3W IDEA. DEVELOPMENT PERSPECTIVES

3W

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Climate change and energy transition are challenges faced by the entire world. The decisions we make every day impact the environment, the state of Polish companies and our entire economy.

BGK's mission is to support sustainable social and economic development in our country. Today, we stand at the threshold of the next civilisational breakthrough on the scale of the revolution brought about by the development of the worldwide web. This will change the way we use the natural resources we have been given, and specifically three, on which we will build our future – water, hydrogen and carbon.

That is why we are launching the 3W initiative [in Polish, "3W" refers to "woda", "wodór", and "węgiel nieenergetyczny". In English, these are "water", "hydrogen" and "carbon"]. Its objective is to draw attention to water, hydrogen and carbon as strategic resources of the future, to shape consumer attitudes to support the development of a sustainable economy, and to build a social and economic ecosystem that Polish scientists, entrepreneurs, local government officials and decision makers who are active in the 3W sector will operate.

Thanks to the 3W initiative, the world of science, in which innovative solutions and technologies are created, will draw near to the world of business. We will create tools to facilitate collaboration between inventors, companies interested in commercialising these innovations, and financial institutions that will help source funding for bold development projects.

Although at present, 3W is starting out as an idea, within the next several years, this will be a real and rapidly growing sector of the economy. We are taking on the role of a project initiator – a link between many different environments – to work towards sustainable development and increasing the competitiveness of the Polish economy.

Introduction

The world is standing at the threshold of huge changes. Climate change is progressing and is a real threat to human existence, which is forcing transformation in all economic sectors towards zero emissions. This will translate into changes in the lives of all inhabitants of the planet – some items, industries and actions that currently fill our day-to-day life will disappear and be replaced by completely new products, sectors and processes.

Despite such comprehensive transformations, some elements of our reality can be used to achieve zero emissions. We will focus on these in the 3W project.

Water, hydrogen, carbon – these are the key substances that are the foundation of life on Earth.

Why are they so crucial to the functioning of our world?

Of what significance are the 3Ws in building new technologies and solutions?

WATER

The paradoxical thing about water is that while water covers approximately 70% of the surface of the Earth, only less than 1% is drinking water, without which humans and animals can survive only several days. The world is working on water desalination and retention technologies.

Despite the fact that the world's drinking water supplies are shrinking and it is becoming a geopolitically managed raw material, we are still wasting huge amounts of it.

For many regions, global warming means problems with water management. There is a risk of a future full of dramatic water wars, known from post-apocalyptic films like "Mad Max: Fury Road". The fight for water may become a reality in the lifetime of modern generations.

One of the countries that already have hydrological problems is Poland. An example of this is frequent and long agricultural droughts – they will become more severe as climate change progresses. They are due to improper water melioration, a decrease in the number of days with snow cover, regional changes in annual rainfall and an increase in evaporation due to rising temperatures. That is why comprehensive water retention, reuse and treatment strategies are important.

HYDROGEN

Changes towards the goal of zero emissions will leave a mark on energy, transport and industry. For these sectors, which are encumbered with a high intensity of greenhouse gas emissions, hydrogen is a huge hope.

This element can be an energy source that will replace coal-fired power plants and coke-fired blast furnaces. Thanks to the possibility of producing hydrogen using renewable energy sources as part of the electrolysis process, the hydrogen industry is appearing as a potential storage facility capturing excess electricity generated by photovoltaics or wind energy. Another option is hydrogen production using nuclear power plants.

The advantages of hydrogen are already being noticed by entrepreneurs – increasingly more companies are starting their own hydrogen projects and getting involved in activities related to this element, creating clusters and hydrogen valleys, and carrying out infrastructure experiments. The development of the hydrogen industry is an opportunity for entities that want to build an advantage in an innovative sector. This can be of benefit to, for example, the Three Seas countries, for which energy transition is a common goal. Poland is one of the largest hydrogen producers in Europe, so we can take on this challenge, using plans for building renewable and nuclear sources, as well as hydrogen valleys.

CARBON

Carbon is an element that is present in all living organisms. However, coal is widely associated with the energy sector, because for decades it was the main fuel of human economic development.

Now – due to its emissivity – it is giving way to new energy sources. But its role does not end with energy.

As an element, carbon appears in many forms with different and very valuable properties. Thanks to new inventions, it is returning in completely different applications. Graphene, fullerenes, carbon nanotubes and activated carbon have enormous potential. They enable us to create lighter and more durable engineering materials, which allows them to be used in many industries, such as electronics, medicine, construction, space, aviation and automotive.

New materials made from carbon nanoparticles can also help solve emissions problems caused by energy generation of bituminous coal and lignite.

3W Idea

The 3W idea meets the challenges of transitioning the economy towards zero emissions. It creates a unique ecosystem that is conducive to the development of technologies in the water, hydrogen and carbon area. Its potential is also based on the strength of social capital.

3W – as part of its format – builds a community of talented scientists and students, bold entrepreneurs, visio ary NGOs and responsible representatives of the public sector and financial institutions.

The 3W idea aims to bring together innovative scientific, economic and legislative solutions. This means it can be a unique opportunity to build real strength and enhance the development of Poland. Matters related to transitioning the economy and moving towards sustainable development already arouse huge interest in public opinion. That is why we are starting the project by informing the scientific environment, entrepreneurs and representatives of the public sector about a possible new approach to matters involving water, hydrogen and carbon. At the same time,

the search for 3W initiatives that can be included in the formula of the project is ongoing. The integration of all entities into one cohesive organisational and communication ecosystem gives huge possibilities for preparing Poland for the coming era of transformation.

3W • WODA • WODÓR • WĘGIEL

WODA

3W

Compared with other European countries, Poland does not have extensive supplies of drinking water. There is approximately 1,600 m3 of water per capita per annum, but in drought, this falls to even 1,100 m3. As a comparison, the European average is almost three times higher at approximately 5,000 m3.

However, according to UN data, the threshold of 1,700 m3 per person is the limit where water scarcity – a risk of a water deficit – occurs.

of both droughts and floods. In accordance with the assumptions of the government "Retention Development Programme", its level is supposed to increase to 15% by 2027. In 2020 Wody Polskie (state water management company Polish Water) finished its works on the first Drought Effects Counteracting Plan (DECP) in Poland. The document is a study of the phenomenon of drought, but it also includes a catalogue of measures which aim is to decrease losses caused by drought and to ensure effective

In Poland, approximately 80% of water collected for the needs of the economy and people comes from surface water resources. The remaining 20% is groundwater. Despite the fact that the country's precipitation has not changed much over the years, the nature of the precipitation is changing.

