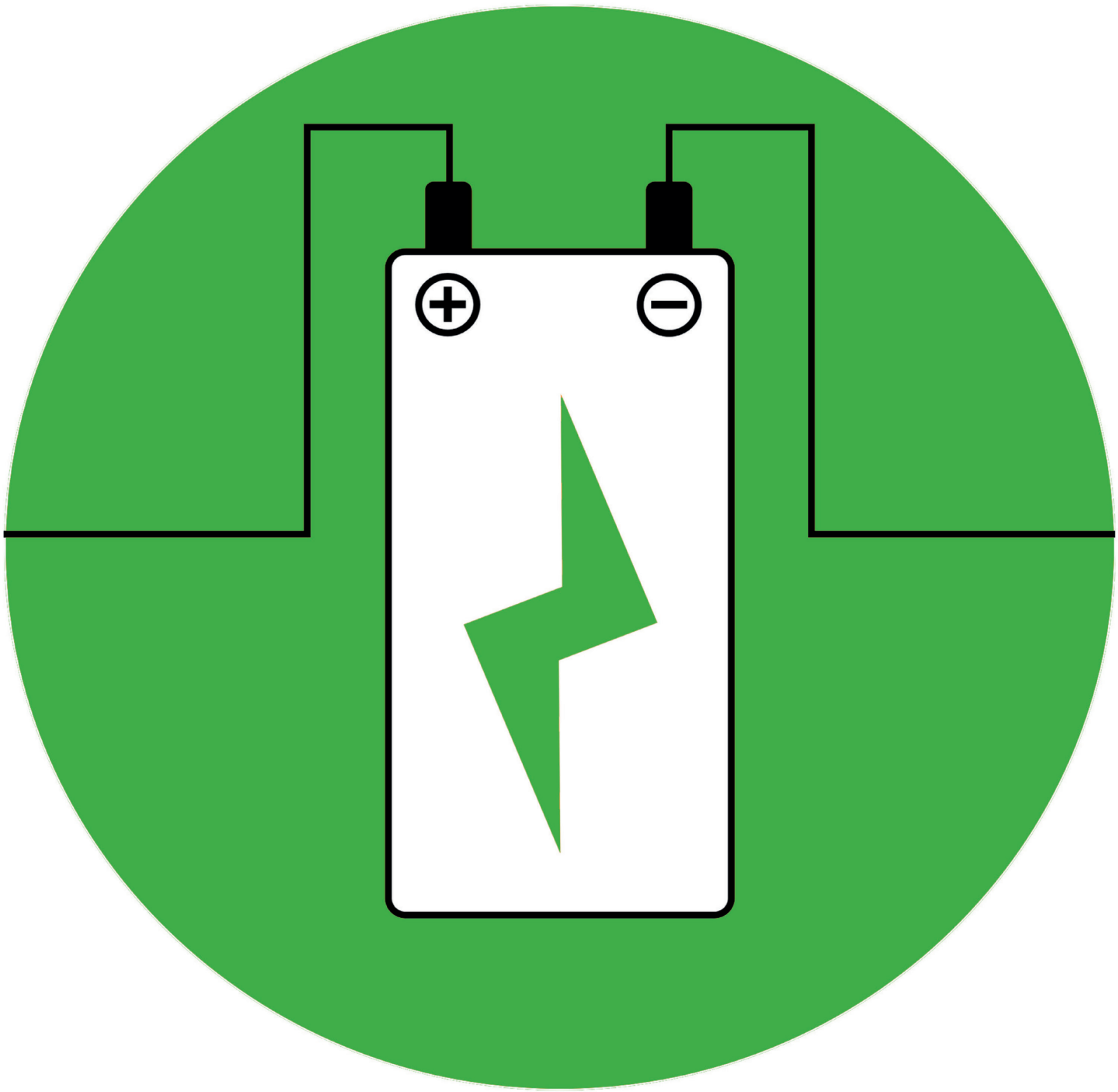

ENERGY STORAGE SYSTEMS (ESS) IN ENERGY POWER SYSTEM AND INDUSTRY – EXAMPLES OF IMPLEMENTATION

We focus on renewable energy!

Electricity prices, and especially their increases, raise the blood pressure of both entrepreneurs and ordinary citizens. We are more and more willing to invest in green energy; photovoltaic panels, wind farms, and hydropower plants have become part of the Polish landscape. The possibilities of obtaining energy from various elements or chemical compounds are also being developed. Poland has a significant share in projects concerning the use of hydrogen and biomass in the energy sector. It is just such research and investments that will help Poland to achieve climate neutrality, which the entire European Union is striving for. That is why most of this issue of "Polish Technical Review" is dedicated to issues related to renewable energy sources, and we also present the examples of the implementation of energy storage – an essential element of renewable energy installations – in various places of the Polish energy system.

Good reading!

Magdalena Borek-Daruk
Deputy Editor in Chief

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ENERGY STORAGE SYSTEMS (ESS) IN ENERGY POWER SYSTEM AND INDUSTRY – EXAMPLES OF IMPLEMENTATION

SYSTEMY MAGAZYNOWANIA ENERGII W ENERGETYCE I PRZEMYŚLE – PRZYKŁADOWE WDROŻENIA

***Summary**: The essential priority for each country is to improve and possess a stable work of the National Power System and to guarantee the break-free supplies of good-quality energy for functioning of industry, transport and individual users. The power system has no possibilities of storing the energy; the stabilization of work by balancing of energy production and receipt is ensured by standby thermal power plants, pumped storage power plants and combined heat and power (CHP) Plants. The transformation of energetics, connecting the unstable energy generations from renewable sources (RES) to the system, causes that the correct work requires the additional distributed micro-regulators such as energy storage systems. In the present paper, we have presented the examples of implementation of the mentioned installations in different places of Polish power system. The configuration and the tasks of each of the mentioned energy storage systems will be described.*

***Keywords**: Energy Storage System (ESS), Battery Energy Storage System (BESS), National Power System, Energy transmission and distribution*

***Streszczenie**: Podstawowym priorytetem każdego kraju jest poprawna i stabilna praca Krajowego Systemu Elektroenergetycznego, zagwarantowanie bezprzerwowych dostaw, dobrej jakości energii dla funkcjonowania przemysłu, transportu i odbiorców indywidualnych. System elektroenergetyczny nie ma możliwości magazynowania energii, stabilizacja pracy poprzez bilansowanie produkcji i odbioru energii, zapewniana jest przez pracujące w rezerwie bloki elektrowni, elektrownie szczytowo-pompowe i wodne. Transformacja energetyki, dołączanie do systemu niestabilnych generacji energii ze źródeł odnawialnych OZE powoduje, że do poprawnej pracy będą potrzebne dodatkowe, rozproszone mikro-regulatory jakimi są magazyny energii. W artykule przedstawimy przykłady wdrożeń takich instalacji, w różnych miejscach polskiego systemu elektroenergetycznego. W artykule przedstawimy przykłady wdrożeń takich instalacji, w różnych miejscach polskiego systemu energetycznego. Dla każdego z tych magazynów energii opiszemy jaką ma konfigurację i jakie realizuje zadania.*

***Słowa kluczowe**: magazyn energii, bateryjny magazyn energii, krajowy system elektroenergetyczny, przesył i dystrybucja energii*

Storage of energy as a significant element of transformation of the National Power System

The National Power System (in Polish: KSE) in Poland is a group of devices serving for generation, transfer and distribution of electric energy from generating sources to a final user.

KSE consists of the following elements:

- Energy generating subsystem; it includes all sources that produce electric energy such as: power plants, combined heat and power (CHP) Plants and renewable energy sources;
- The subsystem of transmission network of the highest voltages, i.e. a group of devices (energy lines and stations), ensuring the transfer and distribution of energy by the lines of high and highest voltage; in Poland, there are lines and stations 750 kV, 400 kV, 220 kV and 110 kV.;
- The distribution network subsystem - the group of devices (transmission lines, stations and switchgears), ensuring the transfer and distribution of energy by the lines of high, medium and low voltages: local lines of high voltage 110 kV, lines of medium voltage: 60 kV, 40 kV, 30 kV, 20 kV, 15 kV, 6 kV and lines of low voltages (first of all, 0.4 kV) to the connection points at the final users;
- The units, dealing with the turnover and trade of energy to the final users and with the participation in energy market;

The total system of generation and distribution of the electric energy may be defined as five-stage system:

1. Extraction and delivery of energetic raw materials;
2. Production of electricity;
3. Transmission of energy by the high voltage lines;
4. Distribution of energy by the lines of medium voltage and low voltage;
5. Delivery to the consumers and sale.

The four last items compose the described above National Power System.

The main idea of activity of the National Power System (KSE) is to supply electric energy for the needs of the users in a stable way. The users may draw energy up to the level of the connection power, at any time and in any way, with any load profile.

From the point of view of the user, the stability is a break-free supply of sinusoidal voltage, with a constant amplitude and frequency. Industrial and distribution operators estimate that the system is stable when it is sustainable and balanced in respect of deliveries and consumption of energy, i.e. the energy produced in generation is equal to consumption and transmission losses. For operators, the frequency and voltage of the network are the indicators of the mentioned state; they are the parameters which inform about balancing of active and passive power in the energetic network. Balancing of KSE has been developed for many years and it functioned effectively in the energetics sector where the energy generation is based upon the utilization of stable generation from traditional power plants (utilizing fossils as fuel, i.e. coal and gas). It is changing, however, as the actions of the European Union in the environmental protection area and counteracting the climatic changes, causes limitation of energy production from the mentioned blocs of power plants (first of all, from carbon" generation) and forces introduction of energy from distributed sources of renewable energy (RES), as being introduced to the system. It was the aim of the introduced package 20-2020 and imposed the duty – up to 2020 – of limiting by 20% of the GHG emissions, by 20% carbon dioxide emissions and reaching by 20% increase of energetic effectiveness (in relation to value which a given country had in 1990 in the discussed areas). After 2020, this trend will be continued via introduction of REDII package which will force – u to 2030 – further measures towards this direction and reaching the level of 27% for each of the mentioned aims. Decarbonisation of Europe is planned, that is, a lack of the possibility of participating in the market of energy production by the units, emitting more than 550 kg CO_2/1 MHWh (reaching this value in the European Union is planned from a half of 2025). All this causes that the increase of energy production from renewable sources will be meaningful. It is estimated that RES participation in total energy production all over the world in 2040 will reach the level of 40%. It will cause the necessity to transform the energetic systems. On one hand, the increase of energy generation form RES sources causes that the energy will be produced from distributed and less stable sources and on the other hand, the energy transfer will be not unidirectional (i.e. from the highest voltages to the lowest ones). The flow of energy in both directions will be possible because the final users will be also the producers of energy, that is, prosumers.

The energetic system has no possibility of storing energy automatically; to balance the power, the reserve sources are necessary. In the present or perhaps – already previous conception of energetics, the sustainability and stabilization were obtained by the reserve generating sources such as: generators of steam turbines, hydro power plants and pumped storage power plants. In the situation of transmission of the national power system and increase of energy generation from RES sources, it may be insufficient. It results from the fact that the mentioned energy sources are very unstable and the runs of the generated power from the discussed sources are quickly varying. The changes in the available production capacities in the system run very quickly, even during a split second. Due to this reason, the problem to appear soon will include not energy generation but ensuring the continuity of its supplies, especially from local generating sources. It will cause (and perhaps it causes already now) the necessity of increasing the storage of energy in the system in aspect of greater availability of energy as well as the number of such installations. There will be necessary the distributed energy-storing installations, which in the case of local disturbances will cause a rapid, local balancing of power.

Energy storage system may be defined as a accumulator which may take energy from the network, keep it and then, send to the network on demand. The most popular electric energy storage systems (they are listed in sequence from accumulators, dedicated to the highest power, counted in hundreds or dozens megawatts to those ones, dedicated to the lowest power, calculated in megawatts, hundreds of kilowatts or even in kilowatts). They are as follows:

- Pumped storage power plants
- Accumulators with the compressed air,
- Accumulators, utilising kinetic energy of rotating mass;
- Accumulators, employing the phenomena of superconducting coil systems;
- Capacitors;
- Chemical batteries;
- Hydrogen and fuel cells.

In the conception of distributed energetics, the main tasks of the energy storage systems may be defined as:

- Regulatory and systemic services, including improvement of energy quality and system stability;
- Obtaining better efficiency of energy generation in the systems and limitation of the losses in the transmission to final users;
- Better utilization of renewable sources of energy;
- The possibility of in-system commercial services, also on energy market and sale of the stored energy in the peak of demand on it at better prices.

The system services, ensuring the improvement of the stability, effectiveness, and quality of energy will be most significant; they ensure the balancing of the system in respect of active and passive power. The energy storage systems, implementing such functions will be installed in different places of KSE, from a direct neighbourhood at big power plants, near renewable energy sources (RES farms), in lines of high, medium and low voltage and in energetic lines of industrial enterprises. The installation place determines the functions which may be implemented. It is illustrated in Fig. 1.

In Poland, all the described above transformations are currently introduced. In different companies, and the sites of the power system, there are introduced and tested the energy storage systems. It refers to the areas of professional energetics as well as industrial customers and the prosumers. In further part of the present work, we will present some of such installations which implement the most interesting functions; in such cases, the accumulators are mainly based upon the chemical batteries.

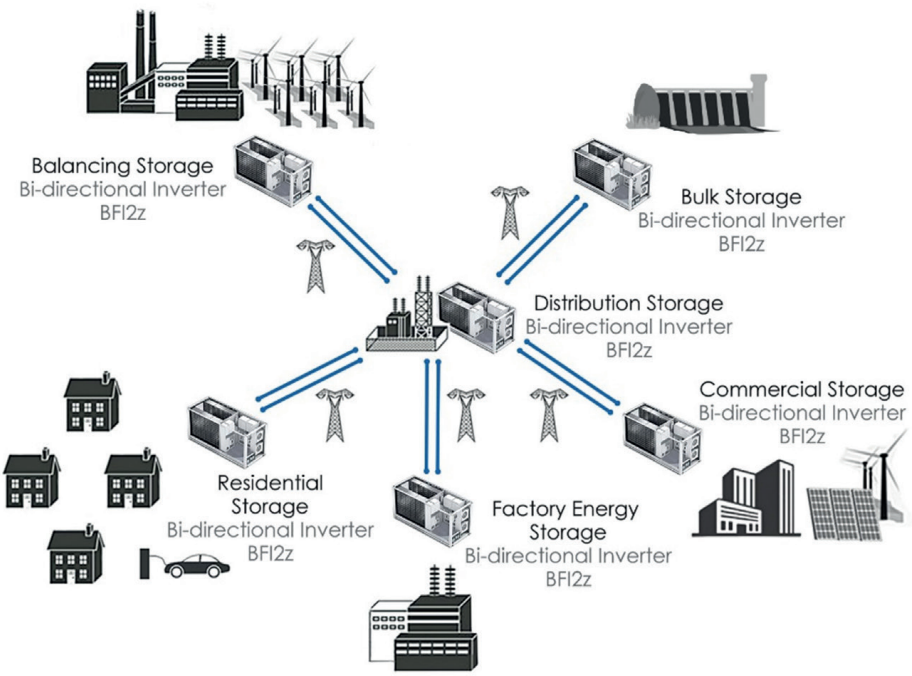

Fig. 1. Sites of installation of energy storage systems in power system [1]

Energy storage system installed by Energa Operator S.A. in RES farm Bystra

Energy Storage System has been installed in wind power farm FW Bystra (power of 24 MW), situated at the north of Poland, in the Pomorskie voivodeship, poviat (district) of Pruszcz Gdański. The mentioned investment was established in cooperation with the following companies: Polskie Sieci Energetyczne S.A. (PSE) – Polish operator of transmission system, Energa Operator S.A. (EOP) – Polish operator of distribution system and Energa OZE S.A. (EOZE) – company of distribution operator, acting in the field of RES sources. The mentioned project is also supported by the Ministry of Climate and Environment.

It is a hybrid battery energy storage system where accumulator includes chemical batteries in lithium-ion and acid-lead technology. Power of the discussed storage system is about 27 MWh and is consists of the following elements:

- Lithium-ion battery, capacity of 0.47 MWh, utility power 1 MW;
- Acid-lead battery, capacity of 26.9 MWh, utility power 5 MW;
- Bi-directional inverter, power of 6 MW;
- The system of management and control of energy storage (EMS, Energy Management System). EMS ensures control of two mentioned types of batteries and implements the tasks of the storage system.

Li-ion battery, having a good characteristic of input and output power, high currents of charging and discharging, implements the system services and regulatory functions in energetic network. Regulatory functions are a quickly varying balancing of the system in respect of active and passive power and maintaining of voltage and frequency. Li-ion battery, which has a possibility of expending a high power in both directions, may ensure such condition. Acid-lead battery has a weak characteristic of initial power and due to this reason, it is not suitable for such tasks whereas it has a good characteristic of output power and low investment costs (that is, price of 1 KWh). Due to the mentioned reasons, it is possible to store here a big capacity of the discussed storage system and implement the so-called capacity functions, i.e. ensuring a local power in the system when a wind power farm becomes suddenly switched off and the area passes to islanding work. The principle of functioning of such system is shown in Fig. 2.

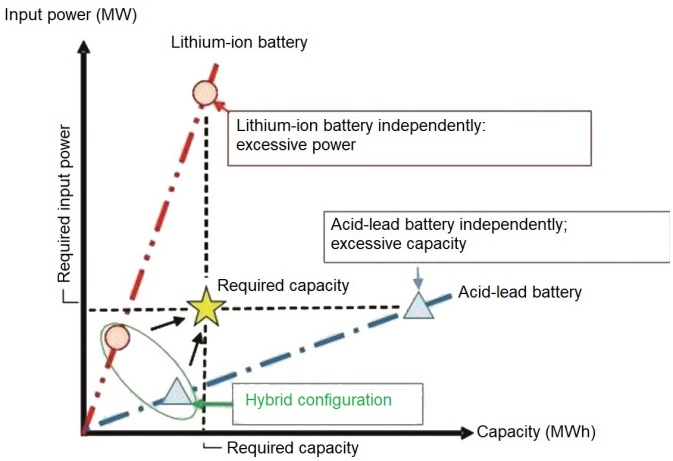

Fig. 2. Operation modes and battery profiles of the hybrid energy storage system

A red curve of discharging indicates implementation of system tasks, cyclic quick charging and discharging; the storage system utilizes here the energy from lithium-ion battery. In the case of implementing the capacity-connected tasks, slower discharging in longer time, the storage system utilizes energy from

acid-lead battery (it is a blue curve of discharging). In the green area, there is a hybrid configuration and the work may be performed by two mentioned batteries. As a result of the discussed project, the task of the operators (PSE and Energa) is to collect the experience concerning the cooperation of the energy storage systems and wind power farms and photovoltaic systems. On the grounds of the obtained results, the principles of integration of renewable energetics and the National Energy System in Poland will be developed. It will be possible to test and evaluate the effectiveness of the work of energy storage technology, with the utilization of chemical batteries in different technologies (lithium-ion and acid-lead0 and checking which technology is more suitable and optimal. Based upon the operation of the discussed installation, it will be possible to check whether and how the power storage systems will improve the safety and quality of work of power system; the role of energy storage systems in limitation of investment outlays on distribution infrastructure will be analysed. Postponing of investment may be obtained by utilization of energy, collected in the storage systems for elimination or mitigation of peak overload in the transmission lines (in such situations, the excess of energy is ensures by the power storage system). The mentioned situations occur in the power system during distribution peaks and failures of local energetic lines. If the operation of energy storage systems is effective, they – perhaps – may become an investment alternative; they may help to postpone or even replace the required investments in respect of developing the system (new lines). Reassuming, even during the operation of the storage systems at Wind Power Farm in Bystra, the tests concerning the implementation of the following tasks will be carried out:

- "smoothing" of the short-term fluctuations of active power, generated by wind power farm;
- Regulation of the frequency restoration;
- Ensuring power reserves for the needs of balancing the loadings;
- Reacting to the changes in demand on power in the systems;
- Checking the efficiency of operation of the storage system in different technologies of chemical accumulators;
- A possible role of the power storage systems in price arbitrage;
- A possible commercial functioning of the storage system, profiting from a difference in prices of energy, consumed from the network when it is cheapest and sending to the network during a peak demand.