Violent storms deliver water in amounts we are not yet able to store. Contemporary problems with water management stem from the decisions made in the country over the last several decades. Rivers were regulated on a large scale, and no ongoing work was carried out on the drainage ditches, which led to their neglect.

The results can be seen only in the long run, and we are experiencing them right now. Regions without implemented water retention solutions are drying out. Currently in Poland we retain only 6% of water (approximately 4 billion m³). We need at least double that to effectively combat the effects

surveillance of water resources as well as water management.

Other actions supported by Poland are: investments in channel retention, small forest retention, or programmes such as Moja Woda (My Water). The following entities will get involved in these activities:

- Ministry of Infrastructure,
- Ministry of Climate and Environment,
- Wody Polskie (state water management company Polish Water),
- National Fund for Environmental Protection and Water Management,
- The National Centre for Research and Development.

The problem of periodic water shortages is particularly visible in cities. This is due to, among other things, earlier regulation of rivers, drainage of swamps and wetlands and channelling of small watercourses in concrete beds. Unfortunately, in Poland, misunderstood revitalisation is increasingly being carried out, which boils down to removing greenery from urban areas and replacing it with concrete, water-impermeable surfaces. The soil in cities is "dry" and is unable to absorb and store rainwater. As a result, we are left with a paradoxical situation – even in periods of drought, cities experience flooding caused by short-term, torrential rainfall. Excess water rapidly flows down to rivers or the sewage system, instead of being retained like it should. This is becoming an increasing problem, because over the last decade, the nature of rainfall in Poland has been changing rapidly. In the spring and summer period, it is becoming heavier and more intense. That is why smart-city ways of retaining water in urbanised areas are being sought. According to the report published by Statistics Poland – "Poland on the road to sustainable development. 2020 Report." – our country's problem is not only that water supplies are relatively small, but in addition, we face seasonal variability and differences within the country. Alongside global warming, the problems of drought, drying up of rivers, decreasing groundwater levels and recurring water shortages will become an increasing challenge.

Poland's geographical location means that in winter, we used to get humid air masses and snowfall. However, in recent years, snow cover in Poland has been decreasing. Its absence increases the frequency and duration of drought periods, particularly in the vegetation period, when we need water the most. In the 21st century, water supplies will be the most important, and their availability will cause conflict, as indicated by the Institute of Meteorology and Water Management in its report "Polish Climate 2020"[1].

However, despite increasing awareness of these challenges, the average Pole directly uses approximately 100 litres of water per day, and their water footprint (which is indirect use in the consumption of goods and services) is already at almost 3,900 litres. Global Compact Network Poland and Statistics Poland highlight that in Poland, the most water is consumed by industry (approximately 72%). Following industry, there is the municipal sector (18%), agriculture and forestry (10%)[2].

Innovations and technologies in managing water supplies

In industry, we are seeking, first and foremost, environmentally and energy-efficient solutions to use and purify water. We need technologies that will enable its use in a circular system. In agriculture, we need solutions that will counteract water deficits in food production. Commerce and services are focusing on innovation to decrease the water footprint of economic activity. In eco-friendly households,microretention and water recovery are popular. Territorial self-government units are seeking solutions for water purification and retention, as well as for managing water relations.

We need to remember that water access problems do not affect only Poland. Technologies are being developed around the world to enable more-efficient water retention, treatment and recovery. They include solutions for using rainwater, and the market related to these is growing dynamically. It is estimated that globally by 2027, it will grow at a rate of approximately 6% per annum (CAGR).

One forecast value at the end of 2027 is meant to reach USD 1.3 billion (equivalent to over PLN 5 billion). The largest shares are held by Europe and the Asia-Pacific region (approximately 81% combined). European leaders are Germany and Great Britain.

Retention and monitoring

In European countries that use high amounts of rainwater, technologies in this region are used by households as well as the commercial and service sector. According to forecasts, by 2027, agriculture will reach approximately 11% share in the global rainwater retention market. In Poland, rainwater stored in tanks and rainwater harvesting systems is used mainly in horticulture. These tanks can be above or below ground. Due to the climate and the nature of the rainfall, rainwater retention in above-ground tanks takes place mainly from spring to autumn. Tanks can be placed outdoors as well as indoors, e.g. in heated cellars, meaning that rainwater can be collected throughout the year. Stored water is mainly used for watering plants and gardening.

Underground tanks are made of more-durable materials, and their design allows them to be placed even underneath pavements or streets. Such tanks can be aggregated, which makes it possible to collect more water during heavy rainfall. Managing water resources requires effective monitoring of not only the quantity but also the quality of the water. It is mainly about the ongoing measurement of its parameters. Popular and constantly developed technologies include the Internet of Things (IoT), as well as software and sensor systems used directly in devices, for example, in water supply pipes, water resevoirs,

etc.It is estimated that by 2025, the global market for water quality monitoring will grow at a rate of 7.3% annually (CAGR) and reach USD 3.8 billion (over PLN 15 billion)[3]. An interesting example of activities in this area is the satellite water monitoring project. Thanks to the cooperation of ESA (European Space Agency) and the World Bank, as well as the use of the Earth Observation system in developed countries, in particular in Africa, a constantly operating, independent and up-to-date source of information on water resources on the water basin scale has been created. This provides important support for agriculture and industry, monitoring the need for fresh water[4].

Treatment

The wastewater treatment market will also be growing rapidly. It is estimated that in 2019–2025 the rate of growth will be 6.5% per year (CAGR), and the value of the entire market in 2025 will reach USD 211 billion, which is over PLN 800 billion). The development of technology related to wastewater treatment visible in recent years is due to the use of new membranes that increase the effectiveness and efficiency of the treatment plants and reduce the costs of their operation. The technology leaders in this area are countries from the Asia-Pacific region, as well as North America, Europe and Latin America.

Purification and desalination

Water purification remains a huge challenge; that is why intensive works are continuing

on seawater desalination technology. The leaders in this field are the US, Israel, China, Spain, Australia and the United Arab Emirates. In Dubai, 99% of drinking water is acquired through seawater desalination, and in 2019 alone, USD 1.6 billion was devoted to projects related to water and energy. One of the biggest outlays in the United Arab Emirates – the recently opened Jebel Ali – can process 182 million litres of drinking water a day, servicing 700,000 residents. The plant uses reverse osmosis technology.

Scientists are still looking for cheaper and more effective desalination methods. One new, very promising idea is using porous material and sunlight. This solution was developed by a team of scientists from China and Australia5.

Another interesting idea of this type is Icemill – a project by Polish researcher Katarzyna Przybyła – involving the purification of salt water based on desalination by freezing.

Scientists from the University of Notre Dame in the US identified a new solvent – an ionic liquid that in laboratory tests is the most effective water desalination method. This solution allows the use of a similar amount of energy to desalination by reverse osmosis, but much less than thermal desalination. Ongoing work on the reduction of the costs of production of the solvent and its application on a larger scale is ongoing.

The future: what else can we do?

Actions aimed at improving water management in Poland include preventing water deficits, ensuring water security, and eliminating the risk of droughts and floods. As a result, this will ensure stable living conditions for the population and business development. This applies to both industry (including conventional energy) and, for example, agriculture and forestry. The efficiency and effectiveness of applied technologies will improvethe competitiveness of agricultural enterprises and farms, decrease costs, and ensure continuity of their operations.

Another result of actions focused on water should be improving energy security. The energy sector is responsible for 28% of annual water consumption in Europe. However, in Poland, this percentage is much higher. The rise in surface water temperatures and decrease in their levels will limit options for using water to cool power plants.

Importantly, in summer, when the waters in rivers are the warmest and at the lowest levels, the demand for electricity rises due to more frequent hot days.If we do not retain water, we will face less of it, and this may cause delays in the supply of water to industry or individual recipients. Water deliveries play a key role in a country's stable economic development, and so the development of technologies supporting water retention and treatment will have positive economic effects.

In Poland, we do not yet have a water desalination plant. The main problem remains powering such an installation, but renewable energy sources and energy storage technologies look promising. The Polish Grupa Azoty Zakłady Chemiczne (Azoty Group, the Chemicals Plants in the town of Police) is working on the implementation of desalination technologies. The water purification station it uses will be equipped with electrodialysis reversal (EDR) membrane technology with new water demineralisation lines.

Solutions that allow reuse or multiple use of water are being developed in parallel to water retention and treatment technologies.

Areas where methods are used to optimise water consumption are, for example, closed-loop systems used in industry or hydroponic cultivation in agriculture. In households, everyone can use simple solutions, e.g.

- aerators (water-saving attachment),
- limiters (limits the diameter of the water outflow),
- dual flush systems,
- changing from two taps to a mixer tap.

Water is necessary for life, and we have less and less of it. In Poland, we will experience increasingly frequent floods, and longer and longer periods of drought. Already now, there are conflicts around the world related to water.

The search for technologies of water reuse, drinking water acquisition, and frugal water resource management is the main challenge that Poland and the world are facing. We will be looking for innovative solutions to this problem as part of the 3W initiative.

Under 3W, we will be looking for, among other things, technologies of water reuse, drinking water acquisition, and skilful, frugal water resource management. This is the main challenge faced by Poland and the world.

Wojciech Racięcki

Director of the Department of the Development of Innovative Methods for Programme Management, The National Centre for Research and Development (NCBR)

In our country, we face three challenges. First, the need to protect deep waters, which Poland has a limited supply of compared with, for example, other parts of Europe. Second, we must prevent floods, and third, we must combat the effects of drought, which is becoming an increasingly common phenomenon. That is why any technological solutions that enable us to keep water in its place, treat it and store it are noteworthy.

The NCBR is running the project “Home retention technologies” aimed at developing an innovative system that is able to treat and store rainwater. It is about minimising t he use of water from the water supply and replace it with rainwater, as well as minimising the amount of wastewater going into the sewage system.

In the future, municipal wastewater will be converted to clean water and fertiliser. That is why we are seeking technologies that will enable us to eliminate microcontaminants, antibiotics, pesticides and microplastics. Transforming problems into a product and providing raw materials for the economy is an element of the circular economy, which is becoming increasingly talked about in Poland and Europe. The recovered water can then be used in agriculture to water crops and as drinking water for animals, and in cities to, e.g. wash roads.

Currently, two countries used highly advanced solutions: in Spain, over 40% of rainwater is retained, and Australia has imposed a legal requirement for every new home to have a rainwater tank installed. I think that with time, such solutions will also become necessary in Poland. Water is becoming an increasingly valuable resource, and we can no longer use deep water resources, which were formed millions of years ago, to flush the toilet. In many areas in industry, agriculture and horticulture, so-called grey water could be used instead of valuable resources that are suitable as drinking water for humans. And that is the type of technologies we are constantly looking for.

WODÓR

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Hydrogen and its role in a transition to climatic neutrality are discussed in the context of the entire economy – industry, energy and transport. There are high hopes placed on this raw material. You could say that the challenges that must be undertaken to create a vibrant hydrogen sector are equally great.

Hydrogen is rightly called the "fuel of the future". It is not just about the potential dormant in this element, but also about the fact that we do not have widely available and economically acceptable ways of producing hydrogen without emissions. As much as 95% of the world's supply of this raw material is due to the processing of fossil fuels, mainly gas and coal, but also light petroleum fractions. Depending on the raw material, hydrogen is called "grey", "brown" or "black".

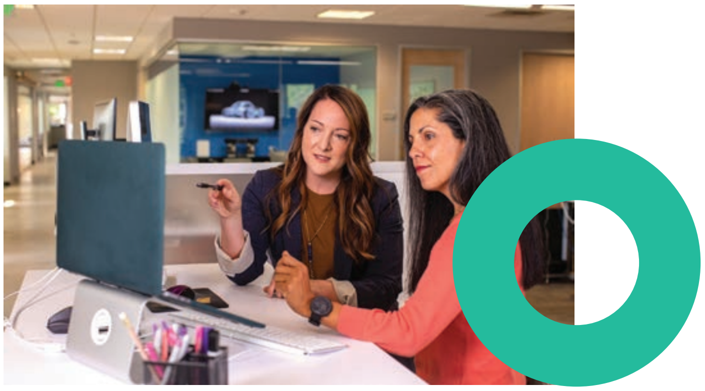
The side effect of these reactions is carbon dioxide, which is a greenhouse gas the emission of which should be reduced under the slowing of climate change.