The energy storage systems in Warsaw distribution network

The example of introduction of energy storage systems in local urban distribution network includes the intelligent transformers station with energy storage system, with the connections to RES sources and charger of electric vehicles (enabling use of accumulator from the mentioned vehicles as a mobile energy source) for Warsaw distribution operator Innogy Stoen Operator Ltd.

The basic task of the energy storage system is to accumulate energy during night time and distributing it during the peak period. The mentioned installation utilizes algorithm allowing the independent control of the cycles of charging and passing the energy to the network (grid) on the basis of measurement of the current in low voltage network (NN). The algorithm is adapting independently to the curve of charging of the observed station during 9 days, when determining the moment of commencement and termination of the accumulator's system.

The station consists of the following elements:

- Transformer of a medium voltage into a low voltage (SN/nN);
- Switchgear of medium voltage (SN) in Smart Grid version;
- Switchgear of a low voltage (nN) equipped with the measurements of each of phases;
- Bi-directional inverter for service of the energy storage system 70 kW;
- Lithium-ion (Li-ion) battery 62.3 kWh;
- Charger foe electric cars V2G (Vehicle to Grid) which has a possibility of transmitting the energy from the car's battery to the grid;
- Photovoltaic installation PV 1.6 kWp.

Due to the necessity of ensuring the safety to the recipients in the station, the switchgear nN was installed in two sections; the aim of the first section is to distribute the energy (specified as distribution section); the second section ensures connection of accumulators (it is specified as storage section). Additionally, installation PV, which is situated on the roof of the station, has been connected to the storage section. Apart from the chemical accumulator (Li-ion battery), the discussed system includes also devices, ensuring the bi-directional, controlled energy flow. It is a bi-directional converter, facilitating the control of charging and discharging of electrochemical battery in accordance with the parameters, indicated by the producer of the battery. It ensures the exchange of energy between electric grid and energy storage system in conformity with the algorithms, ensuring the improvement of the network stability. The discussed solution guarantees the appropriate electric parameters of the distributed energy and gives a possibility of controlling the accumulator based upon the algorithm of management of energy flow by operator in a remote way, or locally, i.e. at the site of the equipment installing.

The application of the mentioned energy accumulators in power stations, belonging to Operator of the Distribution System allows him to implement a series of functions dependent on the employed systems of chemical accumulators and the introduced control functions. The utilization of the accumulated electric energy for balancing of the work of distribution network (by the mentioned above operator) with the utilization of storage solutions (peak shaving, valley filling, load shifting) allows to improve the quality parameters and reliable deliveries of electric energy to a final consumer (indicators of breaks in the distribution grid – SAIDI, SAIFI and MAIFI) and lowering of the costs, resulting from failure to keep the required parameters in a given area [4]. Additionally, there is a possibility of safe leaving a fragment of the distribution network and passing to islanding work in the case of planned and unplanned power cuts.

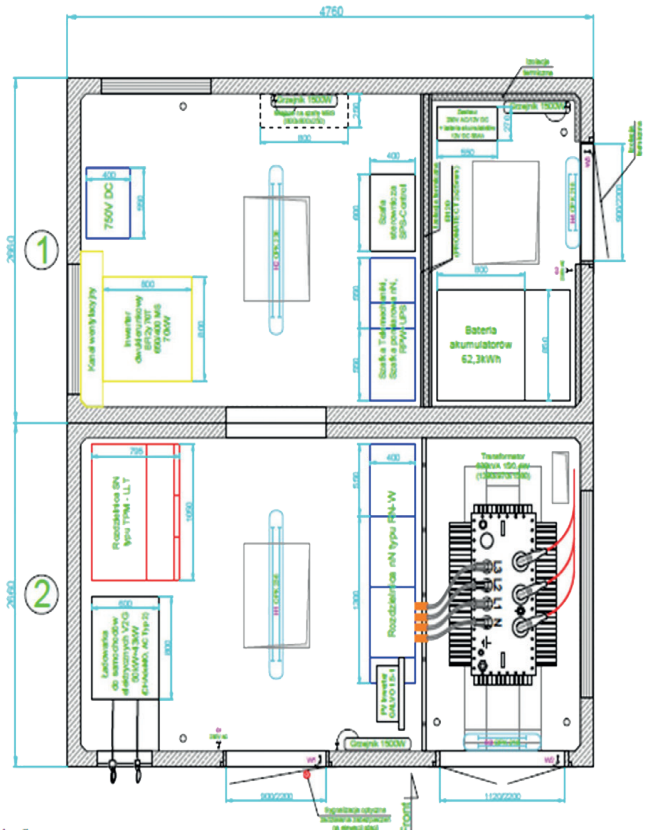

Fig. 3. BESS components into Intelligent Transformer Station - innogy Stoen Operator Ltd. [4]

Moreover, owing to the utilization of electric cars with the function of energy return to the grid (V2G), constituting a mobile energy storage system, cooperating with the power grid, the safety of the energy supplies to final customers will be increased; the process of electric energy distribution will be improved, as well. Additionally, the local storage of energy and connection of car EV directly to SN/nN station will allow limitation of losses, connected with distribution. Electric energy storage system gives also a possibility of autonomic (island) work which may be utilized in the case of decay of voltage on the side SN, e.g. for support of feeding the selected direction in SN/nN station. Function of decreasing the length of the breaks in voltage is interesting. A long break is understood as the decrease on voltage amplitude below 10% of nominal value for longer than 3 minutes (short breaks will be discussed in a further part of the paper). Such breaks are most frequently a consequence of failure in the grid or lasting short-circuit. If the protective automation system is able to remove the problem, it happens usually during up to 3 minutes. The Lithion-ion based battery energy storage system (BESS) may help here by island supply of a given fragment of grid in the case of failure of linear course between the supply points and location of the BESS. It is enough to abbreviate the break below three minutes. As the BESS has the energy reserve and electronic inverters which may behave as sources of energy with a set frequency, it may independently supply a fragment of the grid and the connected users as long as the apparent power of the users does not exceed permanently the apparent power of the BESS and the amount of energy is sufficient in batteries.

Energy storage system, installed by PKP Energetyka S.A. in railway traction substation PT Garbce

The example of implementing the energy storage system, cooperating with railway network is construction of the discussed system by PKP Energetyka S.A., which is a supplier of electric energy to traction railway network. It is also the user of its connection infrastructure. The area of the PKP Energetyka activities includes ca 30 GPZ stations (it is a definition of stations with the highest voltage, that is, the Main Supply Point) and stations of medium voltages, specified as Traction Substations PT (ca 500) and Section Cabins (ca 400). Supply for the mentioned above stations is as follows; for GPZ – high voltage of 110 kV AC, for Traction Substations and Section Cabins – medium voltage of 30 kV AC, 20 kV AC and 15 kV AC. The output voltage is a constant voltage of 3.3 kV DC of the railway traction. The discussed energy storage system was constructed at the Traction Substation Garbce (Low Silesian Voivodeship), with con-financing from the means of the European Regional development Fund, from the European Social Fund and Cohesion Fund; the research part was implemented by PKP and University of Technology of Zielona Góra. Building of the mentioned energy storage system is a work connected with the implementation of the project of Dynamic Reduction of Load of the Traction Substation (DROPT). The aim of the discussed project is to reach the reduction of the ordered connection power in the traction substations. The connection power is a compositional element of the payments for energy tariff; additionally, it is possible to obtain the reduction of construction costs/modernization of the connection of such traction substation (by decrease of nominal power of the equipment). Such energy storage system, as being well-tailored to the needs, may ensure an interesting time of return from investing for the investor. PKP Energetyka will be introducing the projects of Dynamic Reduction of Load in the objects where the utilization of ordered power is small; a profile of demand on energy is a big, peak expenditure of power during a short period of time 9 e.g. during few minutes). Two cases of such characteristics were determined in transition substation Garbce. The first one – when the passage of the train generates consumption of power on the level of 2.5–3 MW during ca. 5 minutes and then, there is a break lasting for several or several dozen minutes. The second case is when the passage of the train generates impulse consumption of power ca. 6 MW during 1 minute and the next such impulse occurs after several minutes. It is illustrated in Fig. 4. Such runs were described in the tender procedure as element of offer inquiry concerning the BESS.

When working in such system, the energy storage system covers, fully or partially, the peak power and then, in the period of breaks, it reproduces the stored capacity, charging the chemical accumulator with power of 0.5 MW. Thus, the reduction of connection power may reach even the level of 3 MW. The scheme of connecting the energy storage system in DROPT to the traction network is shown in Fig. 5.

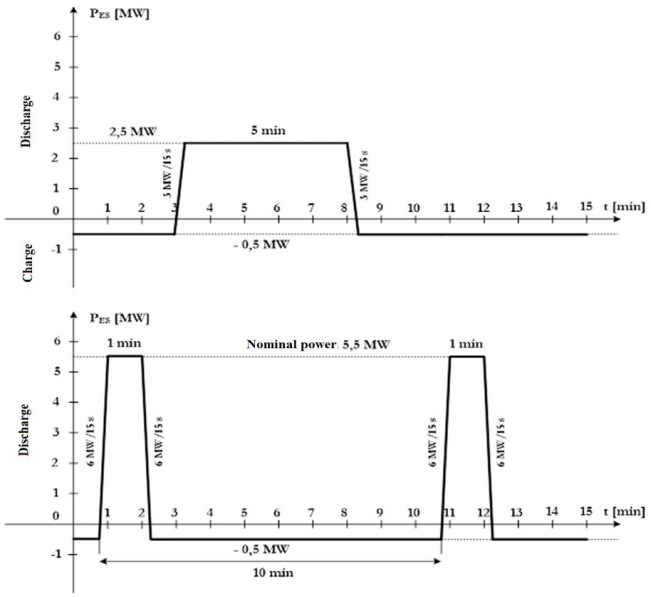

Fig. 4. Illustration of critical conditions of loading of energy storage system in time [5]

The energy storage system, installed in traction substation Garbce is a system with power of 5.5 MW and capacity of 1.2 MWh and it consists of the following elements:

– Set of battery cells in technology: Li-ion with power of 1.2 MWh. The battery is equipped with the system of supervision of the work parameters (battery Management System, BMS), compatible with the control system, facilitating monitoring of the parameters of individual battery cells, its branches and the whole battery. BMS system ensures balancing of energy between the cells and implements the protection of battery from the overcharge or over-discharge, overheating and other unexpected threats and failures;
– System of inverters for transformation of energy DC/DC as connected to grid NC 3.3 kV and AC/DC system for charging of battery from the connection network; it is a system of power electronic converters, working in parallel, with power of 5.5 MW;
– System of control of energy flow EMS (Energy Management System) which carries out the tasks of the storage system (manually or automatically) and supervises the work;
– Containers for development of the systems in standard ISO: 4, with ventilation, acclimatization, fire extinction system and access control system.

When transmitting the energy to the traction network, the energy storage system has a possibility of ensuring the reduction of momentary power of the substation load in the range of 1 MW – 3 MW (with power setting at each 0.1 MW). charging of the energy storage system occurs only from the energy connection, 15 kV AC; charging is implemented with the power in the range of 0.2 MW – 0.5 MW (with the power setting at each 0.01 MW).

PKP Energetyka, as following the occurring changes and transformation of the national power system, perceives the application of the energy storage systems in the implementation of the following functions in the area of the energy distribution:

1) Improvement of unilateral supply (rising of voltage)
2) Cooperation with the renewable energy sources
3) Reduction of peak power (system of Dynamic Reduction of Load of the Traction Substation).

In the area of PKP Energetyka operation, the successive energy storage systems will be installed.

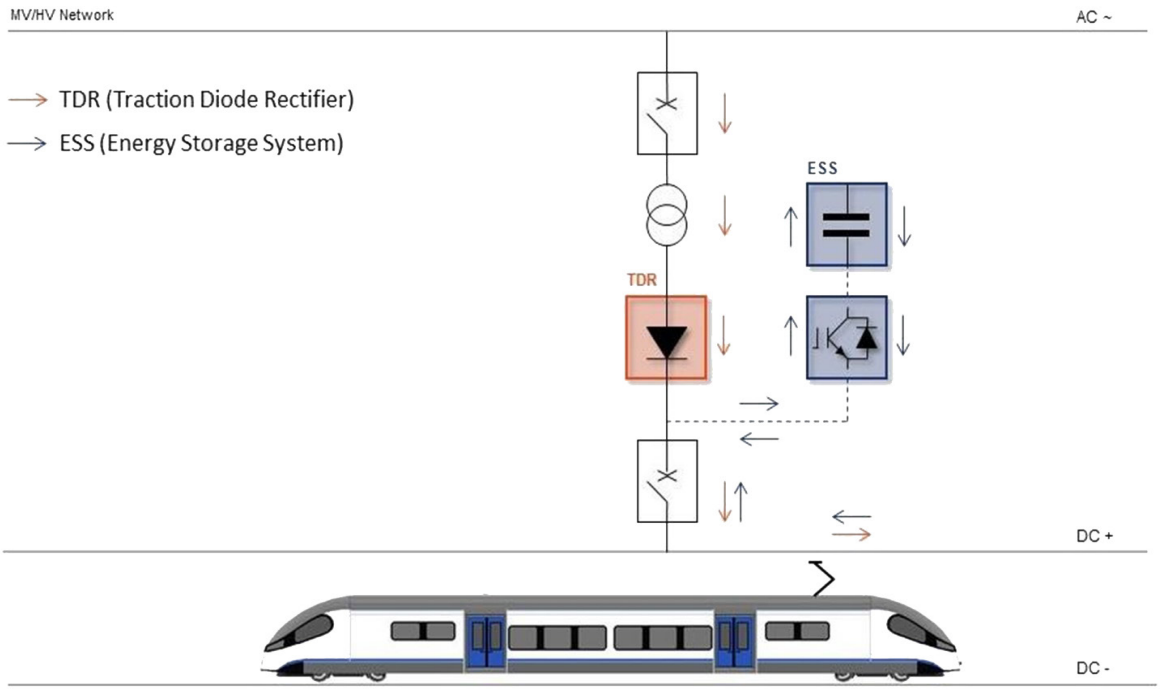

Fig. 5. A single-line diagram of connection of energy storage system in DROPT system [6]

Energy storage system in photovoltaic farm, delivered for the municipal waterworks in the Warmia and Mazury voivodeship

Two energy storage systems together with the photovoltaic installation (power of 0.5 MW) were placed in service in September 2020. The photovoltaic installation supplies the energy for water treatment in the municipal waterworks, the excess of non-consumed energy by the mentioned object during a day is accumulated in two BESS (battery energy storage systems) and then, it is consumed in the evening and night when energy production from photovoltaic farm is decreased.

During a sunny day, photovoltaic farm covers 100-% demand on electric energy whereas in the annual cycle, it is estimated that it covers 30% of the demand, in average. Power production from the photovoltaic farm during a year is characterized by a high variation, affected by a current solar radiation and fluctuations in efficiency of solar panels, depending on the environment temperature. Functioning of energy accumulators consists mainly in "seasonal work" during the greatest insolation i.e. from March to November. Power of each from the installed bi-directional inverters is equal to 30 kW and the capacity of each battery amounts to 51 kWh. The energy storage system was delivered by APS Energia company.

Fig. 6. Twin energy storage systems of APStorage type

The BESS (battery energy storage system) is connected to the object grid of a low voltage (3X400V AC). The implemented Li-ion batteries in LFP technology ensure durability and a high number of charging and discharging cycles. Lithium-ferrum-phosphate technology (Li-$FePO_4$, LFP) combines the advantages of a high current output, long operation time and, first of all, safety of use. Additionally, the discussed cells reveal the increased resistance to operating conditions as compared to other Li-ion technologies. They have the possibility of operating at temperatures below zero and in the case of internal short-circuit, the ignitions does not occur but only the effect of smoking. The rated voltage of Li-ion battery is 512V DC; the sBattery management system (BMS) is responsible for the management of the charging/discharging process as well as for diagnostics of battery and the safety of the cells.

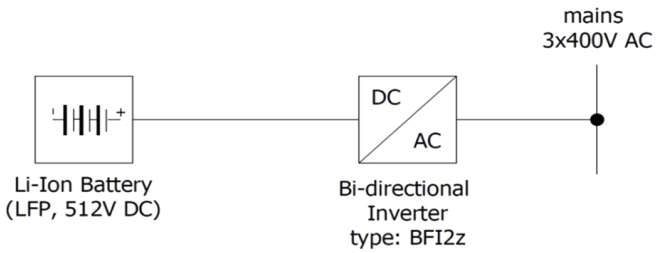

Fig. 7. Bloc diagram of energy storage system by APStorage

Apart from the function of energy accumulating during a day and its consumption in the night, the energy storage system has a function of function of reactive power compensation together with the simultaneous charging/discharging of BESS. The BESS (battery energy storage system) works fully automatically and the mode of operation and the state of charge (SOC) are visualized visualised locally on CD panel and introduced remotely to the supervision system SCADA.

Energy storage system in the industrial plant, production-storage complex Inter-Europol, Swiss Bakery

The example of the application in the industrial plant includes an energy storage accumulator which works for the needs of the high-storage warehouse of frozen products. The energy storage system was installed in 2019. The manufacturing-storing complex is found in Małopole near Warsaw and it belongs to Inter Europol Swiss Bakery. In the mentioned object, all processes are fully automated and are conducted at low temperatures, i.e. in the freezing conditions.

BESS (battery energy storage system) ensure continues and quality power for technological equipment and critical loads in the case of voltage sags and power outages. The installed energy storage accumulator consists of bi-directional inverter with power of 500 kW, type BFI2z and lithium-ion battery with capacity of 250 kWh, performed in NMC technology. The battery and the inverter ware built in the container station SPS.