In the transitional phase of the energy transition, it was assumed that CO2 capture and storage technologies (CCS – Carbon Capture and Storage), which limit emissions in the production of hydrogen, would solve this problem. Hydrogen produced using these technologies was called "blue". However, this is not a perfect solution, as could be deduced from the latest research carried out by scientists at Cornell University and Stanford University, showing that the carbon footprint of "blue" hydrogen is up to 20% higher than in the case of natural gas or coal combustion for heating purposes.

This is why researchers around the world have focused their attention on the hydrogen production method using electrolysis reaction. This process involves the separation of hydrogen from water with the help of electricity using electrolysers. Currently, the most popular devices of this type are alkaline electrolysers. PEM electrolysers are also available on the market – they have lower power than alkaline electrolysers (from 200-1150 kW) and similar efficiency (from 65% to 78%).

On the other hand, solid oxide electrolysers using steam at a temperature of 700 to 900°C, which would be characterised by high efficiency (85%), are under development.

Electrolysers are an opportunity to produce hydrogen without any greenhouse gas emissions; however, they need emission-free sources for this electricity. Renewable sources are emission free (mainly offshore and onshore wind energy and photovoltaics), as is nuclear energy (in the long term also including small SMR nuclear units). Hydrogen produced by electricity from these powers is called "green" and "purple" hydrogen, respectively. It is these "colours" of hydrogen that are most needed in industry because they meet the rigours of climate policies. However, the economy is in the way – the production of "green" and "purple" hydrogen as part of electrolysis is still very costly, and uncompetitive compared with hydrogen acquired from fossil fuels. Manufacturers of electrolysers are already trying to reduce the costs of both the devices themselves as well as the hydrogen production process. Lowering the price to economically attractive thresholds will require adequate legislative and financial support from countries and international organisations such as the European Union. The production of hydrogen is only the first step towards using this raw material in the economy.



The next steps are transmission, distribution and storage. These issues result in many questions, e.g. about the potential use of existing infrastructure for the transmission of natural gas and for the distribution of hydrogen. A number of countries are already assessing their gas networks in terms of including hydrogen in them – such experiments are currently underway in Germany, and Russia and Ukraine also have such plans. Ukraine in particular has high hopes for the transmission of hydrogen through the gas network. Filling gas pipelines with hydrogen would give the Ukrainian transmission system a chance at a second life if the transmission of Russian gas via Ukraine stops or is limited. The natural gas sector can also deliver solutions for hydrogen storage. We can use, for example, cavern stores.

Strategies for supporting the hydrogen industry in Europe

As was mentioned above, the dynamic growth of the competitive hydrogen industry requires support from countries and international organisations. Such strategies, mechanisms and tools supporting the development of the hydrogen economy are created, among others, in Europe.

In 2020, the European Commission adopted a hydrogen strategy entitled "A hydrogen strategy for a climate-neutral Europe", which sets an action plan for the short term (up to 2030) and for the long term (up to 2050). It shows far-reaching ambitions of the European Union in the area of hydrogen technologies. Its main objective is to reach such a capacity of the production of "green" hydrogen that after 2050 it is the only "colour" of this raw material used. Throughout this period, EU Member States can use "blue" hydrogen to some extent.

The Strategy expects that in 2020-2024, with the support of the European Union, electrolysers with a capacity of 6 GW are to be created, and the production of "green" hydrogen will be up decarbonise hydrogen products in the chemicals sector, as well as in transport and heavy industry. In 2025–2030, the power of the EU's electrolyser machinery is meant to be 40 GW, which will translate into an annual production of up to 10 million tonnes of "green" hydrogen. Hydrogen solutions will then enter the metallurgical, railway and water sectors, as well as truck transport. According to the strategy, "green" hydrogen technology will fully develop and become competitive in 2030-2050. Also then, this raw material will start to be used by other sectors that were previously unable to independently carry out the decarbonisation process.

The scale of the European Union's ambitions for the hydrogen industry can also be seen in the budget adopted for the strategy. The EU wants to allocate EUR 470 billion to "green" hydrogen investment by 2050. And the low-emission hydrogen sector is to receive support of up to EUR 18 billion. Up to just 2030, investments in electrolysers are to reach EUR 42 billion. The development of wind and solar energy generation as well as required works to the transmission network will absorb EUR 340 billion. EUR 11 billion will be allocated for the modernisation of existing hydrogen production plants, and EUR 65 billion for the development of transport, distribution and storage infrastructure.

It should be highlighted that individual EU Member States are also setting their own goals in the hydrogen sector. Until now, the biggest plans for the production of hydrogen have been in Germany, which is expecting to start up electrolysers with a capacity of 10 GW by 2040 (5 GW per decade). The cost of this investment will be approximately EUR 20 billion. The Netherlands has also published its own hydrogen strategy and is planning to build electrolysers with a capacity of approximately 500 MW by as soon as 2025, and a subsequent 3.5 GW by 2030. France has ambitions plans in this area as well – it is intending to start up 6.5 GW of electrolysers by 2030, allocating EUR 7 billion for this goal. Spain is also planning to start up significant electrolyser capacity – 4 GW by 2030 and parallel development of hydrogen transport.

Portugal has somewhat more-modest plans – it is endeavouring to build 2–2.5 GW in electrolysers by 2030, which will involve an investment of almost EUR 3 billion in the development of solar energy associated with hydrogen production.

Poland is also working on its own hydrogen strategy. A draft of this document entitled "Poland's Hydrogen Strategy to 2030 with a perspective up to 2040" was presented in January 2021 by the Ministry of Climate and Environment, and then put up for public consultation. It assumes intense development of national and local competences in the production of key components in the hydrogen value chain. The project has a series of goals that make up a comprehensive implementation of hydrogen technologies in the economy. These solutions are meant to reach the Polish energy, transport and industry sectors.

Poland will invest in new hydrogen production installations and transmission networks. The creation of a stable regulatory environment will help achieve this.

Hydrogen technologies in Polish companies

Polish companies are already now trying to catch the hydrogen wind in their sails and realise a range of projects in building competences, carrying out research and developing innovations in the field of hydrogen. One of the leaders in this is Grupa Lotos, which started, among others, an R&D project on electrolysers and their integration into the energy market. Gdańsk's petroleum giant wants to solve one of the most important problems affecting the process of acquiring "green" hydrogen – the variability of the supply of energy generated by renewable sources. Lotos intends to tune electrolysers to the unsteady electricity supply, and to develop the installation to include additional functionalities, such as a hydrogen warehouse and fuel cells. The company is also working on infrastructure for the production and sale of high purity hydrogen, which would go to fuel cells. Such a unit would enable the opportunity to build a hydrogen refuelling station.

PKN Orlen also has ambitious plans regarding hydrogen. This petroleum company from Płock wants to build a hydrogen hub in Włocławek. The installation is to be powered by hydrogen obtained as a waste product

in the brine electrolysis process, then purified using the PSA (Pressure Swing Adsorption) method. This raw material is meant to power vehicles in transport. Orlen is also collaborating with PESA on a prototype for a hydrogen-powered shunting locomotive. It was presented at the TRAKO International Railway Fair in Gdańsk in September 2021. The hydrogen locomotive would replace diesel locomotives on routes where electrification of traction cannot be carried out. PGNiG also has high hopes for hydrogen. This Polish gas giant wants to, among others, build a pilot hydrogen vehicle refuelling station. It would be in Warsaw's Wola. To this end, PGNiG established an arrangement with Toyota, which launched the model Mirai on the Polish market – this is the first serial-produced sedan car powered by hydrogen. The latest generation of this car has a range of 650-900 km, which significantly trumps current electric cars.

PGNiG's next project analyses the potential of caverns for storing hydrogen. The company is carrying out research in Pomerania, where cavern stores would be created for hydrogen generated by offshore wind farms. PGNiG is also conducting studies about the transmission of hydrogen to increase the volume of gaseous fuel in the distribution system and the possibility of delivering hydrogen to remote locations, e.g. filling stations. The research is being carried out on mixtures of hydrogen and methane at various concentrations – from 1 to 23%.

Gaz-System is another Polish company from the natural gas sector – it is conducting studies on the potential of the transmission of hydrogen via existing gas infrastructure. The experiments involve different hydrogen mixtures. They are being carried out as part of the "Hydrogen Agreement" signed in 2020 and initiated by the Ministry of Climate and Environment.

Solaris is manufacturing zero-emission hydrogen city buses, which are then going to the US, Dutch and German markets. And Remontowa Holding is working on solutions using hydrogen in shipping; it is developing conceptual designs of vessels powered by hydrogen cells.

Hydrogen is also very popular among electricity companies.

Polenergia and Siemens are developing electrolysers producing "green" hydrogen using electricity from offshore wind farms, which would then be used in industrial cogeneration. This would be significant for the entire industrial sector. The plans of these two companies include the implementation of hydrogen and gas as well as hydrogen turbines. Also interested in similar solutions is ArcelorMittal, which is investing in Smart Carbon technology using hydrogen as a reducing agent and already used by steel plants in Belgium and France. The team of Elektrownia PAK is working on generating hydrogen using energy from biomass to then inject the obtained raw material into mobile warehouses and power vehicles with it. PGE Energia Odnawialna wants to develop hybrid installations based on power-to-gas technology, integrated with wind farms. Thanks to this, the company wants to produce hydrogen obtained from surplus energy from wind farms. An important player on the national market is Grupa Azoty, which currently produces hydrogen from natural gas. However, the plans of the fertiliser giant include the development of fuel cells and obtaining hydrogen thanks to installations from Grupa Azoty Polyolefins under advisory support for manufacturers and service providers in the area of the implementation of elements of an economy based on hydrogen into the supply chain. In turn, consulting assistance in the preparation of hydrogen projects under the European PDA-Regions project will be given to Gdynia, which wants to invest in public transport powered by hydrogen. The potential of regions in the field of hydrogen can strengthen the concept of so-called hydrogen valleys. These are meant to be both centres of excellence and incubators of development for hydrogen technologies, creating a platform for the integration of enterprises from various sectors that are interested in innovations using hydrogen. Ultimately, in accordance with the assumptions of the draft hydrogen strategy, five hydrogen valleys are meant to be created in Poland, with four of them (in the Podkarpackie, Dolnośląskie, Śląskie and Wielkopolskie voivodships) already existing.

the Polimery Police project ["Police" is a town in Poland], where this raw material would be a byproduct of the propane dehydrogenation reaction. Hydrogen can be used by Grupa Azoty both in the work of the Polimery Police complex and in the production of ammonia in nearb y Zakłady Chemiczne Police. Parallel to the actions undertaken by companies, regions are also undertaking appropriate efforts to build hydrogen competences. It is worth mentioning the "H2 Wielkopolska" initiative, which involves

The central government also runs programmes aimed at supporting entities interested in developing the hydrogen industry in Poland. The National Centre for Research and Development allocates PLN 32 million to the project for developing hydrogen tanks for hydrogen storage. Support in this area is also offered by the Ministry of Development and Technology. It is worth noting here that Poland is already one of the larger producers of hydrogen. Approximately a million tonnes of this raw material are obtained in Poland every year, while the entire global market is approximately 70 million tonnes. The largest Polish producer of hydrogen is Grupa Azoty, followed by Grupa Lotos, PKN Orlen and Jastrzębska Spółka Węglowa. The hydrogen produced in Poland comes entirely from fossil sources.

The future: perspectives for the development of hydrogen technologies in Poland

Poland's hydrogen industry has the chance to come across very favourable development conditions. This is due to the opportunities for

synergy between it and the developing networks of renewable sources and the building of nuclear power plants on a small and large scale. The government has decided that as part of the country's energy transition, over the next 20 years, Poland will create approximately 30 GW of power installed in renewable sources, and from 6 to 9 GW in nuclear power. To this, we need to add announcements of private entrepreneurs (Ciech, Synthos, ZE PAK) and companies of the State Treasury (KGHM, PKN Orlen) in the field of building small SMR nuclear power plants. Such a park of generating units will enable the creation of an energy surplus, which can be used for producing "green" and "purple" hydrogen via the electrolysis process. These properties are particularly needed in the renewable source sector. Basic RES capacities, meaning wind and solar power plants, operate in a predictable but uncontrollable manner, depending on weather conditions or the time of day or night. This gives rise to problems with potential energy deficits caused by the insufficient generation of electricity from RES. The opposite situation, i.e. surplus generation exceeding the consumption capacity of the given system, is also quite problematic and forces, for example, hasty use of excess amounts of energy using neighbouring power systems. That is why aggregating the significant capacities of the electrolysers would help manage these surpluses.