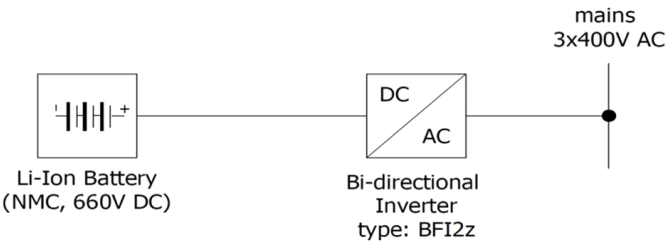

Fig. 7. Bloc diagram of energy storage system by APStorage

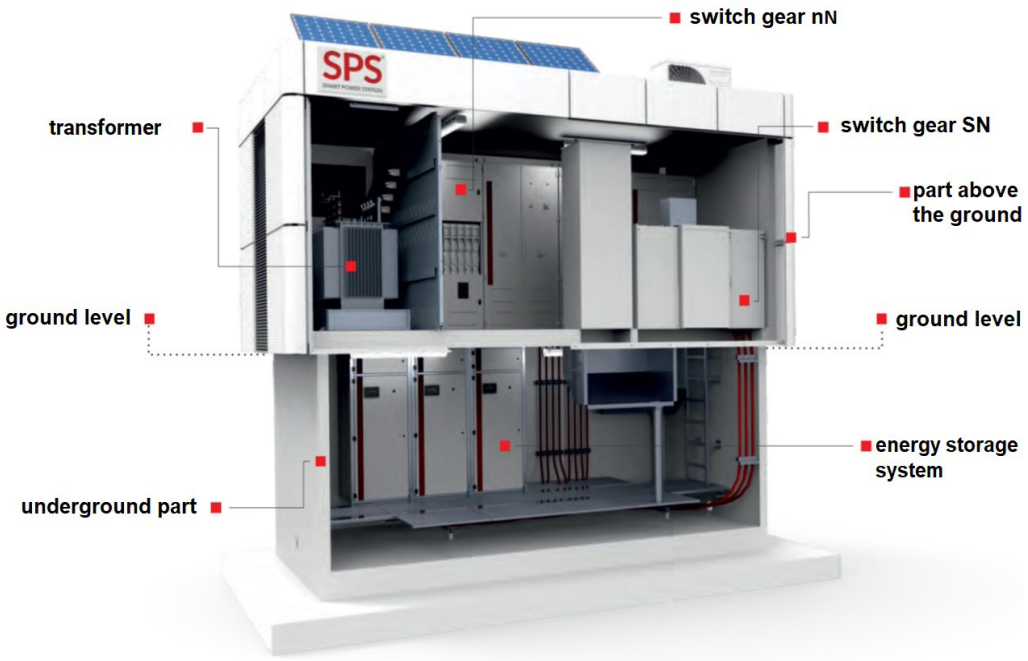

Fig. 9. Container SPS Station [8]

SPS (Smart Power Station) is an intelligent transformer station with energy storage system. It is composed of two parts: ground and underground. In the ground part, being found above the level of the ground, the the main electrical components are: medium voltage switchgear, bidirectional inverter, energy management system (EMS) and low votage switchgear. The underground part contains lithium-ion batterys and a fire extinguishing systems. Such solution is profitable as it increases the safety of installations and Li-ion batterys are operated in comfort range of temperatures (we eliminate high temperatures of work and those ones below zero). It is illustrated in Fig. 9.

Summing up

Development of energetics oriented towards distribution of generation sources, application of a big number of energy generating sources from RSE, separation of self-balancing areas in the distribution system and introduction of smart-grid conception will undoubtedly necessitate the micro-regulators such as energy storage systems are. If they are energy accumulators with power of several hundred kilowatts, or few or several or even several dozen megawatts, their energy storage system will be chemical accumulator (e.g. Li-ion). In the present study, it has been presented how the discussed installations are tested in different parts of Polish power system and what their tasks are. They are the systemic innovations which will allow us acquiring the experience. The mentioned experience concerns evaluation of suitability and learning how to operate them as well as familiarization with the principles of their installation and assessment of their safety system. The technology based on Li-ion cells in the chemical accumulator is characterized by a high energy density. In the case of improper operation, failure of the safety systems, defective functioning of BMS battery supervision system, the internal short-circuits and failures may occur. Frankly speaking, every one of us carries such energy storage system with Li-ion accumulator in his pocket (telephone) or in his bag (laptop) and it is safe and the failures happen incidentally. The same situation may be referred to "large-scale" storage systems. If the mentioned installations are properly and thoroughly technically designed and performed, such applications and installations will become a normal element of power system.

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WE HAVE HYDROGEN AND WHAT NEXT[1]?

MAMY WODÓR I CO DALEJ[1]?

Summary: *Hydrogen atom is the simplest atomic construction. When looking at abundance of the elements, we may state that hydrogen is the element, occurring in the Universe in the greatest quantities. Its structure is composed of one proton and molecular cloud, the particles of which surround its centre. It is so simple... Hydrogen on the Earth is entrapped in a form of H_2O, ammonia NH_3 and hydrocarbons. Its high quantities appear in a form of methane CH_4, especially, in methane hydrates[2] [25]. It is a very interesting source of hydrogen but the question arises: shall we be successful? Whether the humanity – a new Skłodowska-Curie or a new Maxwell [3] – when discovering the successive "obviousness" – will point out to the new horizons?*
Graphene[4] revolution has been hidden in laboratories. The "Azoty" Group (Poland) decided to develop independently the idea of production and popularization of this unusual material. Are we sure that we know and utilize fully a potential of the discussed material? If so, how can it help us to introduce the pre-hydrogen trend?

Keywords: *hydrogen, graphene, pre-hydrogen trend*

Streszczenie: *Atom wodoru jest najprostszą konstrukcją atomową. Patrząc na abundancję pierwiastków – wodór jest pierwiastkiem występującym we Wszechświecie w największej ilości. Na jego strukturalną budowę składa się jeden proton i obłok cząstek materii, które otaczają jego centrum. Takie to proste… Wodór na Ziemi jest uwięziony w postaci wody H_2O, amoniaku NH_3 oraz węglowodorów. Dużo go w postaci metanu CH_4, a szczególnie w hydratach metanu[2] [25]. Bo to bardzo ciekawe źródło wodoru, tylko czy się nam uda? Czy ludzkość – nowa Skłodowska-Curie czy nowy Maxwell[3] – odkrywający kolejne „oczywistości" wskażą nam nowe horyzonty?*

Grafenowa[4] rewolucja zaszyła się w zaciszach laboratoriów. Grupa Azoty postanowiła dalej samodzielnie rozwijać ideę wytwarzania i rozpowszechniania tego niezwykłego materiału. Czy na pewno znamy i wykorzystujemy w pełni potencjał tego materiału? A jeśli tak, w jaki sposób może nam pomóc we wdrażaniu trendu pro-wodór?

Słowa kluczowe: *wodór, grafen, trend pro-wodór*

Future lies in hydrogen

The European energetic-climatic policy forces us to seek for the alternative solutions and sources of cheap electric energy. The introduction of RES policy and the resulting legal regulations run effectively whereas owing to the recent political decisions the hydrogen revolution (although being still ineffective) has a chance to develop dynamically, including also stabilization of the situation in respect of energy storage (*inter alia*, in Poland) and to make the pre-ecological activities[5] real. Constantly increasing participation of hydrogen in energetic sector, especially in global aspect, makes that the leading producers of electric energy increase the additional financing of the mentioned research areas.

The most intensive studies on the properties of hydrogen are implemented, first of all, in the United States, Germany and France. Poland has also the achievements in this field with its project by PKN Orlen and Lotos group, PGE, GAZ-SYSTEM SA, in cooperation with higher education schools, *inter alia*, AGH Unoiversity of Science and Technology in Cracow, Łódź Technical University and Warsaw University of Technology and Silesian University of Technology. A wide popularization of

[1)] The paper has been changed and amended; primarily, it was published as: Klima K., Sikora A., "Universal everywhere. We have hydrogen and what next...? Energetyka Cieplna i Zawodowa 2/2016 (628) p. 48-49. ISSN 1734-7823; and "Entrapped in hydrogen. We have hydrogen and what next?" part 2 Energetyka Cieplna i Zawodowa 3/2016 (634) p. 108-113. ISSN 1734-7823

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[3)] He proved that electricity and magnetism are two types of the same phenomenon – electromagnetism; that electric and magnetic fields are dispersed in vacuum with the light velocity in a form of waves, i.e. that the light is the electromagnetic wave

[4)] It is a flat strcture of carbon atoms – in 2010, Andriej Gejm and Konstantin Nowosiolov received Nobel Prize in the domain of physics for the studies on graphene, University in Manchester

[5)] Cf. For example: https://www.gov.pl/web/klimat/rozpoczely-sie-konsultacje-publiczne-projektu-polskiej-strategii-wodorowej; https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A52020DCO102&qid=1610462287586; COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL , THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. A hydrogen strategy for a climate-neutral Europe COM/2020/301 final https://eur-lex.europa.eu/legal-content?EN/TXT/?qid=1596807561238&uri=CELEX:52020DCO301; COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU strategy to reduce methane emissions; https://ec. europa.eu/energy/sites/energy/files/eu_methane_strategy.pdf; htpps://eur/lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A52020DCO299&qid=1610462203898;

the discussed element in the Cosmos and the simple, though very expensive methods for its obtaining, have resulted in the development of energetics and rendering it a name of ecological (organic) fuel. Why, therefore, the process of replacing the universally employed petroleum or ground gas by hydrogen is inhibited? The so-far existing costs of hydrogen production have been lower than the energy obtained from its combustion what decided on the unprofitability of the process. Let's pay attention, therefore, to the advantages, speaking for the increase of hydrogen participation in the global and national production of electric energy. Its ecological nature, connected with the production of water (water vapour) in the combustion process should be confronted with sulphur dioxide and carbon dioxide, being the by-products of fossil fuel combustion. Moreover, hydrogen has a low ignition temperature and relatively very high combustion temperature in relation to the mass of the discussed element. The cars, driven by hydrogen, are becoming more and more popular; their performance and the application of "clean fuel" convince the users to bear higher expenses and overcome the difficulties connected with the lack of fuelling stations[6].

Aspects of storage and transfer of hydrogen in the industrial scale and the optimization of the mentioned process of its production seem to be a priority.

What may be a role of graphene in the "hydrogen revolution"?

Graphene is a flat structure consisting of carbon atoms; its form resembles a thin (thickness is only one atom) plaster of wax foundation. One of its main features includes heat conductivity (thermal conductivity is equal to 4840–5300 W/mK) which is intensively employed in different industrial branches. Being a very resistant material (100 times harder than steel), it is subjected to elongation even by 25%. Graphene may play a function of a very sensitive gas detector and it is connected with its sorption properties, in which the total surface of material participates. The possibilities of applying it as insulation/dam for the smallest atoms, *inter alia*, of helium or hydrogen, is the essence of the energy storage process and its chemical neutrality to water effect allows implement the idea of catalysis of water hydrolysis process. Graphene is susceptible to modifications and to affecting its physico-chemical properties (creation of materials for construction of organic electrodes, photovoltaic cells or construction of layers of solar collectors).

Some words about sorption capabilities...

Carbon-based materials may absorb well the particles of, *inter alia*, H_2. The results of physical sorption, conducted with graphene, have indicated its very high affinity to absorption of the hydrogen molecules and, what is most important (in storage aspect) owing to the mechanical tensions, the control of gas release from graphene is possible[7] [2]. When looking at the mentioned problems, it seems to be an ideal material, increasing the possibilities of energy storing in a form of hydrogen, isn't it so?

The above fact was considered, inter alia, by the research team of the University of Technology of Łódź , developing the graphene tank which allowed driving about 800 km without the necessity of refuelling the car (hydrogen as a fuel[8]) [3]. The process of absorption and recovery of the particles was carried out on the principle of temperature changes with the consideration of the earlier mentioned feature of graphene in control of sorption-desorption cycles. "As compared to the graphene, as produced now by the available methods, the graphene produced at the Technical University of Łódź has a higher durability and repeatability of physico-chemical properties in variable conditions of pressure and temperature[9]". Based upon the discussed graphene, nanocomposite for the reversible storage of hydrogen was produced; it is found under the development within the frames of the project implemented by the University of Technology of Łódź and company Seco Warwick S.A., entitled: "Graphene nanocomposites for a reversible storage of hydrogen – GraphRoll". The searches for the methodology and materials for the development and improvement of the currently obtained results in respect of the quantity as well as quality of hydrogen in the reversible gas storehouses are a priority in the hydrogen-promoting policy.

Whether to increase the effectiveness of hydrogen production?

Hydrogen is one of two gas products, generated during water hydrolysis process. Electric energy breaks the relatively strong links between oxygen and hydrogen atoms in water molecule, transforming both elements in a gas form. The excess of electric energy, resulting from RES is the first stage of the process of "entrapping the energy in hydrogen molecule". The period of demand on electric current during the year or even 24h varies and therefore, the storage of energy is necessary to make a buffer and ensure the energetic stabilization of the network in

[6] „Institute of Car Transport (ITS) has developed the plan of the project for construction of a network of several stations in Poland where it would be possible to fuel the vehicles (buses and personal cars) powered by fuel links, with hydrogen. ITS is one of the institutions, implementing the European Project Hit-2-Corridors, the aim of which is to create and later on, integrate with the European infrastructural network, serving for utilization of hydrogen as a fuel in road transport" Wojciech Gis explains. One of the effects of the work in the discussed project includes the plan of building the stations in Poland, mainly in the courses of the European transport corridors TEN-T. The answer to the question: "When it will be possible?" is not easy. The Institute assumes the construction of 9 such objects up to 2030, depending on the interest. "https://www.pb.pl/4365094,94750,polska-bedzie-miala-stacjewodorowe?utm_source=copyPaste&utm_medium=referral&utm_campaign=Firefox(access 2015/12/03) and 2021/01/22

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[8] Vision of Prof. Piotr Kula, Director of the Material Engineering Institute of University of Technology of Łódź, based upon the so-far obtained results of the studies on the application of graphene in the motorization revolution. The interview by Jacek Krywko for wyborcza.pl

[9] https://www.p.lodz.pl/pl/grafen-politechniki-lodzkiej

a given country. During the process of hydrolysis, platinum is a catalyst of reactions on anode (where hydrogen is released); it is cheap and rare in nature. The scientists have found also here the application for graphene. The catalyst based upon the mentioned materials is derived from Texas. It reaches not only a high efficiency but also is a cheap material in comparison to platinum. Signed Co-NH complex is cobalt, distributed in graphene matrix with the participation of gas ammonia[10] [4]. The obvious aim is to lower the cost of hydrolysis and, consequently, to lower the price of the obtained hydrogen.

When speaking about electrolysis, we cannot forget about PEM (Polymer Electrolyte Membrane) method that is the alternative to less effective but cheaper method (Alkaline Water Electrolysis). The only one but deciding disadvantage of PEM is its high cost. We might try to lower the costs of the mentioned method by replacement of platinum by graphene as catalyst.

Fuel cells are known all over the world. Their power generating capabilities place them higher than the traditional primary cells. How to utilize graphene, also in this aspect? It would allow lowering the production costs and improve durability and quality of the cells. Owing to the studies, conducted in the USA, the idea of the application of graphene catalyst in fuel cells has been positively considered[11] [5]. The research program was born from the same need as in the case of water hydrolysis. There are the attempts to replace the currently used catalyst, platinum, by the cheaper but equally effective material. Graphene is ideal for this purpose. A special attention should be paid to the studies of 2013, where the so-called "graphene nanoplatelets"[12] [6] in combination with one of the elements from 17.group – halogens. Synthesis with iodine occurred to be the most durable combination; it allowed generating by 33% more electric energy more in comparison to platinum-catalyst cells[13] [20]. A series of the so-far conducted studies on the application of graphene, carbon nanomaterials in power-generating processes seems to be optimistic.

In friendship with Renewable Energy Sources (RES)

One of the applications of the discussed above element includes graphene as a building material of the outer layer of solar collectors. A flat structure of carbon atoms is a very durable, flexible material with a low specific gravity. In respect of RES, and, more precisely, voltaic cells, it conducts the electric current by 50 times better than the earlier employed silicon. When considering its physical properties i.e. transparency, possibility to work at each light wave length and a perfect conductivity, we may state that graphene may be utilized both in the systems of energy conversion and in the processes of energy storage. The present work is focused on the construction of supercapacitors, being able to carry out the cycles of charging and discharging quickly and effectively; it could have the effect on the process efficiency. The mentioned studies include improvement of LFP cell (Lithium-Phosphorus-Ferrum), using a reduced graphene oxide[14], increasing its capacity and durability [7]. The researchers form University of California paid their attention on graphene layers with manganese dioxide[15], owing to which a high energy density was obtained (by 42 Wh/l) with the consideration of a very short time of charging (16 seconds) in comparison to lithium-ionic capacitors [8]. We should also mention an innovating discovery of the scholars, working under the guidance of Prof. Dan Li at Monash University in Australia in 2013. They employed the so-called graphene gel[16] with the aim to construct a supercapacitor with capacity of 60 Wh/l. Owing to such applications, the time of charging cycle of capacitor may be not only abbreviated but also a high electric capacity may be maintained; it is the essence of the application of cells/capacitors in aspect of motorization and renewable energy [9]. As far as sector of Renewable Energy Sources (RES) is concerned, we should mention that according to the opinion of scientists from MIT, the application of graphene cells may double value of maximum solar energy conversion in photovoltaic cells . The higher efficiency of the process means a higher production of electric energy which may be stored in a form of hydrogen; graphene will be the element, consolidating the mentioned processes.

If not graphene and carbon materials, so what then?

The answer to this question may come from the successive complex compounds, belonging to a group which generates molecular sieves, that is, **zeolites**. These unusual compounds,, characterized by a porous structure, possess very good sorption possibilities. We may distinguish natural and synthetic zeolites. A question arises: whether their sorption properties could be utilized in storage of hydrogen? Such studies were conducted at Latvian University[18] [22]. Pure zeolite does not possess high sorption possibilities (Fig. 1); however, the modification of the discussed material and the appropriate conditions may improve its physico-sorption possibilities. A group of the researchers[19]

[10] Paper by Ewa Buczyńska „Graphene may lower the costs of hydrogen obtaining from RES for FCEVs" published in swiatoze.pl http://swiatoze.pl/aktualnosci/grafen-moze-obnizyc-koszty-pozyskiwania-wodoru-z-oze-dla-fcevs _385.html

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Fig. 1. A diagram, representing value of adsorption for the particular zeolites and carbon materials[21] [Source 18]

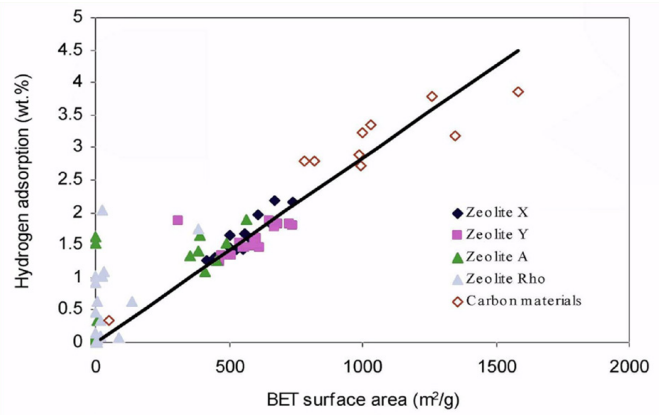


Fig. 2. A diagram, illustrating the process of Zeolite adsorption after ionic exchange Mg^{2+} and zeolite, washed with distilled water (pure zeolite, weight percentage of water content at time[22] [22]

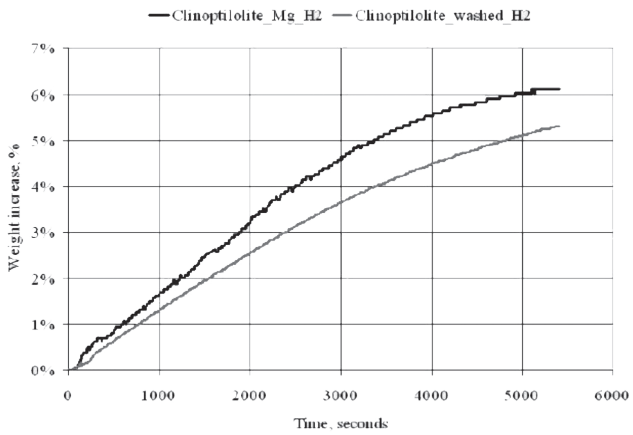
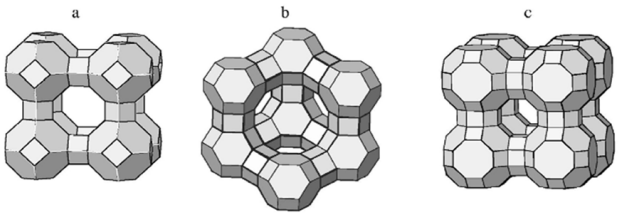


Fig. 3. Zeolite of type: 1/A; 2/X and Y; 3/RHO[24] [23]

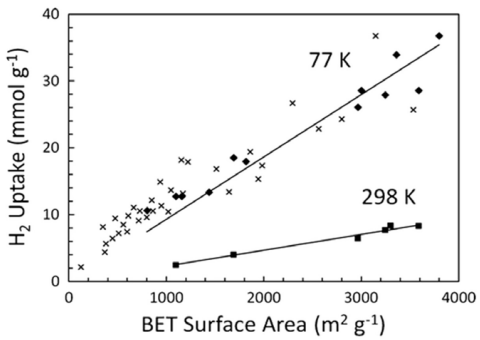


utilized naturally occurring zeolite material, klinoptylolite and the process of ion exchange with the used magnesium ions Mg^{2+} at temperature of 77 K what increased the sorption abilities of hydrogen. Ionic exchange in total improves adsorption-desorption properties of zeolite material; on the grounds of the results of the studies of Latvian scientists, the complex: zeolite-magnesium seems to be promising as compared to other sorbents[20].The obtained result – 6.2% by weight of adsorbed hydrogen for zeolite with Mg ionic exchange and 7% for pure zeolite, heated in nitrogen atmosphere allows optimistically looking at a wide spectrum of zeolite applications (Fig. 2); however, with the consideration of cryogenic conditions [22].

In 2003, a group of the scientists at Birmingham University worked upon a similar problem, i.e. sorption of hydrogen on synthetic zeolites A, X, Y and RHO[23] [23].

The conducted studies revealed[25] the best sorption properties of sodium zeolites NaA, NaX and NaY in relation to the complexes based upon the cadmium atoms [23]. Temperature was also a variable factor. The results, showing the highest value after adsorption-desorption cycles at temperature of 77K, that is, in cryogenic conditions, were unfavourable for the development of hydrogen technology (Fig. 4). In this aspect, we should pay attention to the necessity of increasing the costs connected with the maintaining the system in isothermal conditions. The successive disadvantage of the discussed application includes a low value of sorption (maximum 1.81% for NaY zeolite) at temperature of 77 K. The discussed technology has undoubtedly a potential but it requires many modifications. It should be mentioned that the present numerous studies and the trials to optimize mass production of zeolites from volatile ashes run in a very dynamic way. The utilization of by-product of combustion of coal and lignite in production of sorbent and later on, its use in storage and transfer of hydrogen affects a vision of environment-friendly future.

Fig. 4. A diagram, representing sorption H_2 on zeolite matrix at temperature of 77 K and 298K[26] [26]



[19] Source: footnote [15]

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Over the states, there is a supreme-state [....] until I am going! [27] [24]

We know what hydrogen is, we know its properties, we are able to accumulate it and transform into electric energy. The ideas of its storage are dynamically developing. We hope that after the lecture of this paper, the Reader will have a question: when the "outburst of the hydrogen era" will take place. In our opinion, the mentioned period was commenced in the second decade of the 21st century. Hundreds of articles concerning the possibilities of utilizing hydrogen-driven mechanical vehicles, planned hydrogen refuelling stations, or construction of underground storehouses for H_2 in salt caverns are the premise of this trend. Perhaps it is enough that some would lie down under the apple tree or enter the tub with water and cry: "*Eureka*"!! (The motto for today is: to introduce graphene revolution and RES into the era of hydrogen!).

Economic aspects in such approach include optimization of manufacturing processes, storage and transmission of hydrogen in the industrial scale. The key may be the so-called wax foundation – the "leaven" of chemical honey plaster – Graphene. And perhaps the future belongs to sorbents with a high capacity! Michio Kaku wrote: *"In this century, we will harness the power of the stars, a source of the energy of Gods. In a short perspective, it will be the introduction of era of solar-hydrogen energy, which would replace fossil fuels; and in a longer time perspective –control of nuclear synthesis and even solar energy from the outer space"*[28] [21].

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ANALYSIS OF THE SELECTED FACTORS INFLUENCING THE MANAGEMENT OF FOREST RESIDUES IN POLAND

ANALIZA WYBRANYCH CZYNNIKÓW WPŁYWAJĄCYCH NA ZAGOSPODAROWANIE POZOSTAŁOŚCI ZRĘBOWYCH W POLSCE

***Summary**: Modern energy management uses solid biomass in combustion processes with a great success. The amount of biomass increases along with properly conducted forest management, the development of agricultural production and the growing scale of post-production waste. Statistical analyses, determining the dependence of the factors on the tested parameter and also, supporting the priority of activities, may facilitate the development of certain pro-ecological activities in a given region. The article estimates the economic use of forest residues as a source of renewable energy fuel in the context of the market situation.*

The performed statistical analysis of multivariate ANOVA method and the AHP method as well, determined the possibilities to manage the forest residues for energetic purposes. In one case, the critical significance level determining the assignment of the analyzed factor to a particular homogeneous group was below 0.05. This means that there is a relationship between the number of public roads and the number of enterprises. Therefore, due to the number of roads, the greatest prospects for the development of a company in the wood industry are found in the Małopolskie, Mazowieckie, Śląskie and Wielkopolskie voivodeships.

***Keywords**: forest residues, energy management, biomass, forest management, wood industry*

***Streszczenie**: Współczesna gospodarka energetyczna z powodzeniem wykorzystuje biomasę stałą w procesach spalania. Ilość biomasy wzrasta, wraz z właściwie prowadzoną gospodarką leśną, rozwojem produkcji rolnej i rosnącą skalą odpadów poprodukcyjnych. Analizy statystycznych określające zależność czynników na badany parametr a także wspomagające priorytet działania mogą wspomóc rozwój pewnych działa proekologicznych na danym terenie. W ramach artykułu oszacowano ekonomiczne wykorzystanie pozostałości zrębowych jako źródła paliwa odnawialnego w kontekście sytuacji rynkowej.*

Przeprowadzona analiza statystyczna określiła możliwości zagospodarowania biomasy leśnej przeznaczonej na cele energetyczne, wykorzystując wieloczynnikową analizę wariancji ANOVA i metodę AHP. W jednym przypadku krytyczny poziom istotności decydujący o przypisaniu analizowanego czynnika do określonej grupy jednorodnej wynosił poniżej 0,05. Oznacza to, że istnieje zależność pomiędzy ilością dróg publicznych a liczbę przedsię-biorstw. W związku z powyższym, z uwagi na ilość dróg największa perspektywa rozwoju przedsiębiorstwa działającego w branży drzewnej istnieje w województwie małopolskim, mazowieckim, śląskim i wielkopolskim.

***Słowa kluczowe**: pozostałości zrębowe, gospodarka energetyczna, biomasa, gospodarka leśna, branża drzewna,*

Introduction

During the recent years, many improvements in respect of innovative ecological solutions have been carried out in the heating and energetic industries. It results from the duty of adapting the energetic policy to the assumptions of energy-climate package of the European Union. According to the binding legal legislation, a part of biomass is utilized in heat plants and power plants. The mentioned activities have a direct relationship with the reduction of greenhouse gases, utilizing the mechanisms, acting of the principle of clean development mechanism (CDM[1)]). The idea of limiting the unfavourable environmental changes was ratified within the frames of the UN Conference in Kyoto, contributing to resolution of Directive 2003/87/CE, limiting the exploitation and excessive use of fossil fuels.

Raw material

The chosen strategy inclines Poland as well as other countries, to deeper interest in the possibilities of managing and use of commonly available, pro-ecological waste raw materials from forest territories. The mentioned group includes material, generated on forest surfaces and the residues from

[1)] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003, establishing a scheme for greenhouse emission allowance trading within the Community amending Council Directive 96/61/CE p. 631

Tab. 1. The percentage of individual parts of wood in the total weight of pine

No.	Properties	Literature
1.	- longitudinal thickness: 64% - stacked thickness: 8% - general limb: 5% - brushwood: 7% - roots: 16%	[4]
2.	- wood arrows: 61% - bark arrows: 8% - branches: 12% - needles: 3% - snag: 16%	[1]
3.	- treetops, branches, needles: 20% - branches thinner than 40 mm and needles: 15% - branches thicker than 40 mm: 5%*	[1]
4.	- trunk 69% - top, branches 16% - stump, roots 15%	[8]

** Including the above-ground biomass part of the harvested wood*
Source: Own study

forest raw material-producing industry, being treated as a waste. The obtained forest residues, resulting from forest work, have been officially defined as forest biomass (Official Journal of Laws, 2015, item 317). This group consists of firewood in a form of chips and waste coming from forest in a form of small-dimension wood: branches, tops, bushes, brushwood and tree stumps, and also, wastes from wood industry (chips, sawdust). In relation to a part of the mentioned residues, we can observe the tendency of increasing the interest in the wastes which in the forest management until now have not been commonly used for heating and energetic purposes. The discussed forest residue as small-dimensional material was produced and used by the local inhabitants or sold for a symbolic sum.

The terminology of the described forest residues has not been consolidated. In literature, the mentioned material is described as logging residues, after-logging residues or slash [3]. The forestry residues are the material, remaining as a result of wood logging. In order to prepare the area for renovation, the branches and tops of the trees should be removed after felling (forest operations). They should be collected in piles on post-logging area or at exit routes. When disintegrated, they may be mixed with soil, using specialist machines. Forest residues are characterized by a high content of bark and needles.

According to literature data, the present area of forests in Poland covers about 9.2 million hectares. It corresponds to ca. 29.6% of the territory of our country. Climatic and habitat conditions are favourable for development of coniferous trees which constitutes 69.6% of the total afforestation [Wasiak 2014]. Common pine (*Pinus silvestris L*), being also called Scots pine [7] is most frequently found and acquired tree species in Polish forests. The potential of wood industry is expressed in its production functions. In Poland, 34352103 m^3 of total coniferous thickness are acquired annually [2].

During the process of wood acquiring, a big amount of waste is produced from which, *inter alia*, we may distinguish forest residues. The mentioned forest residues consist mainly of branches and tops of the trees. The participation of logging residues is differentiated and amount to ca. 15%. According to estimates, about 6 million m^3 of logging residues are generated during logging of 34 million m^3 of coniferous thickness. The preparation of wood material consists in fragmentation of the raw material to a form of wood chips, using disintegrator. The percentage participation of the particular wood parts in the total mass of pine, as described in literature, has been presented in Table 1.

The percentage participation of the particular wood parts in the total weight of pine, characterizes the amount of generated forest biomass as a result of thickness harvesting. The estimated quantity of forest residues inclines us to undertake the problem of their management. In practice, the forest residues may be left at the site of logging in a form of fertilizer; however, their utilization as a solid fuel allows producing the additional source of renewable energy. The undertaking of the action towards management of forest residues is justified by an insufficient amount of information on the possibilities of their economic utilization; carrying out the economic analysis would allow extending the information concerning the economic utilization of forest residues.

Economics

It is mentioned in literature that the entrepreneurship is a certain ability of utilizing the available technology, information, different types of resources and the management methods in order to achieve the intended aim. Utilization of disintegrated forest residues fits widely the idea of entrepreneurship as it may

Table 2. The selected data concerning the factors according to the particular voivodeships

Voivodeship	Number of enterprises	Coniferous wood acquisition, m³	Total public roads, km	EU funds,/ person
Dolnośląskie	2541	2 760 541	24 333,4	22
Kujawsko-pomorskie	1628	2 428 896	27 516,5	59
Lubelskie	1521	1 332 704	38 115,4	37
Lubuskie	1005	3 050 218	15 579,6	28
Łódzkie	2078	1 170 489	26 045,8	72
Małopolskie	5943	864 462	31 444,0	24
Mazowieckie	5095	1 865 031	55 008,5	49
Opolskie	1007	1 054 616	10 504,8	13
Podkarpackie	2285	1 583 928	21 122,9	30
Podlaskie	1008	1 626 952	26 673,5	63
Pomorskie	2154	4 801 999	22 720,0	30
Śląskie	4552	1 308 918	24 756,4	36
Świętokrzyskie	1059	1 108 281	17 491,7	20
Warmińsko-mazurskie	1105	2 669 944	22 360,0	46
Wielkopolskie	4661	3 336 411	41 042,1	69
Zachodniopomorskie	1533	3 388 714	19 849,3	16

Source: Main Statistical Bureau (GUS)

occur to be the undertaking with a high economic potential. Introduction of the conception of utilizing the disintegrated forest residues requires economic analysis which has been carried out in the present paper, using the available statistical tools. Table 2 includes the data, according to the voivodeships, which were used during the statistical analysis. The mentioned data describe the factors which may affect the development of the enterprises.

The aim and methodology of the studies

The aim of the study was to perform the statistical analysis of the possibilities to manage the forest biomass, destined for energy purposes. To analyze the selected factors, affecting the level of forest biomass management in Poland (as assumed), the statistical methods were used (ANOVA, AHP).

Statistical ANOVA analysis

To elaborate the statistical results, the analytical tools in a form of multi-factor variance analysis ANOVA were employed. The mentioned method allows determining the influence of the selected factors on the initial parameter and the mutual relationships between the analyzed parameters, with the assumption that the remaining factors are constant (unchanged) i.e. *ceteris paribus*. The mentioned relationship is expressed in formula 1.

$$\omega = f(\tau, \varphi) \tag{1}$$

During the analyses, value α, characterizing significance level and expressing the probability of performing the error in the choice of confidence coefficient, was considered [10][2]. The allocation of a given factor to a specified uniform group is determined by a critical confidence level. Value of test probability α was adopted on the level equal to 0.95, i.e. F=1-α. The results of the conducted statistical analysis were also affected by the nature of the problem and accuracy of the distribution of means [Statistics performed manually 2015; in Polish: "na piechotę"][3]. The definition of the resulting inter-group error consisted in determination of the ratio of the sum of inter-group squares and the number of freedom degrees[4]. The inter-group error may be determined, using formulae 2, 3 and 4.

$$SS_T = \sum_{i=1}^{a} m_i(\bar{y}_{(i.)} - \bar{y}_{(..)})^2 \tag{2}$$

[2] J. Jakubowski, R. Sztencel: Introduction to theory of probability, Script, Warsaw 2004, p. 59

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[4] http://www.naukowiec.org/wzory/statystyka/jednoczynnikowa-analiza-wariancji_371.html.

$$df_T = a - 1 \quad (3)$$

$$MS_T = \frac{SS_T}{df_T} \quad (4)$$

where:
m_i – number of units in the particular groups,
a – number of the groups under comparison in variance analysis, number of factor levels,
$\bar{y}_{(...)}$ – general mean, for all observations,
$\bar{y}_{(i...)}$ – the mean for a given level of factor, for the tested group,
SS_T – inter-object, inter-group sum of squares,
df_T – inter-object, inter-group degrees of freedom,
MS_T – inter-group variance.

The analysis of variance with multiple classification allowed examining the effect of the components on the population. Theoretical scheme of statistical analysis is shown in formula 5.

$$Xijk = xsr + ai + bj + ck + (ab)ij + (ac)ik + (bc)jk + (abc)ijk + eijkl \quad (5)$$

where:
X_{sr} – general mean, for the whole population,
ai – effect of A factor on level i (i=1, 2,....., n)
bi – effect of B factor on level i (i=1, 2,....., k)
ck – effect of C factor on level i (i=1, 2,....., m)
$(ab)ij$ – effect of interaction of A and B factors on the levels i and j, respectively
$(ac)ik$ – effect of interaction of A and C factors on the levels i and k, respectively
$(bc)jk$ – effect of B and C factors on the levels i, j and k, respectively
$(abc)ijk$ – effect of interaction of A, B and C factors on the levels I, j and k , respectively
$eijkl$ – random error with a normal distribution, mean equal to zero and constant variance.

AHP method

The definition of final results requires construction of the appropriate structure of the example to be solved, with modeling of the proper scheme of the problem's hierarchy. To develop the alternative to the choice from among the analyzed variants, the method, developed by Thomas Saaty, called AHP, was employed. The mentioned method requires the construction of the appropriate structure of the example to be solved with modeling of the scheme of the problem's hierarchy. During the analysis, all elements, constituting the matrix of the variable criteria, are compared. The accuracy of alternative of the solutions is increased proportionally to the degree of the proceeding in respect of the adopted scheme [10].

AHP method compares all elements, creating the matrix of variable criteria, expressing value of the specified traits. The assigned values of the elements will be plotted out and compared in the prepared square matrix. The specified traits correspond to the numerical values, assigned according to the priority recognition. During evaluation, the intermediate values and even reverse values are also admitted. The reciprocal occurs in the case when the second element is more important than the first one. The assignment of numerical values is facilitated owing to specially prepared nine-score grading scale, corresponding to the equivalent of the rank of the factors [5, Przybyło and Krężołek 2010]. Table 3 contains the standardized 9-score scale of gradation.

Table 3. Characteristics of the assessed objects according to Rycąbel

Importance degree	Explanation
1	Both elements have the same weight
3	The first element is a little more important than the second one
5	The first element is more important than the second one
7	The first element is much more important than the second one
9	The first element is decisively more important than the second one

Source: [11]

For development of the results, the counting module in a form of computer program, called AHP method was employed. The mentioned program was elaborated in the Delhi environment within the fames of the author's research activities. The discussed program has a designed counting module in a form of matrix algorithm, for diagnostic and comparative evaluation of the analyzed criteria. The analysis, employing AHP method, was conducted based on the selected factors affecting the management of the logging residues in Poland.

The results of the studies and conclusions

In the examined case, ANOVA analysis allows determining the effect of individual factors on the input parameter and, also, defining the mutual relationships between the analyzed parameters. The numerical interval, as estimated with the assumed probability as a confidence interval, contained the unknown, real value of the parameter, belonging to a general population, which characterized the vertical columns, having a range of 0.95. The confidence intervals may be determined for the arithmetical mean. The probability, specifying the real location of the defined parameters has been determined by confidence interval (1-α) (percentage confidence interval 100 (1-α))[5]. A critical level of significance, determining the assigning a

[5] Manual statistics http://home.agh.edu.pl/bartus/index.php?action=statystyka&subaction=przedzialy_ufnosci

given factor to the specified homogenous group should amount at least to less than 5%. As a result of the conducted estimates, three basic output parameters and factors were chosen. The analyzed parameters and output factors have been presented in Table 4.

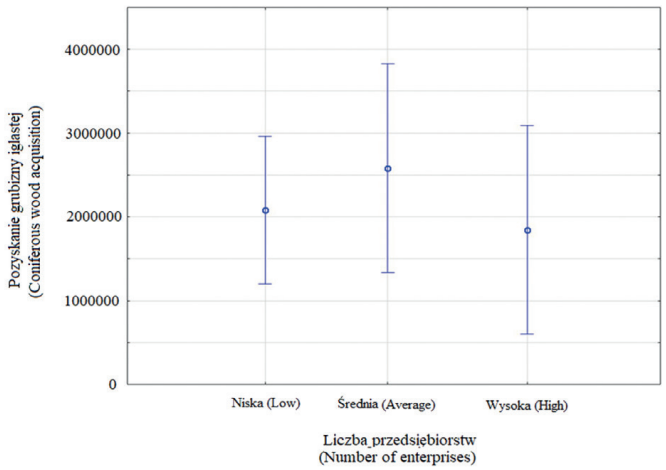
Table 4. The analyzed parameters and output factors

Output parameter	Factors
(Number of enterprises – subclass 16.29.Z, Manufacture of other wood products Grouping factor: • Low - < 2000 • Average 2000 ÷ 4000 • High > 4000	Coniferous wood acquisition, m^3
	Total public roads - hard and unpaved surface, km EU funds – RDP 2014–2020 – 6.4. Support for investments in the creation and development of non-agricultural activities), person

Source: Own study

As a result of statistical analysis (ANOVA), the impact of coniferous wood acquisition, length of public roads and the possibilities of additional financing from the EU means on the number of enterprises in wood material processing industry was determined. In the case of the effect of coniferous wood acquisition on the number of enterprises, the statistical analysis die not show any effect. The significance level was higher than 0.05 and had value p = 0.659. The empirical value of statistics was equal to F (2, 13) = 0.43139. The characteristic of the relationship between the number of the enterprises and coniferous wood acquisition is given in Fig. 1.