It is expected that the development of hydrogen technologies will impact mainly the Polish transport and energy sectors. It will power passenger cars, buses and locomotives with electricity, by battery-powered vehicles (i.e. a decrease in the capacity of the battery in periods of low temperatures, limited range and long battery charging times).

This will help decarbonise the transport sector, which is one of the most important challenges on the path towards climate neutrality.

In the energy sector, hydrogen can act as an energy store, using energy surpluses from renewable sources in the electrolysis process and consuming them in periods of high demand for power.

Piotr Maksyś

Director of the Cluster of Hydrogen Technologies
Regional Pomeranian Chamber of Commerce

We already know that RES can help limit greenhouse gas emissions. However, due to their instability, we must continue seeking new ways of storing energy. This is the context that the world first noticed hydrogen in. It is in the electrolysis process, also thanks to energy from RES, that we can produce hydrogen and then store the energy it contains in order to generate electricity at the right moment and deliver it to the power grid.

The Hydrogen Cluster creates concepts for limiting CO2 emissions in accordance with the guidelines of the Green Deal and Fit for 55 programmes, focusing on innovative projects. One of these is the "NeptHyne" project. It aims to produce hydrogen offshore using electricity from wind farms. It provides the opportunity to store and process surplus electricity that cannot be taken in by the Polish Power System. On the other hand, it enables hydrogen to be supplied to ships, making planned maintenance of offshore windmills possible. An important element of the "NeptHyne" project is the need to create a whole technology and processes of desalinating seawater and adapting it chemically to the electrolysis process to produce hydrogen.

The draft of the "Polish hydrogen strategy" project indicates that conditions for the start-up of a hydrogen production installation using low- and zero-emission sources must be created by 2030. It is planned for incentives for innovative activities to be introduced, which will enable Polish entrepreneurs to take advantage of the developmental moment and funding offered by the European Union and international financial institutions. These include FCH JU hydrogen programmes, the European Investment Bank and Environmental Bank, including NFOŚiGW (National Fund for Environmental Protection and Water Management).

Financial support for large projects for the production of hydrogen and synthetic fuels based on the process of electrolysis is key in terms of Poland reducing the emission of harmful gases into the atmosphere. Currently, the entire world is focusing on hydrogen!

In Poland, the installed capacity of electrolysers will reach 2 GW in 2030. The government wants to also provide conditions for the construction of hydrogen-production installations at nuclear power plants.

Therefore, it is crucial that we use the high competences and qualifications of our production regions to create Polish windmills, turbines and electrolysers. Our companies are already developing and building innovative electrolysers. Our shipyards are also manufacturing CTV units to service wind farms, and so we already have most of the pieces of this zero-emissions puzzle. The matter of funding for these projects is still an open topic faced by Polish administration and enterprises.

WĘGIEL

3W

Carbon will remain with us for longer, but not as we know it today.

C for carbon – carbon is an element without which there would be no life, and hence no economy. We need to differentiate between carbon (the element) and coal (the raw material). Carbon as an element appears in many forms with different physical properties. Depending on this, it can be soft (graphite in pencils) or hard (diamonds in grinders), it can conduct electricity (graphene) or be a good insulator (diamonds do not conduct electricity). Its many different forms enable many applications.

Technologies and materials developed based on carbon:

Nanotubes

Currently, carbon nanotubes are the biggest carbon-based hit, and they may remain so over the next few years.

What are they?

Carbon nanotubes are empty tubes made up of rolled-up sheets of graphene, which is a material that is as thick as a single carbon atom. This unique structure and accompanying properties endow carbon nanotubes with special characteristics, giving them unlimited potential in nanotechnology applications. Carbon nanotubes are related to fullerenes. The first fullerene particles were discovered in 1985 and not promoted until 1991 by Sumio Iijima, who reported about his discoveries regarding carbon nanotubes in nature[6].

Flawless carbon nanotubes are resistant to most chemicals. They show excellent mechanical strength, with the highest known tensile strength and elasticity modulus among known materials, many times higher than, for example, steel. As regards thermal properties, carbon nanotubes exceed even diamonds as the best conductor of heat. This is most likely the technology of the future, whose development should be supported and focused on.

Currently, carbon nanotubes have applications in many areas, mainly in light and durable composites, thanks to which they can be a building material for the production of bicycle frames and tennis rackets. They are also used in batteries and accumulators, mechatronics and optics, and under laboratory conditions in electronic systems (transistors, memories, electrodes, displays). The aviation sector is also looking for an opportunity to take advantage of this technology. Carbon nanotubes demonstrate very good hydrophobic properties, meaning they are being considered as a substitute for expensive anti-icing systems that place a load on the structure[7].

Engineering materials using carbon nanotubes as additions have demonstrated the ability to produce plastic composites with increased electrical conductivity and mechanical strength. In biomedical applications, carbon nanotubes are promising as vehicles for targeted drug delivery and nerve cell regeneration. However, their future success in applications related to biology is largely dependent on toxicity studies, which are still in the early stages.

Given the diversity of nanotubes, they can also act on the body. Relatively few studies have been conducted to establish whether the crushing or burning of products containing nanotubes at landfills creates a threat to human health.

Nevertheless, such research should be carried out without hindering the development of these technologies – in parallel – so that it can be clearly stated that we are dealing not only with the high quality of the product, but also with the highest level of its safety.

Graphene

Graphene is a flat structure with a thickness of a single carbon atom and resembling honeycomb (hexagonal structure).

In 2004, physicists at The University of Manchester isolated single-layer graphene sheets using graphite exfoliation. Their "Scotch-tape method" used adhesive tape to remove the top layers from a graphite sample and then to lay the layers on a substrate material. After the tape was removed, some graphene remained on the substrate in single-layer form[8].