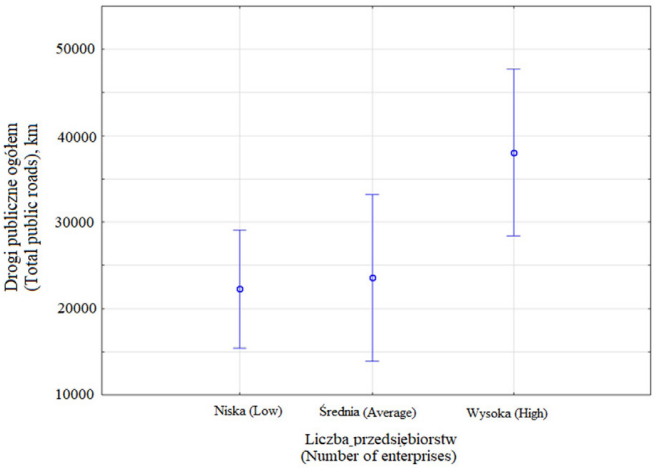
Fig. 1. Characteristics of the relationship between the number of enterprises and coniferous timber acquisition



A different situation occurred in the case of the number of enterprises and the quantity of roads. The level of significance: p= 0.034 where the empirical value of statistics F (2, 13) was equal to 4.4565. The statistical analysis showed the effect of the number of public roads on the number of enterprises. The characteristic of the relationship between the number of enterprises and the number of public roads is given in Fig. 2.

The result of Duncan analysis in the recent case showed a significant effect on the number of enterprises. It may be

Fig. 2. Characteristic of the relationship between the number of the enterprises and the number of public roads



concluded that the discussed situation reveals a certain adaptation of transport in the voivodeships where there is a high development of enterprise in the field of wood material processing. The specified homogenous groups of the relationships between the number of enterprises and the number of public roads are illustrated in Table 5.

Table 5. The relationships between the number of enterprises and the number of public roads

Number of enterprises	Homogeneous group	
	I	II
Low	X	
Average	X	
High		X

Source: Own study

In the case of financing the undertaking with the utilization of the EU funds, statistical analysis did not found any significant effect on the studied factor on the number of the created enterprises. The statistical analysis revealed that the level of significance p = 0.759 for value of empirical statistics F (2, 13) was equal to 0.28230. The statistical analysis ANOVA did not show any effect of the quantity of allocated EU funds within action 6.4 (Support of investments in creating and development of non-agricultural activity) on the number of enterprises. The characteristic of the relationship between the number of enterprises and the amount of the allocated EU funds is given in Fig. 3.

According to the methodology, the application of hierarchic choice method (AHP) requires construction of square matrix together with the ascribed traits of the factors. In the upper right corner of the matrix, the declared values of the analysed traits should be marked. From the analysis of the results, we may conclude that the number of public roads with the hard ground

Fig. 3. Characteristics of the relationship between the number of enterprises and thre amount of the allocated EU funds

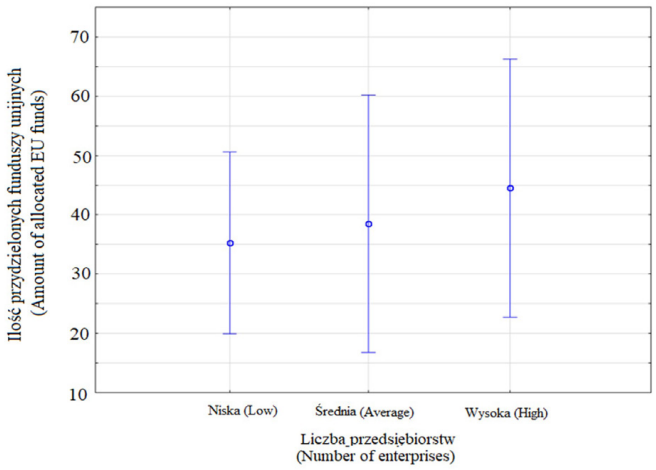


Fig. 4. Values of weights

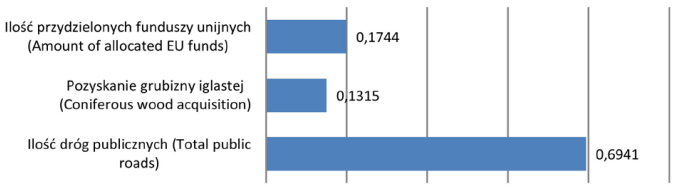


Table 6. Pairwise comparative matrix

Criteria preferences	IDP	PGI	IPFU
Total public roads	1	7	3
Coniferous wood acquisition	1/7	1	1
Amount of the allocated EU funds)	1/3	1	1

Source: Own study

and the dirt roads has the highest weight (impact) from among the analysed factors on the development of entrepreneurship.

We should remember that the selected example is a model as the potential development of the enterprise is determined by greater number of factors than those ones chosen to the given example. As a result of analysis it was established that the maximum own value of matrix was equal to 3.0803. The Consistency Index (CI) amounted to 0.0401499 what means that it satisfied the condition of consistency ($\lambda max - n) / (n - 1) \leq 0.1$). Values of weights are given in Fig. 4.

Observations and conclusions

The conducted analysis allowed formulating the following conclusions:

1. In Poland, there are quite big resources of material in a form of forest residues.
2. According to statistical analyses, there is a group of factors which may affect the development of enterprise in respect of management of the forest residues.
3. When starting a business activity in the field of wood chip processing, we should be driven by infrastructure of public roads. Statistical analysis showed that public roads with hard ground surface and the dirt roads are a significant factor in respect of wood waste processing.
4. According to grouping factor, the Małopolskie, Mazowieckie, Śląskie and Wielkopolskie voivodeships are the most developed regions in relation to the number of enterprises and public roads.

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INDUCTION OF DECISION TREES FOR BUILDING KNOWLEDGE BASES OF PRODUCTION PROCESSES

INDUKCJA DRZEW DECYZYJNYCH DLA BUDOWY BAZ WIEDZY PROCESÓW PRODUKCYJNYCH

***Summary**: The article presents the process of acquiring the knowledge based on the induction of decision trees, graphically illustrating the differences between acquiring the knowledge in a traditional way, from the expert, and the process of acquiring the knowledge supported by the machine learning methods. The methods of acquiring the knowledge are discussed and specified. The practical part represents the use of De Treex 4.0 software dedicated to the induction of decision trees, which is a part of the Sphinx 4.0 artificial intelligence package.*

***Keywords**: decision trees, production processes, knowledge bases, knowledge acquisition, production engineering*

***Streszczenie**: W artykule przedstawiono proces pozyskiwania wiedzy w oparciu o indukcję drzew decyzyjnych, w sposób graficzny zilustrowano różnice pomiędzy pozyskiwaniem wiedzy w sposób tradycyjny, od eksperta, a także procesem pozyskiwania wiedzy wspomaganym metodami uczenia maszynowego. Omówiono i wyszczególniono metody pozyskiwania wiedzy. W części praktycznej przedstawiono wykorzystanie oprogramowania DeTreex 4.0 dedykowanego do indukcji drzew decyzyjnych wchodzącego w skład pakietu sztucznej inteligencji Sphinx 4.0.*

***Słowa kluczowe**: drzewa decyzyjne, procesy produkcyjne, bazy wiedzy, pozyskiwanie wiedzy, inżynieria produkcji*

1. Acquiring the knowledge from production processes for construction of knowledge bases

Construction of knowledge base in expert system, supporting the design of technological treatment processes requires, in many cases, development of the methods for acquiring technological knowledge. The process of acquiring the technological knowledge is aimed, first of all, at obtaining the knowledge and experience in a strictly defined range of the tasks in the field of designing the technological processes from the identifiable knowledge sources as well as recording of the acquired knowledge in the way enabling its application in the process of supporting the decision-making during solving the tasks concerning design of technological processes [1].

The knowledge acquisition from a viewpoint of building the knowledge bases is strongly connected with the conception of machine learning. Speaking in general, the knowledge acquisition may be defined as learning, i.e. obtaining a symbolic knowledge, connected with acquiring the capabilities of utilizing the mentioned knowledge in the effective way [2].

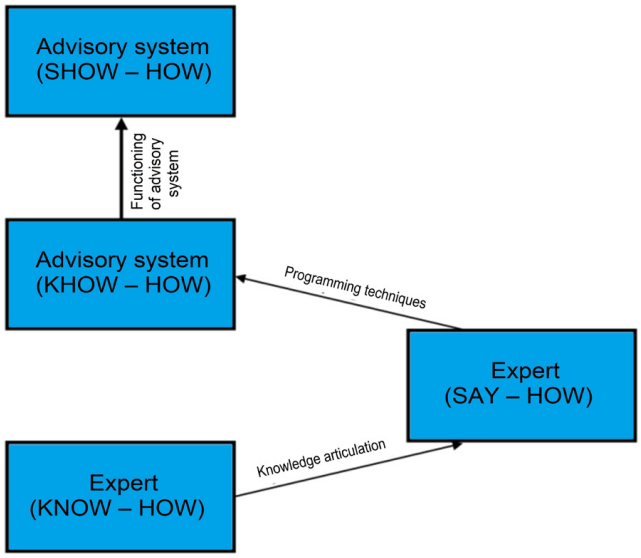
Together with the development of the studies in the field of constructing expert systems, the obstacles appeared; they resulted mainly from the necessity of possessing more and more advanced knowledge bases. It was necessary to develop such methods for knowledge acquiring which would be effective due to the abbreviation of the time of constructing and verifying the knowledge bases in respect of their non-contradiction, completeness and elimination of the excess of information. The most frequently employed methods for knowledge acquiring directly from the expert are as follows:

- Direct consultations with the expert,
- Analysis and observation of the work, performed by the expert,
- The knowledge records, made by the expert in the intentionally developed electronic or paper document.

The presented below figure shows a scheme of the traditional process of knowledge acquisition from the expert what makes the verification, construction and control of the complicated knowledge bases difficult due to the frequent problems in the knowledge articulation by the mentioned expert and the errors in the knowledge records.

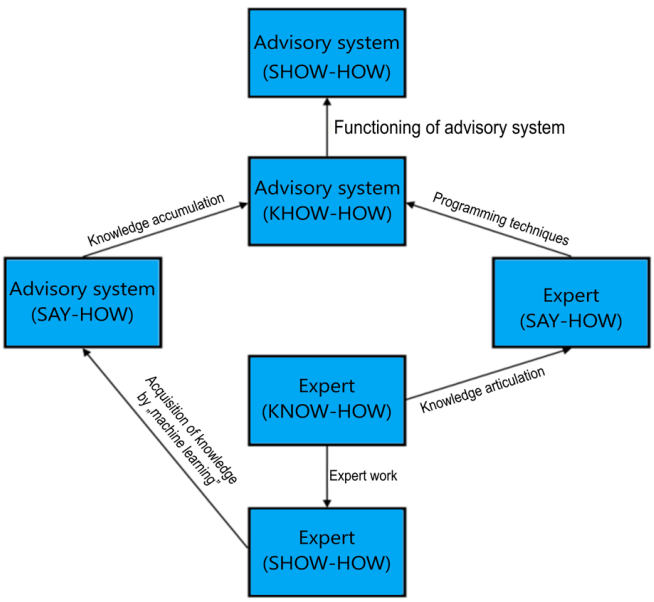
To support the partly characterized above process of acquiring the knowledge from expert, many methods have been developed which facilitate the computerised automated acquiring the knowledge. When employing the mentioned methods, we do not require a direct participation of the expert

Fig. 1. The knowledge acquiring in the "traditional" way; own development on the grounds of [3]



in the process of the knowledge acquisition. The knowledge which was acquired by the above described methods is obtained basing on the results of the expert work and the earlier collected data. The scheme as shown below (Fig. 2) illustrates acquisition of the knowledge from the expert in the process supported by the methods of machine learning.

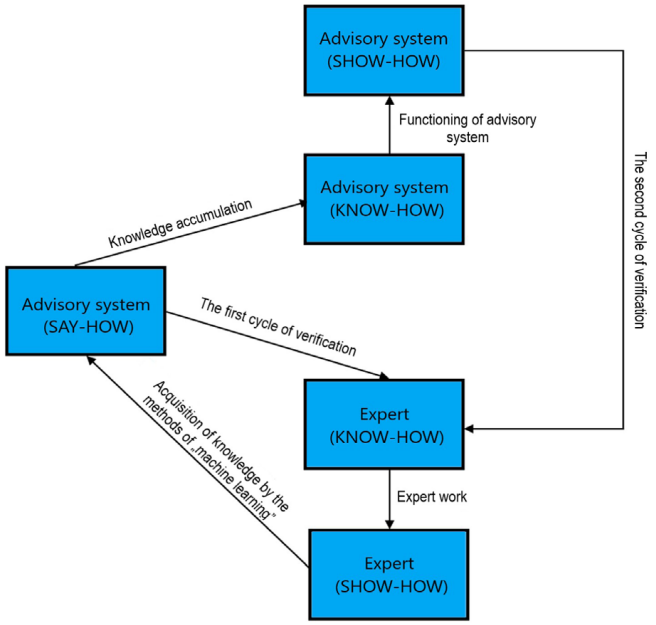
Fig. 2. Acquisition of the knowledge directly from the expert s a process which has been supported by the methods of machine learning; own elaboration on the grounds of [3]



The successive diagram (Fig. 3) illustrates the successive stage in the processes of knowledge acquisition. In the discussed process, the expert does not transfer his knowledge but performs its precise verification. The knowledge was acquired by the methods of machine learning and the task of the expert is also to verify the correctness of expert system functioning as well as to check the conclusions and explanations, obtained from the system. In the case of stating the errors and other irregularities, the expert should recognize the corrections in the knowledge basis as being necessary or even repeated acquisition of the discussed knowledge, based on the supplemented and amended data. The presented below process is more efficient in comparison to two previous ones due to the following reasons:

- Acquisition of the knowledge with the application of the methods based on machine learning is quicker,
- The knowledge bases obtained in the automated way contain lower number of errors or, at optimum situation, do not contain them at all,
- Verification of the knowledge acquired in the described way by the expert is a task considerably simpler and quicker for him than the articulation of the mentioned knowledge.

Fig. 3. The process of acquiring the knowledge supported by the machine learning methods; own elaboration based on [3]



1.1. The methods of knowledge acquisition

The basic idea of learning includes acquiring the knowledge with the application of few methods of reasoning – induction, deduction or analogy. In the specific case, learning may require only duplication of information, supplied by the environment or transformation of the mentioned information and separation only certain part of it which is relevant for us. The process of acquiring the knowledge is classified in dependence on many criteria. We may distinguish the following methods of the knowledge acquisition:

- Direct knowledge acquisition – it does not require concluding and knowledge transformation from the system subjected to learning; it is implemented, as an example, via direct programming; the method is applied in relation to the simple bases of knowledge;

- Acquisition of the knowledge on the grounds of instructions – it requires the necessity of cooperation between the teacher and the learner; it is implemented via the application of the appropriate knowledge sources, indicated by the teacher and their transformation into the language, being acceptable by the learner;
- Acquisition of the knowledge based on the analogy – it consists in such transformation of the existing information that it could be used for the description of facts, similar to those ones, being contained in the knowledge base; they are implemented, for example, by the modification of the computer program;
- Acquisition of the knowledge based on the examples – the method is very often employed when constructing the knowledge bases; it consists in generation of a general description of the classes on the grounds of the collection of examples and counter-examples, representing the mentioned classes; general description is obtained on the basis of induction principle.
- Acquisition of the knowledge based upon the observation – the mentioned methods requires greater participation of the learner during the learning process; the learner may make passive and active observations

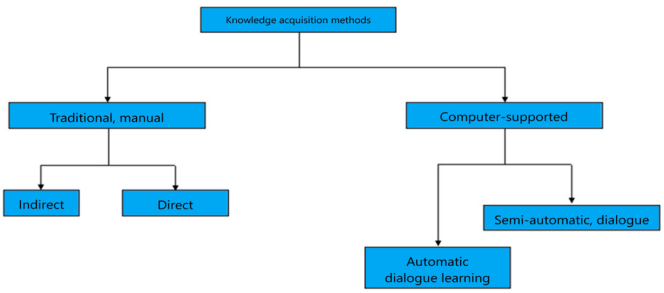
From among many induction methods, we may distinguish the following methods (on the grounds of examples):

- Induction of the rules, using generation of coverage [4],
- Induction of decision trees [5],
- Induction of the rules, with the application of approximated sets [6].

When reassuming the above, the methods of the knowledge acquisition may be classified in a following way (due to the involvement of the software in the process of knowledge acquisition (Fig. 4) [7] :

- Manual methods
- Semi-automatic methods
- Automatic methods

Fig. 4. Classification of the knowledge acquisition methods on the ground of [7]



To employ the mentioned methods, it is necessary to use the so-called attribute model of the description of the area concerned, i.e. determination of the so-called Domain. To make the acquisition of the knowledge possible based upon the examples, it is necessary to specify:

- Objects – phenomena, problems which are to be classified;
- Attributes, describing the given objects and
- Values which will be adopted by particular attributes. Values of the attributes for the selected group of the objects constitute the teaching set and the examples, describing the objects, are called learning examples.

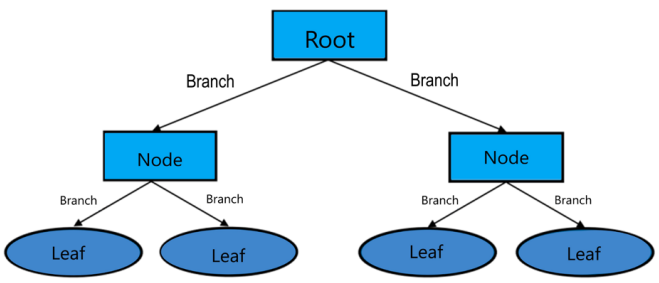
When possessing the above data, we may commence the work on the induction of decision trees from which the rules are created later on. Quinlan algorithm, which is very helpful in this procedure, is employed when we have the data on the grounds of which it is possible to generate the rules. Construction of the decision trees based upon the data may lead to extremely developed trees and, consequently, complicated, developed rules, giving no effects in the concluding process; when basing on the data, we cannot say that the presence of a certain trait or its absence implies the immediate conclusion. Owing to the application of software based upon the Quinlan algorithm, it is possible to specify the sequence of attributes, chosen when building the decision tree [8].

2. The structure of decision tree

To have a correct induction of decision tree, it is indispensable to get familiarized with the structure of decision tree (Fig. 5). The formal definition of the decision free is as follows: the decision tree is a tree-like structure, each node of which corresponds to conducting of a certain test of value of one attribute and each leaf contains decision on classification of the example. From particular nodes as many branches are led out as many possible results of the test, corresponding to the mentioned nodes, are obtained. Each of the branches leads to sub-tree (node) serving for classification of the discussed objects for which the mentioned test has a defined result.

The decision trees are constructed by the recurrent division of the training data into subsets, based on the fact how the mentioned division affects the states of the output variable [9].

Fig. 5. The structure of the decision tree shown in a form of graphical presentation with nomenclature of the particular componential elements of the tree, own development based on [10]



The nodes of the decision trees, as described above, represent the attributes of the considered problem. The edges of the tree are connected with the finite sets of the values of attributes. The decision tree should be constructed with the commencement from the most significant attribute. Then, the remaining attributes on the lower levels of the tree should be utilized. The choice of the attribute is also based on its abilities

of classifying. The measure of the significance of the attribute has a nature of entropy. After building the tree, each new object may be classified by passing through the tree down – from the root (top) to leaf (final node) [11].

3. Utilization of the software dedicated to the induction of decision trees

In the present part of the study, practical utilization of software DeTreex 4.0, dedicated to the induction of the decision trees, entering the composition of the artificial intelligence package Sphinx 4.0, has been presented. The application of De Treex is a tool serving, first of all, for the support of the knowledge acquisition process. Owing to the employed induction method of machine learning, it is possible to construct the decision trees and recording the mentioned trees in a form of rules; it is worth pointing out that the rules are the most frequently applied method of knowledge representation in the knowledge bases of expert systems.

DeTree 4.0 is independent in respect of domains and may be utilized not only in the construction of decision trees in the production processes but also in other domains, inter alia, in economy or medicine. The discussed application may be used where there is a problem of decision-making, classification of the objects, quick verification of the acquired rules or quick acquisition of the decision rules from the set of teaching examples.

In order to make the induction of decision tree with the software utilization possible, we have based on the teaching example which refers to the process of glass production; the output variable in the described example was a type of the produced glass while the input variables included: refraction coefficient and the content of the particular elements in the produced glass: sodium, magnesium, aluminium, silicone, potassium, calcium, barium and iron.

Based upon the teaching set consisting of 214 examples, the domain was generated and the attributes were presented below together with their values given in a form of intervals (Fig. 6).

Then, using the option of decision tree generation, the minimum number of examples, creating the leaf of the tree was adopted as 5 and the option of cutting the tree by 25% (with the program assumption that such possibility is available) was chosen. After setting and confirming the mentioned above parameters, the tree was generated. The generated tree is legible (readable) and the effect of the work, in a form of graphical and text tree has been presented below in Fig. 7 and 8, respectively.

Fig. 6. Domain of the problem presented in a form of screenshot from software DeTreex 4.0

Dziedzina problemu

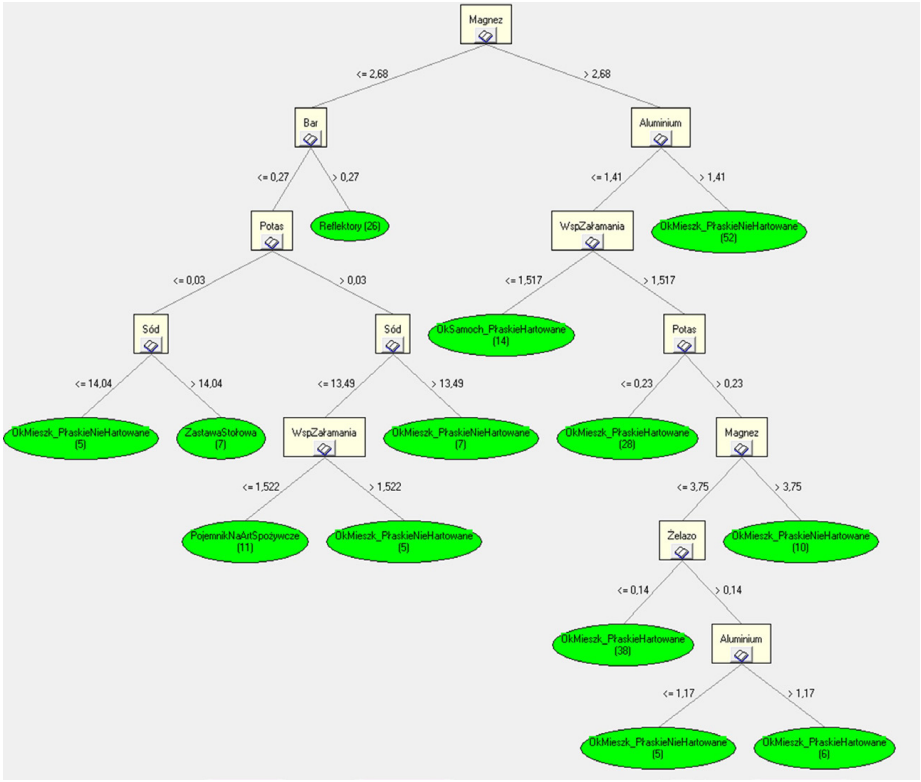
WspZałamania	Sód	Magnez	Aluminium	Krzem	Potas	Wapń	Bar	Żelazo	RodzajSzkła
min. 1.51115	min. 10.73	min. 0.00	min. 0.29	min. 69.81	min. 0.00	min. 5.43	min. 0.00	min. 0.00	OkMieszk_PłaskieHartowane
max. 1.53393	max. 17.38	max. 4.49	max. 3.50	max. 75.41	max. 6.21	max. 16.19	max. 3.15	max. 0.51	OkMieszk_PłaskieNieHartowane
									OkSamoch_PłaskieHartowane
									PojemnikNaArtSpożywcze
									ZastawaStołowa
									Reflektory

Fig. 7. The decision tree, generated with the application of software Detreex 4.0, as presented in a text form

RodzajSzkła - drzewo decyzyjne

```
RodzajSzkła
  Magnez <= 2.68 :
    Bar > 0.27 : Reflektory (26.0)
    Bar <= 0.27 :
      Potas <= 0.03 :
        Sód <= 14.04 : OkMieszk_PłaskieNieHartowane (5.0)
        Sód > 14.04 : ZastawaStołowa (7.0)
      Potas > 0.03 :
        Sód > 13.49 : OkMieszk_PłaskieNieHartowane (7.0)
        Sód <= 13.49 :
          WspZałamania <= 1.52152 : PojemnikNaArtSpożywcze (11.0)
          WspZałamania > 1.52152 : OkMieszk_PłaskieNieHartowane (5.0)
  Magnez > 2.68 :
    Aluminium > 1.41 : OkMieszk_PłaskieNieHartowane (52.0)
    Aluminium <= 1.41 :
      WspZałamania <= 1.51707 : OkSamoch_PłaskieHartowane (14.0)
      WspZałamania > 1.51707 :
        Potas <= 0.23 : OkMieszk_PłaskieHartowane (28.0)
        Potas > 0.23 :
          Magnez > 3.75 : OkMieszk_PłaskieNieHartowane (10.0)
          Magnez <= 3.75 :
            Żelazo <= 0.14 : OkMieszk_PłaskieHartowane (38.0)
            Żelazo > 0.14 :
              Aluminium <= 1.17 : OkMieszk_PłaskieNieHartowane (5.0)
              Aluminium > 1.17 : OkMieszk_PłaskieHartowane (6.0)
```

Fig. 8. The decision tree, generated with the application of software Detreex 4.0, as presented in a graphical form



4. Conclusions

In the paper, the process of knowledge acquisition was described and the methods of acquiring the knowledge with the consideration of the method of induction of decision trees were presented. The mentioned method was also presented on the practical example with the utilization of the software dedicated to the mentioned procedures. The software Sphinx 4.0 allows generating the decision tree in relatively simple way and, also, based upon the readable interface of use, obtaining the searched knowledge in a form of the rules, on the grounds of the teaching set. The acquisition of the knowledge using the decision trees is extremely important for the decision-making problems in the production enterprises which have the heuristic nature of the solutions. In the case of such problems, the application of expert systems in the selected areas should be purposeful.

The basis for the development of the method for construction of knowledge base for production processes, especially for the field of technological production includes a symbolic and object representation of data and their mutual relationships which may be recorded in a form of the rules, with the application of the appropriate methods of knowledge acquisition and the correctly conducted induction of the decision trees.

It should be also mentioned that the correctly developed schemes of processing the technological knowledge, beginning from its acquisition, via the presentation and ending at construction of the knowledge base, facilitate the preparation and recording of the indispensable knowledge in expert system what has a direct effect on optimization of the costs and optimization of the production processes in the enterprise.

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ARE POLISH CHEMICAL PERIODICALS DOOMED TO COLLAPSE?

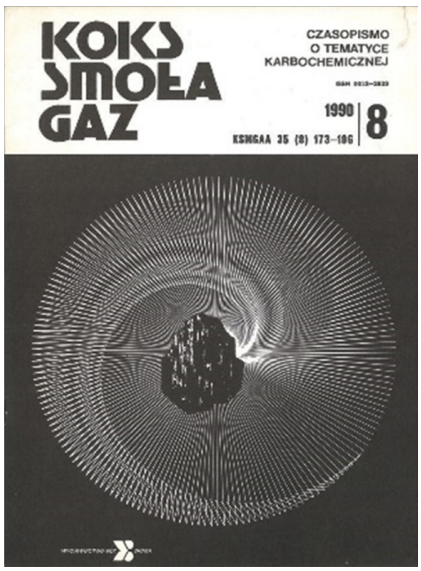
CZY POLSKIE CZASOPIŚMIENNICTWO CHEMICZNE MUSI UPAŚĆ?

The effective communication between the scientific institutions and industry (i.e. between the scientists and employees of the industry sector) in the field of science and engineering has been for many years ensured by scientific and engineering literature items. It is especially important in respect of chemistry which is an "arcane" science and the knowledge on the chemical processes is not universal. The creators of the Second Republic of Poland were aware of this fact; one of the important aims of their activity included creation of national periodicals which would (in the language understandable for majority of citizens) transfer the knowledge on the situation in chemical laboratories and universities, to the companies which would be able to utilize the possessed knowledge in their industrial practice.

Therefore, the decision of Prof. Ignacy Mościcki, the later President of the Republic of Poland, on creation of the first Polish-language "Chemical Industry" monthly, as undertaken in 1916, was not a surprise[1)]. There was created a platform where the employees of the nascent Polish chemical industry could contact Polish scientists, informing them about their needs and the scientists could make an offer for their cooperation with the industry. The mission of the mentioned journal at that time as well as now has been oriented to the supply of the knowledge on the international progress in chemical technology and engineering and the achievements of Polish research institutes and higher education units in the discussed domain, to Polish engineers-chemists, employed in Polish chemical industry. The mentioned aim included also creation of the conditions for publication of original scientific papers, illustrating the achievements of Polish research institutions and chemical factories. Due to this reason, the mentioned journal is published in Polish language. It is read not only by engineers and managers of chemical industry sector but also by the scientific employees of research institutes and higher education universities, designers from design offices and by the students of chemistry and related disciplines. They are informed about the problems which are pervading the national chemical industry and they develop their research studies as to meet the challenges set by the discussed sector of economy [1].

During the 1st Convention of Polish Chemists in Warsaw (5 April, 1923), Prof. Jan Zawidzki from Warsaw University of Technology and the President of Polish Chemical Society, presented univocally Polish "reason of state" in the field of Polish chemical journals. In his lecture [2], he said that 1 during the first 8 years of the present century (since 1901 until 1908) Polish chemists published 2070 original contributions in total, that is, 259 contributions per year, in average. [...]. It is not a small number; however, before the world war any of foreigners did not realize that there were Polish chemists and that Polish chemistry was in *status nascendi*. It originated from the fact that a dominating part of the mentioned contributions, i.e. 57%, was published in foreign

Fig. 1. The illustrative cover of Koks Smoła Gaz



[1)] Original spelling (ed.)

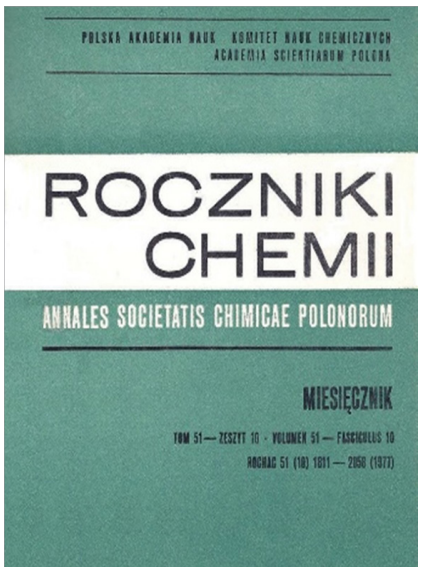
languages, mainly in professional foreign periodicals. It could not be otherwise as more than a half of the experimental contributions (50.25%) were performed in foreign labs, usually German, Russian and Swiss laboratories. [...]

A general agreement should be arranged between the chemists, stating that all research work, the experimental papers from the domain of pure chemistry, especially inorganic, organic and physical and physiological chemistry should be published in Polish, first of all, in "Annals of Chemistry"; more important of these articles should be presented in foreign-language periodicals (French, English or German) of Polish Academy of Skills in Cracow, with the aim to publish those materials in Bulletins of Academy. The papers from the field of technical chemistry, especially those experimental ones with a scientific nature, should be focused in "Chemical Industry". Foreign-language texts of the discussed papers could be announced by Academy of Technical Sciences in its Bulletins. When proceeding so, we could achieve a concentration of a prevailing part of our scientific achievements in the field of chemistry in two central units, in the "Annals of Chemistry" and in "Chemical Industry".

Apart from the mentioned above periodicals, during the interwar period in the chemistry domain, there were also active Polish-language "branch" journals such as e.g. *Chemik Polski* (eng. Polish Chemist), *Czasopismo Towarzystwa Aptekarskiego* (eng. Magazine of Pharmacists' Society), Wiadomości Farmaceutyczne (eng. Pharmaceutical News), *Gazeta Cukrownicza* (eng. Sugar Industry Magazine), *Roczniki Farmacji* (eng. Annals of Pharmacy), *Przegląd Gazowniczy* (eng. Gas Production Review), Nafta (eng. Petroleum), *Przemysł Piwowarski* (eng. Brewing Industry), *Technika Gorzelnicza* (eng. Distilling Technology) and *Przegląd Ceramiczny* (eng. Ceramics Review). The mentioned above periodicals are the evidence that „*the Poles are not geese and have the language of their own*" (taken from famous Polish poet, Mikołaj Rej). As not to have the knowledge contained in the papers and published in the mentioned periodicals dispersed, the First Convention of Polish Chemists[2)] expressed the wish: "*Annals of Chemistry" and "Chemical Industry" shall publish, constantly, the meritorious summaries of all chemical research papers, being published in other Polish scientific journals*.

After a break in publishing the Polish-language chemical periodicals, being caused by the Second World War, such journals as *Annales Chimicorum Polonorum* (*Annals of Polish Chemistry*) and *Chemical Industry* appeared again as early as in 1945. In the successive years, together with the reconstruction of the Country and development of different branches of chemical industry, and especially in connection with generation of the "branch" scientific-research institutes, many new specialist magazines, representing often a very high scientific level, have appeared in the market. We may mention here such periodicals as *Koks Smoła Gaz* (eng. Coke, Tar, Gas), *Inżynieria Materiałowa* (eng. Materials' Engineering), *Przegląd Włókienniczy* (eng. Textile Industry), *Polimery* (eng. Polymers), *Polimery w medycynie* (eng. Polymers in Medicine), *Nafta-Gaz* (eng. Petrol-Gas), *Chemia Analityczna* (eng. Analytical Chemistry), *Chemia Stosowana* (eng. Applied Chemistry), *Inżynieria Chemiczna i Procesowa* (eng. Chemical and Process Engineering), *Inżynieria i Aparatura Chemiczna* (eng. Chemical Engineering and Apparatuses), *Problemy Eksploatacji* (eng. Problems of Exploitation), *Ochrona przed Korozją* (eng. Protection from Corrosion), *Archiwum Ochrony Środowiska i Elastomery* (eng. Archives of Environment Protection and Elastomers) and many informational bulletins and scientific publications, issued by scientific-research institutes and higher education universities. A special role at that time was played by English-language *Bulletin of the Polish Academy of Sciences - Chemistry*, being founded in 1980. The mentioned periodical promoted Polish science abroad. We should also mention *The Chemist* monthly, founded in 1948 by the Central Board of Chemical Industry in Gliwice (recently published by the Association of Chemical Technicians and Engineers); it promoted chemistry in circles; then, *Chemical News* monthly, founded in 1947 by Polish Chemical Society which published review articles from different chemistry branches. There was also bi-monthly "*Chemistry at Schools*", published since 1955 by the State Publishing House of School Publications (under auspices of the Ministry of Education), supporting the teachers in teaching chemistry at various levels of education. Institute of Economics of Chemical Industry in Warsaw published, at that time, informational bulletin *Chemical Industry in the World* which appeared even after the liquidation of the mentioned Institute.

Fig. 2. The exemplary cover of Annals of Chemistry



The mentioned above periodicals managed to resist the pressure of the communistic authorities and, as a rule, did not publish the papers, promoting the Marxist ideology. There were the cases of promoting the achievement of the Soviet science but often the there were conducted the debates on scientific subjects where the periodicals (if it was possible) took the side of truth. Such was the case of dispute on the principle of uncertainty and electronic resonance in organic chemistry [3]. The mean-

[2)] Original spelling (ed.)

ing of the mentioned periodicals in popularization of scientific and technical knowledge cannot be nowadays overestimated. They played especially important role in respect of word formation as together with a rapid development of chemical sciences, the need of complementing Polish-language chemical terminology has appeared. The author of the present paper remembers the discussion conducted in *Polymers* magazine concerning the word "recycling"; there were the attempts to replace this word with terms: "recirculation" or "recyclisation" (the author personally supported this last term!). The periodicals appeared in a high circulation; they were additionally financed from the state means and owing to low prices, they were widely available in manufacturing plants. The circulation of *Chemical Industry* in the seventies of the 20th century reached to 3.5 thousand copies and it was available for engineers and technicians, employed in the industry not only in the factory libraries and reading rooms but even directly at the work place (e.g. in a control room of the production departments). The situation was fundamentally changed at the moment of the system transformation in 1989. Under the conditions of the market-oriented economy, chemical magazines were forced to change the philosophy of their functioning, as being deprived of the patronage of the state; they had to find themselves the financial means necessary for their functioning. It required big efforts of the editors and publishers. At the same time, the requirements of the readers (and of the authors!) were also increased; the magazines were expected to have a modern graphical form, good paper and a "full colour". In the situation of the lack of indispensable means for their activities, the discussed periodicals were often faced before the necessity of suspending their activity. Many magazines undertook the decision of passing from Polish to English in their publications what considerably limited the number of domestic subscribers, not causing simultaneous interest of the foreign readers.

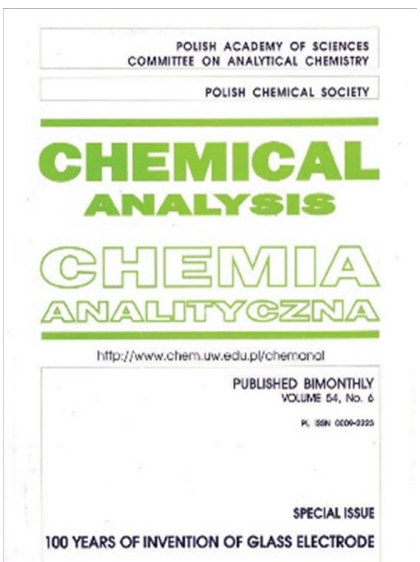
Fig. 3. The illustrative cover of Chemical Engineering and Apparatuses

Bulletin of the Polish Academy of Sciences, Chemistry occurred to be the first bankrupt. It stopped to be published as early as in 2003. Then, other periodicals disappeared, e.g. *Annals of Chemistry* (their name was changed into *Polish Journal of Chemistry*), as being sacrificed "on the altar of the European integration" and transmitted (in 2009) to the Consortium ChemPubSocEurope where they "exist" further in a form of the *European Journal of Inorganic Chemistry* and the *European Journal of Organic Chemistry*. The author has never heard, however, that any person in Polish chemical industry reads and utilizes the mentioned magazines. A similar situation happened in the case of *Analytical Chemistry* (changed into *Chemical Analysis*) which has entered the composition of *Analytical and Bioanalytical Chemistry* (in 2010), published by Springer-Verlag and in the case of *Chemia Stosowana* (eng. Applied Chemistry) (changed into *Polish Journal of Applied Chemistry* in 1991 and liquidated in 2011).