According to the Markets and Markets analytics company, in 2020, the graphene market reached a value of USD 620 million. Over the next five years, the cumulated annual growth rate (CAGR) is supposed to reach 19%. In 2025, the value of graphene is expected to reach USD 1.5 billion[9]. Currently, graphene has very wide applications, from medicine to photovoltaics, construction, and transport, and its significance in these and other areas of life will continue to increase. Several years ago, Professor Tadeusz Knych

carried out graphene research at the AGH University of Science and Technology; he demonstrated that graphene is not only 200 times more durable than steel of the same thickness, but is also a great conductor of electricity, in which electrical charges move 200,000 times faster than in silicon. These remarkable possibilities of graphene led scientists to the concept of adding it to copper or aluminium, which should result in a material with higher electrical conductivity[10].

Such an application in power networks would allow better energy transmission with smaller losses compared with those

we currently have in power lines, which would also translate into economic indicators of the energy sector, which is struggling with the problem of transmission losses.

Thanks to good electrical and thermal conductivity, as well as high transparency, graphene also supports photovoltaic solutions. In 2019, the first photovoltaic power plant comprising photovoltaic modules with a graphene layer in the country was erected in Feliksów near Sochaczew. This technology was patented by the Polish company FreeVolt. The photovoltaic power plant has a capacity of 1.8 MW, made up of two projects with 0.9 MW each[11].

The faster and efficient electronics, flexible displays, efficient solar panels and many other unmentioned applications of graphene clearly prove the enormous technological potential of this material. Problems often appear in the context of implementation into the industry. This is where printed electronics techniques come into play. The production of conductive pastes based on graphene nanoflakes dedicated to screen printing, flexography and similar technologies, opened the way to faster incorporation of graphene into everyday life. Of note here are various types of efficient and precise sensors and electrodes – from electrochemical sensors to the detection of harmful gaseous substances and health monitoring.

Different biosensors are made as both parts of larger devices and singular microdevices, including smart clothing. There are sensors for measuring heart rate, blood pressure and oxygenation, body temperature, respiratory rate, blood glucose and the ECG signal.

And how is graphene perceived in medicine? Scientists involved in tissue engineering are still looking for the ideal material for medical applications. They are working on a material that would provide the right cell adhesion, differentiation and growth. Research has shown that graphene has the necessary biocompatibility with mammalian cells. It turns out that graphene scaffolds can be used to accelerate the differentiation of bone stem cells. Thanks to its high mechanical durability, graphene can be used in tissue engineering. In the future, it may be used in surgery on hard tissues, in particular to strengthen artificial bone implants.

Today, graphene is popular in medications, and as a biosensor or biological agent. Research shows that methods using graphene will be very significant in developing new antibacterial products once we move away from antibiotic therapies[12].

However, currently the largest consumer of graphene is the transport sector, in particular, the automotive industry, where this material is used, among others, in the manufacture of composite structural elements, batteries, tyres and brake systems.

What if charging a car battery was as fast as refuelling? At the end of 2021, GAC AION is meant to start serial production of electric cars with accumulators based on graphene. What is different about them is that they can be charged in a dozen or so minutes. The range of the car on a full accumulator is meant to be 1,000 km. The manufacturer claims that the time taken to charge the accumulator can be compared with the time it takes to refuel a vehicle with an internal combustion engine, and that the accumulator will provide the vehicle with a mileage of up to one million kilometres. The basic version will enable charging the car up to 80% in 16 minutes, and to 30% in 10 minutes. The upgraded version will halve these times (80% in 8 minutes and 30% in 5 minutes). However, such rapid charging will require stronger chargers (even 500 kW)[13].

Fuel cells

During the transformation, Poland looked for its chance in carbon fuel cells. Already 11 years ago, an industrial and scientific consortium was set up – it was meant to implement the "Carbon fuel cell" programme. The main assumption was to build a prototype of a carbon fuel cell that, for example, in a car, instead of a fuel-consuming engine, would generate electricity[14].

Carbon-based fuels can power cells in two ways: indirectly and directly. In the former, carbon is gasified and synthesis gas is obtained, containing mainly H2 and CO, is further processed – as a result of the reaction between water

vapour and CO, it is enriched with additional amounts of H2. Such a gas can be used to power fuel cells adapted to hydrogen fuel. In the latter case, solid carbon is introduced directly into the cell, and there undergoes electrode reactions[15].

However, the question of whether this is a direction in which the manufacture of fuel cells will go remains open. The Institute of Power Engineering – Research Institute – is of the opinion that fuel cell technology is one of the most promising future energy generation technologies. The efficiency of fuel cells significantly exceeds other types of energy conversion – depending on the type of fuel, the electrical efficiency of a typical cell is 40–60%, and complete efficiency can reach 80–90%.

Treatment

Carbon can also play a significant role in industrial processes using water to treat waste using activated carbon filters. These technologies are available in the form of mobile filters and are used where water contamination from production prevents it from being disposed of in sewage. Importantly, solutions in this area are also used in plants that must manage rainwater falling on industrial sites or landfills.

Carbon filters are used, for example, in the petrochemical industry. These technologies are also found in applications in composting plants, waste sorting plants, food processing plants, the plastics industry and the pharmaceutical industry.

The last sector is one in which carbon filters are particularly important tools for the reduction of contaminants. This is because during the production of pharmaceuticals, wastewater is released that contains, for example, adsorbable organic halides, which are particularly hazardous to human life, health and the environment. Regulations regarding the concentration of this type of substance are very stringent due to the potential harms that these compounds can cause.

Carbon filters are able to reduce the concentration of adsorbable organic halides to almost zero, at the same time removing the risk associated with these substances. Activated carbon is obtained mainly from peat, wood, lignite and bituminous coal. It is worth noting that the use of activated carbons in the treatment process is also beneficial from a logistics point of view. The use of such agents creates high-density, low-water-content deposits. Thanks to this, the filtride is easy to remove, and in some cases can be dehydrated, dried, roasted and used for further industrial work.

In addition to the filtration of sewage, we should also mention the applications of activated carbon in the absorption of gases. Carbon used in this way can be applied in, e.g. gas masks, as well as in filters and air conditioners. Activated carbon is widely used in air purifiers, mainly combined with a HEPA filter.

A carbon sponge for waste can also be created using nanotubes. Italian scientists presented such a structure made of carbon nanotubes with the addition of sulphur. Industrial, agrarian and municipal residues and waste combined with watergenerate sewage that contributes to the pollutionof natural water sources. It is increasingly difficult to find water that does not contain an increased amount of aromatic hydrocarbons, which bioaccumulate in living organisms in the liver, brain, kidneys and heart, and have a toxic effect on the nervous system.