Another unpleasant blow for Polish chemical literature concerned the suspension (in 2017) of publishing *The Chemist* (Polish: Chemik) which was very popular among the readers. The

Fig. 4. The exemplary cover of Chemist

Fig. 5. The example of the cover of Analytical Chemistry

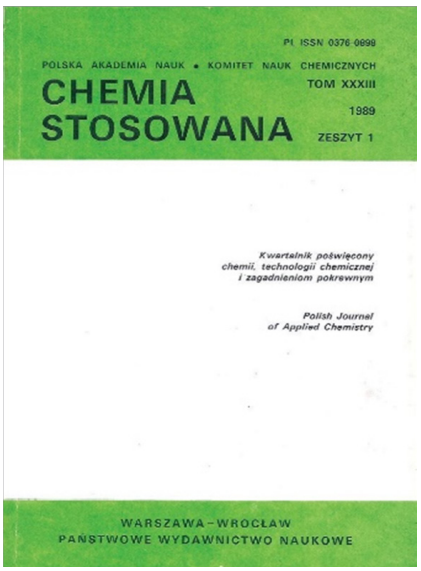


mentioned decision was undertaken due to the financial troubles of the Publishing House *Chempress*, issuing the discussed magazine at the order of the Association of Chemical Engineers and Technicians. The Association undertakes the attempts aimed at reactivation of the mentioned title but until now, without success. Also, a liquidation of the renowned magazine *Koks Smoła Gaz* (in 2016), published by the Institute of Chemical Coal Treatment in Zabrze (recently under the name of Karbo) was a big surprise.

After the economic transformation and liquidation of many chemical periodicals, the initiatives of founding new specialist magazines were born at the higher education entities. Thus, at the West-Pomeranian University of Technology in Szczecin (in 1999) there was created *Polish Journal of Chemical of Chemical Technology* which was expected to replace the liquidated Applied Chemistry; the Silesian Technical University began to publish (in 2005) the *Archives of Waste Management and Environment Protection* which was, in a certain sense, a competitor of the *Archive of Environmental Protection*, published by Polish Academy of Sciences (PAN). Institute of Synthetic Materials and Paints in Gliwice commenced (in 1993) publication of two magazines: Farby i Lakiery (eng. Paint and Lacquer Coatings) and Przetwórstwo Tworzyw Sztucznych (eng. Processing of Plastics). The new magazines were also created, such as e.g. Polska Chemia (eng. Polish Chemistry), published by Polish Chamber of Chemical Industry and also, the periodicals having a commercial nature such as e.g. Chemia i Biznes (eng. Chemistry and Business), published by a private publishing house EPS Media; journal Analityka (eng. Analytics), being dedicated to promotion of the methods and equipment in the field of chemical analysis, published by private publishing house Malamut and the magazine Reporter Chemiczny (eng. Chemical Reporter) published by a private physical person (Mr Jacek Romanowski, www.reporterchemiczny.com).

Not all of these initiatives were successful. Although *Polish Journal of Chemical Technology* is still present (only in on-line version) but it does not constitute a bridge between Polish science and Polish industry because it publishes mainly foreign papers

Fig. 6. The example of the cover of the Applied Chemistry



what gives it a guarantee of financial incomes. Unfortunately, the mentioned papers do not originate in the renowned American or German scientific centres but they come from the Third World countries which do not have much to offer to the Polish chemistry. They same method of survival was employed by other chemical magazines, published in Poland (*Polymers in Medicine*, *Polish Journal of Environmental Studies*). The periodical *Archives of Wastes Management and Environment Protection* stopped to be published in 2019, similarly as *Problems of Exploitation*.

In the contrary to the mentioned above magazines, *Paints and Lacquers and Synthetic Materials Processing* became fused in 2020, into one Polish-language periodical *Plastics and Paints* when were encountered with the serious troubles in obtaining the papers. It is expected that 2 editions of the mentioned magazine will appear in 2020. Also, *Nafta-Gaz* journal has not given up its mission and publishes the articles in Polish language, informing the readers about the results of the work conducted by the Petroleum and Gas Institute.

What is the reason for disappearance of the successive Polish chemical periodicals? The ministry of Science decided to perform the assessment of the quality of Polish scientific magazines and entrusted the dedicated team with this task. The mentioned team consisted of the authors (or potential authors) of papers, destined for publication in the discussed magazines. The team did not consider the meaning of the mentioned periodicals in the system of information exchange in the country and only compared the domestic journals with the foreign periodicals (see table below). It was *a priori* known that such comparison would bring the result favourable for foreign magazines. But when it was established that the number of scores (points) granted by the article would decide not only on the career of the scientists but also on the level of governmental donations on the research work, a specific "*punctosis*" phenomenon (striving at the highest number of scores for a paper) appeared and the university authorities recommended their scientific workers to publish their papers in the periodicals which gave at least 70 scores (points) for the paper. As in Poland such chemical periodicals have not existed, a wide stream of papers went to foreign magazines. They were not necessarily the best ones such as e.g. *Journal of American Chemical Society* (200 points) or *Angewandte Chemie International Edition* (200 points) but also, to many minor periodicals such as *Brazilian Journal of Chemical Engineering* (70 points). In effect, scientific and research papers, paid by the Polish taxpayer, not only do not serve this taxpayer but he even does not know about their existence! The magazines connected with environment protection have been found in better situation. One of them, *Archives of Environmental Protection*, obtained even 100 points and may compete with foreign magazines in respect of acquisition of scientific papers from Polish scientific and research units. But any chemical magazine has not been given such chance. It is a proverbial "nail to coffin" of Polish chemical periodicals!

Table. Score evaluation of periodicals from the field of chemistry and chemical engineering, as published in Poland, and of the related domains (environment engineering, materials engineering) as being assessed by the Ministry Scientific and research-

Table. Score evaluation of periodicals from the field of chemistry and chemical engineering, as published in Poland, and of the related domains (environment engineering, materials engineering) as being assessed by the Ministry Scientific and research-scientific periodical which have not been found on the Ministry list, are evaluated at the level of 5 points

Name of magazine	Publisher	Language	Number of points
Archives of Environmental Protection	PAN, Zabrze	English	100
Polimery	IChP, Warszawa	Polish/English	40
Przemysł Chemiczny	SIGMA-NOT, Warszawa	Polish	40
Chemical and Process Engineering	PAN, Warszawa	English	40
Ecological Chemistry and Engineering S	Opole	English	40
Fibers and Te tiles in Eastern Europe	IBiWN, Łódź	English	40
Polish Journal of Environmental Studies	Olsztyn	English	40
Polish Journal of Chemical Technology	Z T, Szczecin	English	20
Archives of Materials Science and Engineering	PAN, Gliwice	English	20
Ochrona przed Korozją	SIGMA-NOT, Warszawa	Polish	20
Ecological Chemistry and Engineering A	Opole	English	20
BioTechnologia	PAN, Warszawa	English	20
Polimery w Medycynie	M, Wrocław	English	20
Inżynieria Materiałowa	SIGMA-NOT, Warszawa	Polish/English	5
Nafta-Gaz	INiG, Kraków	Polish	5
Elastomery	IIPTiB, Piastów	Polish	5
Przetwórstwo Tworzyw Sztucznych	IIPTiB, Gliwice	Polish	5
Farby i Lakiery	IIPTiB, Gliwice	Polish	5
Wiadomości Chemiczne	PTCh, Wrocław	Polish	5
Environmental Protection and Natural Resources	IOŚ-PIB, Warszawa	English	5

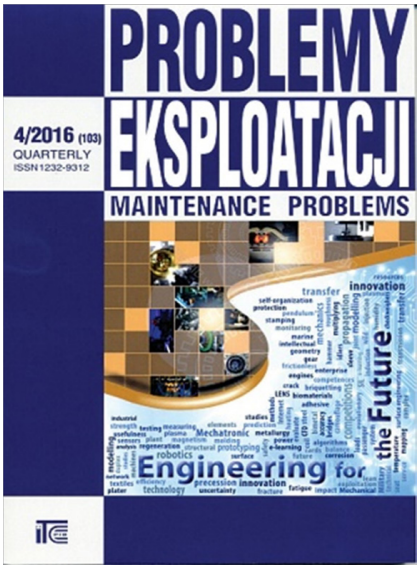
scientific periodical which have not been found on the Ministry list, are evaluated at the level of 5 points

Any of the civilized countries has not introduced such system of score evaluation. In Germany, the results of all studies, financed from the public means by Bundesministerium f.ir Bildung und Forschung and by Bundesministerium f.ir Wirtschaft und Energie are, as a rule, made available at the request of the interested economic entities and natural persons, earlier in a form of report brochures and today – on the Internet pages. Our scientists work for their own sake! None of the ministerial officials got an idea that all studies financed (or co-financed) from the public means were – after their termination – published in Polish scientific – technical press, even in a form of short release. Later on, they could be published at any magazines. Such offer was submitted few years ago, by *Chemical Industry* when reviewing a list of "strategic projects", implemented from the governmental financial means in the field of chemistry [4]. The mentioned offer has remained without reply until now. The assessment of the value of periodicals should be performed by experts who utilize the published papers. Many years ago when cooperating with one of the greatest German data banks, conducted by Fachinformationszentrum Technik in Frankfurt n. Men (development of Russian periodicals for this institution), the author of the present paper suggested to include certain Polish scientific-research journals, being unknown for them, to the mentioned base. I supplied, at the own cost, several "advance" copies of Polish scientific-research periodicals which were subjected there to professional evaluation (the author of the present paper did not participate in it). As a result of the mentioned evaluation, German experts selected some journals, published in Poland and the published papers were found in the resources of the great data bank which is now called TEMA (Technology and Management). I must state regretfully that only two periodicals have survived the period of reform i.e. Chemical Industry and Polymers. But their ministerial evaluation has been considerably lowered (from 20 points in scale 0-50 points to 40 points in scale of 0-200 p.). The remaining magazines have not been found at all in the Ministerial list of the best periodicals (see Table above) or have ceased to be published, or are found in the state of deep collapse.

But even those magazines, which have survived, have the problems with the decrease of the number of papers, submitted for printing. In the case of monthly *Przemysł Chemiczny* (eng. Chemical Industry), the mentioned number dropped from 487 in 2016 to 343 in 2019 and 243 in 2020 (state for 12 November).

During the recent 2 years, the number of the papers to be printed in *Przemysł Chemiczny* as submitted by chemical institutes, grouped in the Research Network Łukasiewicz has been dramatically decreased. Aren't they performing research there? Chemical industry in Poland covers not only State Treasure companies but also several thousand small and medium-size private enterprises which gain the knowledge about the work of scientists in the institutes and universities just from scientific-technical press; they would like to get familiarized with the mentioned knowledge in Polish language which is the official language in our Country. An access to such knowledge has become recently considerably limited.

Fig. 7. Example of the cover of Problems of Exploitation



The need of promoting the achievements of Polish chemistry abroad cannot be negated. At present, Polish papers published in foreign periodicals are dispersed from among thousands of articles, being found there every year and they do not meet their function. It would be a good initiative to publish English-language magazine: *Chemistry in Poland*, *International Edition*, which would contain translations of the best Polish-language papers, published in such periodicals as *Przemysł Chemiczny* (Chemical Industry), *Wiadomości Chemiczne* (Chemical News) *Nafta-Gaz* (Petrol-Gas), *Polimery* (Polymers) and magazine *Polska Chemia* (Polish Chemistry). Such periodical, as being published e.g. as a quarterly in a form of a special additive to the universally known Chemical Industry, and dedicated to chemical concerns all over the world and international research centres, would ensure a real promotion of Polish achievements in this respect. It is a pity that the Ministries do not have financial means for such purpose. A similar initiative in the field of technology has been already undertaken by Publishing House SIGMA-NOT – *Technical Review*. It is implemented in a form of English-language periodical – *Polish Technical Review* (Editor-in-chief – Prof. Michał Szota, the Vice-President of FSNT-NOT).

The discussed above problem has also a "political" aspect. In the ruling camp, we can hear constantly the voices about the necessity of "re-polonization" of media. In the case of chemical periodicals (and more widely, scientific-research magazines) the imprudent governmental policy has brought about the ruin of the achievements of few generations and destroying of national periodicals which were Polish in origin and their "re-polonization" was unnecessary.

It is difficult to perform a full evaluation of the history of scientific magazines published in Poland and their importance for information circulation in the science-industry system when doing it in a short comment. We have, however, to sound the alarm and carry out the complete analysis of the existing situation as well as to undertake the appropriate measures before it is too late. It is also necessary to withdraw immediately all decisions, which lower value of national Polish periodicals as they were undertaken without any substantive justification. A "good change" is urgently necessary just in this respect!

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[2] J. Zawidzki, Przem. Chem. 1923, 7, nr 5, 124.
[3] J. Polaczek, Przem. Chem. 2014, 93, nr 10, 1661.
[4] J. Polaczek, Przem. Chem. 2013, 92, nr 4, 429.

WOMEN IN POLISH SCIENCE

KOBIETY POLSKIEJ NAUKI

The first election of the authorities of the universities after the entry of the Constitution for Science into life had place in 2020. The higher education schools carried out the election of Rectors for the period of 2020-2040; everything indicates that it will be a cadence different than all others. The universities became headed by historically high number of women.

For the first time in the history, more than 20 women became the heads of universities. Moreover, such situation has never had place in certain scientific units – e.g. in Białystok University of Technology where Prof. Marta Kosior-Kazberuk was the first woman at this post in spite of 70 years-old history of the mentioned university. What is more interesting, the situation was unprecedented at Polish technological universities because two women competed for the post of rector. There are more described situations what is a proof that the position of women in the university world becomes to change. We hope that cadence of 2020-2024 will commence a new, good trend among the university authorities. The silhouettes of some from the newly elected Their Magnificences are presented below (*source: http://perspektywy.pl/rektorzy*).

dr hab. (PhD) Elżbieta Aleksandrowicz,

Associate professor, THE GRAŻYNA AND KIEJSTUT BACEWICZ MUSIC ACADEMY IN ŁÓDŹ

Prof. Elżbieta Aleksandrowicz (born in 1964) is a graduate of Music Academy in Łódź, specialist in the method of Emil Jacques-Dalcroze. In 1989, she obtained the title of Master of Arts (M.A.) in rhythmics. When studying, she finished also, simultaneously, Pedagogic Study and 2-year course of dance instructors, conducted under the patronage of the Department of Culture and Arts of the City Hall of Łódź. Since 1990, she has been employed in her alma mater. She is a lecturer at the Faculty of Creative Arts, Interpretation, Education and Production of Music and at the Faculty of Performing Arts. In 2002, she obtained the title of habilitated doctor (PhD). Since 2012 she has been the Vice-Rector for didactic affairs of the mentioned above Academy (since 2019, the range of her duties has included also science problems). Since 2019, she has been the President of the Commission for granting the degrees in the Academy. During the earlier years, she performed the following functions: Vice-Dean of the Faculty of Composition, Theory of Music, Rhythmics and Piano Improvisation and manager of non-stationary studies. Apart from the Academy activity she is the expert of Polish Accreditation Committee (since 2016) and consultant of the Centre of Artistic Education in the field of rhythmics (since 2019). Since 1988 she has been the lecturer at the Acting Faculty of the Leon Schiller National Film School in Łódź.

She delivers the lectures and runs the workshops and methodological consultations in the field of rhythmics, improvisation and composition of movement and piano improvisation. She is the author of interpretation of movement music pieces, including, inter alia, the work of Johann Sebastian Bach, Ludwig van Beethoven, Gioacchin Rossini, Frederic Chopin, Johann Strauss, Modest Mussorgsky, George Gershwin, Zbigniew Preisner, Wojciech Kilar and Steve Reich.

Source: http://perspektywy.pl/rektorzy/article/prof-elzbieta-aleksandrowicz-nowym-rektorem-am-w-lodzi

dr hab. (PhD) Milenia Fiedler

THE NATIONAL LEON SCHILLER NATIONAL FILM SCHOOL IN ŁÓDŹ

PhD Milenia Fiedler (born in 1966) is an editor. In 1989, she graduated the Faculty of Film and TV (FAMU) at Academy of Performing Arts in Prague. She is also the graduate of Film Editing Faculty FAMU in Prague. In 2005, she obtained the degree of doctor of film art and in 2009 – the degree of habilitated doctor (PhD) of film art. She has been related to film school for more than 20 years. She is a lecturer at the Department of Film Editing of the Faculty of Film and TV Directing and of Film School in Łódź. Since 2016, she has performed the function of the Head of Department.

She is the member of Polish Film Academy and the European Film Academy. She is the co-author of more than 240 feature films, series and spectacles of TV theatre. She cooperated with the prominent directors such as Andrzej Wajda, Janusz Majewski, Wojciech Marczewski, Jerzy Stuhr and Janusz Zaorski. She was 4 times nominated to Polish Film Award for the best editing. She received Eagle (Polish: Orzeł) distinction for the work at production of "Weiser" in 2002. She received also the award for the mentioned above film during the Festival of Polish Feature Films (2001). In 1997, she received the award

for "Czas zdrady" (eng. Betrayal Time). Besides it, she was laureate of Women's Independent Film Festival in Los Angeles, for film"Umbra" in 2016. She was awarded four times for editing during the Festival of Polish Radio Theatre of Radio and Polish TV Theatre "Two Theatres" in Sopot for the following pieces: "Spiskowcy" (2018); "Marszałek" (2018), "Bezdech" (2013) and "W roli Boga" (2010).

Source: http://perspektywy.pl/rektorzy/article/dr-hab-milenia-fiedler-nowym-rektorem-pwstit-w-lodzi

dr hab. (PhD) Mirosława Jarmołowicz

Associate professor, ART ACADEMY OF SZCZECIN

PhD Mirosława Jarmołowicz (born in 1958) graduated architecture studies at the Faculty of Construction and Architecture of the University of Technology of Szczecin, and obtained the title of M.Sc. in engineering in 1984. She was granted a doctor's degree in 2002 at the Academy of Fine Arts in Poznań, in the field: fine arts, discipline: interior design. In 2020, on the grounds of the decision of the Senate of Artistic University in Poznań, Mirosława Jarmołowicz obtained the title of habilitated doctor in fine arts (PhD). Since 1996, she was the lecturer in Academy of Applied Arts where she was a Vice-Dean of the Department of Interior Design in the period of 2006-2007. Since 2010, she has been the lecturer at the Art Academy in Szczecin. In the years 2010 – 2013, she played the function of the first Dean of the Faculty of Visual Arts; at present she is the Head of Department of Interior Design and Virtual Space.

Artistic interests of Mirosława Jarmołowicz include design of interiors and buildings architecture as well as activities in space of urban interiors of the 19th-century constructions of Szczecin in the context of meaningful social role of art in degraded public space. In 2017, she commenced artistic projects in public space: City for art – city for everybody within the frames of the project, announced by the city authorities of Szczecin: Levelling of infrastructural errors via street art. Mirosława Jarmolowicz is also involved in drawing and painting, travel and artistic photography and, also, photography inspired by geometry. The recent activity was many times rewarded in the successive editions of the Competition: "Mathematics in Camera" in the years 2010-2016, organized by the Faculty of Mathematics and Physics of the Szczecin University and being annually presented during post-competition exhibitions "Mathematics in Camera 2010-2016". Since 2017, she has been the member of the Jury of the mentioned competition which since 2012 has become the international competition.

Source: http://perspektywy.pl/rektorzy/article/dr-hab-miroslawa-jarmolowicz-nowym-rektorem-akademii-sztuki-w-szczecinie

prof. dr hab. Bogumiła Kaniewska

THE ADAM MICKIEWICZ UNIWERSITY IN POZNAŃ

Prof. Bogumiła Kaniewska (born in 1964) graduated the literary studies at the Adam Mickiewicz University in Poznań in 1988. In 1995, she obtained the degree of doctor in human sciences (PhD) on the grounds of the dissertation: "The first-person narration in Polish contemporary prose". In 2001, she submitted the dissertation "Following the footsteps of Tristram Shandy" what gave her a title of habilitated doctor (at the Adam Mickiewicz University in Poznań). In 2015, she received the title of professor of human sciences. In the period of 2005-2012, she was the Deputy Head of the Institute of Polish Philology. In 2012, as the first woman, she took the position of Dean of the Faculty of Polish and Classical Philology and since 2016 – the Vice-Rector for Students' affairs of the Adam Mickiewicz University. She is the Head of Department of the Semiotics of Literature.

She is specialized in history of literature, contemporary literature and theory of literature. She is connoisseur of literature, theoretician on literature, researcher of contemporary literature and, recently, also literature for children, translator of English-language prose, mainly literature for children; the latter subject is also her scientific interest.

Source: http://perspektywy.pl/rektorzy/article/prof-bogumila-kaniewska-nowym-rektorem-uam-w-poznaniu

prof. dr hab. Marta Kosior-Kazberuk

BIAŁYSTOK UNIVERSITY OF TECHNOLOGY

Prof. Marta Kosior-Kazberuk (born in 1971) is a graduate of Bialystok University of Technology, Faculty: engineering, speciality: building and engineering constructions. In 2002, she obtained a doctor's degree in technical sciences in discipline: construction, speciality: concrete constructions, building materials; in 2014, she was granted the title of habilitated doctor of technical sciences (PhD) on the grounds of monograph "Evaluation of the degradation of constructional concrete, subjected to frost destruction". She commenced to work in Białystok University of Technology in 1995 at the post of assistant in Department of Concrete Constructions at the Faculty of Building and Environment Engineering where she is employed until now (as associate professor). In the years 2004-2006, she conducted the

lectures at the Ełk branch of Higher School of Finances and Management in Białystok.

Her research interests concern effectiveness of material-structural protection of capillary-porous materials, effect of active mineral additives of the properties of concrete, historical mortars, applied in construction of hydro-technical objects of Augustowski channel and the application of composite reinforcement in the constructions made from concrete with the increased durability. She is the author and co-author of ca. 190 scientific publications. She participated in more than 40 national and international conferences. She is the member of Administrative Council of the European Network for Accreditation of Engineering Education (ENAEE), the Accreditation Commission of Technical Universities (KAUT) and the expert of Polish Accreditation Committee.

Source:http://perspektywy.pl/rektorzy/article/prof-marta-kosior-kazberuk-nowym-rektorem-politechniki-bialostockiej

prof. dr hab. Hanna Kostrzewska

THE IGNACY PADEREWSKI MUSIC ACADEMY IN POZNAŃ

Prof. Hanna Kostrzewska being presently the Dean of the Faculty of Composition, Conducting, Theory of Music and Rhythmics of the mentioned above Academy, became elected the Rector of Music Academy in Poznań on June 1, 2020. There were three candidates for the mentioned position. The rectorelect received 34 voices of 67 electors, participating in voting; she obtained the required, absolute majority of valid voice speaking for "yes"; Prof. Alicja Kledzik, the Dean of the Faculty of Instrumental Studies, Jazz and Popular Music received 29 votes and Prof. Janusz Stalmierski, the Vice-Rector for Artistic and Scientific Affairs and the International Cooperation – 4 voices.

Prof. dr hab. Hanna Kostrzewska is a theoretician of music. In 1982 she graduated the I.J. Paderewski Music Academy in Poznań. In 1993, she obtained the degree of doctor of humanities (PhD) in the field of philosophy at the Faculty of Social Sciences of the Adam Mickiewicz University in Poznań. In 2012, she received the title of habilitated doctor of arts in the field of music theory at the Faculty of Creative Arts, Interpretation and Music Education of the Music Academy in Cracow. She obtained the title of professor of music arts at the Faculty of Instrumental Studies of the Paderewski Music Academy in 2014.

Prof. Kostrzewska has been professionally related to the mentioned above Academy since 1985. She was, inter alia, the plenipotentiary of the Rector in the matters of cooperation with the Ministry of Science and Higher Education (MNiSW), the head of the Department of Theory of Music, and the manager of the Academy's publishing office. At present, she is the Dean of the Faculty of Composition, Conducting, Vocal Studies, Theory of Music and Artistic Education. She played also the function of plenipotentiary of the Rector in the matters of the evaluation of the scientific activity of the Academy.

She was also involved in the studies on the creative achievements of composer, Feliks Nowowiejski, being connected with Poznań. She is the author of or co-author of 5 scientific monographs, 40 scientific papers and 30 scientific lectures in the field of music theory and widely understood music culture. She is the expert of Polish Accreditation Committee. And since 2008 she has been the Vice-President of the Feliks Nowowiejski Society in Poznań.

Source:http://perspektywy.pl/rektorzy/article/prof-hanna-kostrzewska-nowym-rektorem-akademii-muzycznej-w-poznaniu

dr hab. (PhD) Barbara Marcinkowska

Professor at the MARIA GRZEGORZEWSKA UNIVERSITY (APS) IN WARSAW

PhD Barbara Marcinkowska Professor of APS graduated the Maria Grzegorzewska Higher School of Special Pedagogy in Warsaw (the earlier name of the University) in 1991. In 1995, she obtained there the title of PhD in discipline: pedagogy on the grounds of dissertation: "vocational needs and sense of control of the female teachers of classes I – III of primary schools for lightly mentally invalid persons and all-available schools (the comparative studies)". Prof. dr hab. Jan Pańczyk was the thesis advisor. In 2014, she obtained the title of habilitated doctor in the field of social sciences. She is professionally related to the Department of Education and Rehabilitation of the Persons with Intellectual Invalidity at the Institute of Special Pedagogy of her alma mater. In the years 2012 – 2016 she was the Associate Dean of the Faculty of Pedagogic Sciences and in the period of 2016 – 2020 – the Vice-Rector for Education Affairs.

The scientific interests of Prof. Barbara Marcinkowska include as follows: recognition of the possibilities and limitations of the persons with deeper intellectual invalidity and with conjugated invalidity; communication of the persons with the deeper intellectual invalidity – diagnosis and support for development; rehabilitation of the persons with the deeper intellectual invalidity and conjugated invalidity; support of the teachers in performing their tasks, resulting from the education of the pupils with the invalidity in integrative and all-available school units.

Source: http://www.aps.edu.pl/aktualno%C5%9Bci/profesor-barbara-marcinkowska-zosta%C5%82a-rektorem-akademii-pedagogiki-specjalnej-im-marii-grzegorzewskiej-na-kadencj%C4%99-2020-2024/

prof. dr hab. Celina Olszak, Eng

UNIVERSITY OF ECONOMICS IN KATOWICE

Prof. Celina M. Olszak (born in 1958) is a graduate of the Faculty of Computer Science and Management of Wroclaw University of Science and Technology. In 1993, she received the scientific title of PhD in economic sciences at the University of Economy in Katowice for the dissertation: "Generators of decision-supporting systems" and in 2001 – the title of habilitated doctor (PhD), also at the mentioned above University, in the field of economy – economic informatics on the grounds of dissertation: "The outline of multimedia decision-supporting systems in management". In 2010, she was nominated as Professor. She has been related to the University of Economics in Katowice since 1985. She was a vice-director of Katowice Business University (in Polish: Śląska Międzynarodowa Szkoła Handlowa) in Katowice (2004-2008), Dean of the Faculty of Computer Science at the general Jerzy Ziętek Silesian School of Management in Katowice (2003-2007), the Associate Dean for Science Affairs of the Faculty of Economy of the University of Economics in Katowice (2008-2016), the Head of the Chair of Economic Informatics of the mentioned above University (since 2006) and the Dean of the faculty of Economy (2016-2019). Her scientific interests include the problems of designing and introduction of computer-based systems in organizations, digitalization of the enterprises, managerial decisions-supporting systems, and computerized support of organizational activity, Business Intelligence, big data and impact of computer-based technologies on economy and society. She has been a scholarship holder of the Swiss State at the University of Technology in Zurich, Deutsche Akademische Austausch Dienst at the University of Tier in Germany and Bekker Programme in University of Technology in Sydney, Australia.

Source:http://perspektywy.pl/rektorzy/article/prof-celina-m-olszak-nowym-rektorem-uniwersytetu-ekonomicznego-w-katowicach

prof. dr hab. Dorota Segda

THE LUDWIK SOLSKI NATIONAL ACADEMY OF THEATRE ARTS IN CRACOW

Prof. Dorota Segda graduated the Ludwik Solski National Academy of Theatre Arts in Cracow in 1988. Since 1987 she has become related to the Helena Modrzejewska Old Theatre in Cracow. In the period of 1997-2000 she was also the actress of the National Theatre in Warsaw. Her achievements - until now - include more than 50 roles at the theatre scene and 40 roles in TV theatre. In the theatre, she played, inter alia, Salome in "Srebrny Sen Salomei" (eng. Silver Dream of Salome) by Juliusz Słowacki (1993) and Margaret in "Faust" by JohannWolfgang Goethe (1997), directed by Jerzy Jarocki. She received the Aleksander Zelwerowicz Award for both the mentioned above roles, being granted by the monthly Teatr (Theatre). We should also mention the following roles: Księżna Joanna (Duchess Joanna) in November Night (1997), Joas in "Sędziowie" (eng. Judges) (1999) and Rachel in "Wesele" (eng. Wedding Party) (2000) - dramas by Wyspiański, directed by Jerzy Grzegorzewski. In TV theatre, she played, inter alia, the title roles in "Maria Stuart" by Friedrich Schiller, performance directed by Robert Glinski (1995) and Królowa Krystyna (eng. Queen Christina) by August Strindberg, directed by Piotr Mikucki (1996). Her achievements include also many film roles such as e.g. title Faustine in film by Jerzy Łukaszewicz (1994, the Main Award for Actress of the III. International Film Festival in Riga), Eve in film "Daddy" (Polish "Tato") directed by Maciej Ślesicki (1995, Award Gold Duck (Polish Zlota Kaczka, granted by weekly magazine Film). Apart from the mentioned above examples, she is a laureate of Award of Festival of Acting Art in Kalisz (1989), the Stanisław Wyspiański Award 91989), twice – the Award of the Festival of Polish Classics in Opole (1994, 2001) and the Zbigniew Cybulski Award (1995). In 2001, she became the laureate of the Award of Cracow City; in 2005, she was awarded the Silver Medal "Merits for Culture" – Gloria Artis.

Source: http://krakow.pl/prof-dorota-segda-ped

Prof. dr hab. Elżbieta Skorupska-Raczyńska

THE JACOB OF PARADIES UNIVERSITY IN GORZÓW WIELKOPOLSKI

Prof. Elżbieta Skorupska-Raczyńska (born in 1955) is a philologist, professor of humanities, specialist in the history of the Polish language and linguistics. In 1992, she graduated in philosophy at the Pedagogical University of Tadeusz Kotarbiński in Zielona Góra. In 1999, on the basis of the dissertation entitled She obtained progressive borrowings of Latin origin in the Polish language of the nineteenth century at the Faculty of Polish and Classical Philology of the University of Adam Mickiewicz in Poznań, PhD. in linguistics, with a specialization in Polish linguistics. In 2004, she received at AMU, on the basis of her academic achievements and the dissertation entitled Dykcjonarz Michał Amszejewicz against the background of New Polish dictionaries of foreign words, a postdoctoral degree in humanities in the field of linguistics, in the discipline of linguistics. In 2014,

she was nominated as a professor.

From the beginning, she has been associated with the State Higher Vocational School in Gorzów, currently the Academy of Jakub from Paradyż. She was the vice-rector there, and since 2011 she has been the university rector. She also lectured at the University of Szczecin and at the Major Seminary of the Zielona Góra-Gorzów Diocese in Paradyż. He is an honorary doctorate of the Podkarpackie National University. Vasyl Stefanyk in Ivano-Frankivsk.

Source: http://perspektywy.pl/rektorzy/article/prof-elzbieta-skorupska-raczynska-ponownie-rektorem-akademii-w-gorzowie-wielkopolskim

dr hab. (PhD) Anna Szylar

Professor at the THE STANISŁAW TARNOWSKI STATE VOCATIONAL UNIVERSITY IN TARNOBRZEG

PhD Anna Szylar graduated the MA studies – history at the Jagiellonian University and doctoral studies at the Pedagogical University in Krakow. In 2002, she obtained a doctoral degree, and in 2013, a postdoctoral degree. He has been working at the University since its inception in 2001, first as a lecturer and senior lecturer, then as a university professor, in the years 2007-2008 he was the Director of the Institute of Pedagogy, and since 2016 he was Vice-Rector for Development and Scientific Research. In 2020, she was elected the Rector of the prof. Stanisław Tarnowski in Tarnobrzeg for the term of office 2020-2024. He is the author of over 100 scientific publications, including original monographs and edited books. She has prepared over a dozen of publishing author's books reviews, including promotion ones, and several dozen articles published in collective studies and scientific journals. Organizational experience includes functions and work in numerous task teams operating at the University, work in expert teams appointed by the Ministry of Science and Higher Education, international cooperation under the Erasmus + program, organization of conferences, seminars and the implementation of research and training projects. He combines professional experience gained in education, teaching staff development and higher education with scientific work, university management and activity in scientific societies and associations acting for the benefit of the local environment.

Source: http://perspektywy.pl/rektorzy/article/dr-hab-anna-szylar-nowym-rektorem-puz-w-tarnobrzegu

Prof. dr hab. Elżbieta Wtorkowska

THE FELIKS NOWOWIEJSKI MUSIC ACADEMY IN BYDGOSZCZ

Prof. Elżbieta Wtorkowska, is a professor of arts in the artistic discipline: conducting. In the years 2012-2016, she performed a function of Dean of the Faculty of Conducting, Jazz and Musical Education at the Feliks Nowowiejski Music Academy in Bydgoszcz. She is also employed at the Social-Artistic Institute of the Jan Grodek State University in Sanok. She is a lecturer and scientific manager at Postgraduate Choral Maestro and Voice Emission Studies at Music Academy in Bydgoszcz and vocal consultant of "Opera Nova" Choir in Bydgoszcz. Besides it, she has been (since 1993) the lecturer at Studies for Conductors of Polonia Choirs within the frames of Polonia Choral Academy in Koszalin where she has conducted the Choir of Polonia Conductors "Fatherland" since 2002. She conducted the seminars and choir workshops for conductors of Polish choirs in the following countries: Byelorussia (1996-2005), Ukraine (1998-2008), Lithuania (2003-2008), the Czech Republic (1999-2001, 2007-2008), the United States (2006, 2007, 2014 and 2016) and in Great Britain (2008 and 2015). In 2008, she delivered the lectures and choir workshops in Australia; in 2009 – in Scotland, in 2013 – in Mexico and in Spain (2014 and 2015). She is the initiator and artistic director of the International Choir Festival named after the priest Edmund Szymański in Murowana Goślina. The annual edition of the mentioned event has been held since 2007.

Source: http://www.amuz.bydgoszcz.pl/wykladowcy/prof-dr-hab-elzbieta-wtorkowska/

prof. dr hab. Anna Wypych-Gawrońska

THE JAN DŁUGOSZ ACADEMY IN CZĘSTOCHOWA

Prof. Anna Wypych-Gawrońska (born in 1966) graduated Cultural Studies (M.A.), speciality: theatre study, at the University of Silesia. In 1996, she obtained the scientific title of doctor of human sciences in discipline: literary studies on the grounds of dissertation: "Lvov opera and operetta theatre in the years 1872-1918". In 1999, she received a reward "Theatre Book of the Year" granted by the branch of

Theatre Critics of Polish Centre of the International Theatre Institute for the published, mentioned above PhD dissertation. In 2007, she obtained the degree of habilitated doctor (PhD) in discipline: literary studies at the Faculty of Polish Philology of the Jagiellonian University in Cracow on the grounds of monograph: "Warsaw opera theatre in the years 1832-1880". She graduated also musical school of the second degree in piano class, in Częstochowa. She has been employed at the Jan Długosz Academy (transformed into the Jan Długosz University of Human and Natural Sciences in 2018) for more than 20 years. In the period of 2008-2012 she was the Associate Dean for the Science Affairs at the Faculty of Philology and History. In 2016 she became elected as the Rector of the mentioned University.

Her research interests result from her humanistic and musical education. She conducts the studies having the interdisciplinary nature; the implemented two scientific projects of the Ministry of Sciences and Higher Education in the field of literary studies and sciences of art, and one project of the National Centre of Sciences in respect of theatre science and performance arts. She is the member of a few scientific societies, including Polish Society of Theatre Studies, the Adam Mickiewicz Literary Society, Branch in Czestochowa, and Société Internationale D'histoire Comparée Du Théâtre, De L' Opéra et Du Ballet with the seat in Sorbonne in Paris.

Source:http://perspektywy.pl/rektorzy/article/prof-anna-wypych-gawronska-ponownie-rektorem-ujd-w-czestochowie

dr hab. (PhD) Danuta Zawadzka

Professor at the UNIVERSITY OF TECHNOLOGY IN KOSZALIN

PhD Danuta Zawadzka (born in 1974) graduated MSc. Studies in 1998 at the University of Technology in Koszalin, Faculty of Economy and Management, direction: economy. Since that time she has been professionally related with her alma mater – initially as assistant and since 2002 - as assistant professor. From March 2011 she has been employed at the post of professor of the University at the Department of Finances of the Faculty of Economic Sciences of the mentioned above University of Technology. D. Zawadzka received the scientific title of doctor in economic sciences in speciality: finances and banking at the University of Technology in Szczecin, at the Faculty of Management and Economics of services (PhD. Thesis advisor: Prof. dr. hab. Aurelia Bielawska; the title of dissertation: "Effectiveness of financing the enterprise with the capital, obtained from the emission of short-term debt securities". In 2010, she obtained the scientific title of habilitated doctor (PhD) of economic sciences in discipline: economy, speciality: 'finances of enterprise', at the University of Economy in Poznań, the Faculty of Management (title of dissertation: "Determinants of demand of small enterprises on commercial credit. Identification and evaluation"). In 2009, Danuta Zawadzka received the Medal of the Commission of National Education, and in 2010 – the Gold Badge of Honour of Polish Economic Society; in 2013 she was awarded with the Bronze Medal for Long Service. In the period of 2012-2016 she was the member of the Accreditation Commission of Technical Universities. In the cadence of 2016 – 2020 she was the member of the Commission for Education, functioning within the frames of the Conference of the Rectors of Polish Technical Universities.

Źródło:https://danutazawadzka.edu.pl

Prof. dr hab. Elżbieta Żądzińska

UNIVERSITY OF ŁÓDŹ

Prof. Elżbieta Żądzińska (born in 1967) is a graduate of the Department of Biology and Life Sciences at the University of Łódź. In 1990, she received the title of M.Sc. in biology. In 1999 she obtained the degree of PhD in natural sciences and in 2005 – the degree of habilitated doctor of natural sci- ences (DSc.). In 2014, the President of the Republic of Poland awarded her with the title of full professor of natural sciences. During 25 years of work at the University of Łódź, she passed all degree of scientific career – from scientific-technical worker to the university professor and since March, 1, 2015 - full professor. In the period of 2005-2008 she was the Associate Dean of the Faculty of Biology and Environment Protection; from 2008 to 2016, she played a function of Dean of the mentioned Faculty. In cadence of 2016-2020 she was Vice-Rector for the Science Matters of the University of Łódź. Prof. Elżbieta Żądzińska is the President of the Commission for Science Matters of the Conference of the Rectors of Academic Polish Schools (KRASP). Since 2014, she has been also the Honorary Visiting Research Fellow of Medical Sciences School at University of Adelaide. Her main research directions include; biology of human contemporary and historical populations, determinants of population stress (secondary gender parity index, fluctuating asymmetry, disturbances in weight-height proportions) and odontology.

Source: http://perspektywy.pl/rektorzy/article/prof-elbieta-zadzinska-nowym-rektorem-uniwersytetu-lodzkiego