Fuel and oil spills released during bottom drilling, failure of ships and pipelines, and the rinsing of tanks are also significant contributors to water pollution. Due to their large specific surface area, high mechanical strength and absorption properties, nanotubes are considered excellent candidates

for wastewater treatment. One such candidate is a carbon sponge[16].

Carbon in medicine

Activated carbon also has medical applications. It is used widely as a medicinal product for diarrhoea, indigestion and poisoning – all thanks to its properties of removing bacteria and toxins through absorption of compounds from solutions. In recent years, many oral hygiene products containing this raw material have appeared. Carbon also works well as a substance that reduces the effects of irradiation in the body. Scientists are also continuing work on the application of nanostructured carbon materials for medical purposes. The experiments involve, for example, placing anti-cancer drugs in the above-mentioned carbon nanotubes and the use of nanoparticles as a marker in biological tests. Surgical reconstruction uses lightweight and durable carbon fibres, for example, for implants as connecting elements, for reconstruction of the bone structure and in endoprostheses.

Construction

Thanks to its low mass, high mechanical strength and exceptional durability, carbon has also found applications in construction. In this sector, composite materials mainly made up of carbon fibres have proven successful. They are not only extremely strong and lightweight, but also have shaping plasticity and are resistant to corrosion. They are mainly used to strengthen structures and reinforce edges. These materials are also utilised to protect buildings against beyond-design-basis events, e.g. earthquakes.

Not many people know that one of the main sources of the world's CO2 emissions is the production of concrete. It is responsible for approximately 8% of the global emissions of this greenhouse gas. If concrete was a country, it would be third in terms of CO2 emissions, just behind China and the US. Using the properties of carbon, scientists have developed graphene concrete. According to estimates, its global use would result in a 2% reduction in global CO2 emissions, not including the carbon footprint from the transport of concrete.

The first building built using enhanced concrete – a gym – is in Great Britain. During construction, 30% less of the raw material was used, and reinforced concrete was not required. Froma Nationwide Engineering, which erected the building, has a framework agreement with National Rail (a network of passenger rail connections in England, Wales and Scotland) and can potentially implement the so-called HS2 (Britain's high-speed railway project). It will need approximately 20 million tonnes of concrete. Just this one infrastructure project will be responsible for 1.4% of Great Britain's annual CO2 emissions. The implementation of just this project using graphene concrete will reduce CO2 emissions by 1.5 million tonnes[17].

Carbon's desirable properties also include chemical stability, which contributes to high resistance to temperatures and impermeability to gases, including oxygen. The use of this element allows us to obtain materials that are resistant to rust and corrosion. They can be applied in primer and different types of metal protection paints. The Łukasiewicz Institute for Engineering of Polymer Materials and Dyes in Toruń has developed super-paints and super-primers of very high strength that will be able to protect metals for up to a quarter of a century and work in highly corrosive environments, including marine environments. This manufacturing process uses, among others, graphene oxide and carbon nanotubes, which allow

reduced use of zinc, which is a typical primer ingredient (zinc is harmful to living organisms). The scientists have already seen interest from the market, but their product will be highly specialised[18].

The future: advanced material technologies

The long-term burning of fossil fuels has significantly contributed to global warming associated with climate change. Poland is a signatory to the 2015 Paris Agreement, which assumes the stopping of global warming, and is also a member of the European Union, which declares climate neutrality by 2050. The perspective of the European Green Deal and the ongoing energy transition of Poland greatly changes our approach to carbon.

The future of carbon is related to its use as a building block for materials of the future, and not its energy application.

Carbon cells? Graphene? Fuel production? Carbon nanotubes? As part of the 3W idea, we look to the future of carbon not in the form of coal for fuel, but as an element.

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Carbon is not just a fossil rock – it is also diamonds, graphite, carbon black, fullerene, carbon nanotubes and, finally, graphene. A carbon-carbon bond is extremely strong and stable. This ability allows carbon to create an almost infinite number of compounds. There are also endless carbon applications.

Of course, there is a lot of money to be made on carbon – proportionately to the advancement of the given product. Just like with silicon you can sell sand or chips, and there are silicon monocrystals, silicon wafers and transistors as well, it is similar with carbon. However, to be able to make money on it, you must be the best at selling products that are the most advanced, and after being transformed into a ready product, go directly to the consumer.

The team I head has developed a series of composite materials containing graphene for printed electronics. Our start-up has developed or is developing different types of single-use ECG electrodes, including electrodes for monitoring the heart rate when the chest is opened, electrodes for stimulating the work of the brain (together with the Leibniz Association in Germany), pressure sensors for shoe insoles to monitor the distribution of pressure on the foot for orthopaedic treatment, pH sensors for monitoring the condition of wounds, infrared heaters printed on foil or fabric (e.g. on an image), T-shirts monitoring human physiological parameters, electronic tattoos, etc. Everything is done using printing techniques, and so it is cheap and usually single use. Let us remember that these actions need investment support, and then need to be commercialised.

At the current stage of our research, at the moment we are ahead of world leaders, but this distance is closing. Groups such as ours need support from individual managers who will help us search for investors, get through the complicated certification process, find a place for production, etc. In addition, this is an opportunity for the printing industry, which is currently in stagnation due t o the development of the internet. It could produce and sell our products.

The road to the development of economic sectors based on carbon should focus on searching for and creating conditions for the production of the most advanced forms of carbon (e.g. carbon nanotubes or graphene), and then seeking market niches for products based on carbon forms or compounds.

prof. dr hab. inż. Krzysztof Stańczyk

Central Mining Institute, Clean Coal Technology Centre

Currently, the production of graphene, nanotubes, fullerenes and fuel for carbon cells does not use bituminous coal, but other substrates containing carbon. Research is being conducted on producing these attractive products from pitch, which is created during the process of coking coal, but it has not yet reached the commercial stage. The diverse and continually increasing use of carbon materials in contemporary techniques and environmental protection results from the huge possibilities in forming systems with extremely different characteristics – from porous materials exhibiting an unprecedented development of the internal surface to construction materials with unique physical and mechanical properties. Bituminous coal and lignite are already traditionally used as raw materials in the production of activated carbons, and their share in the production of activated carbons is approximately 40%. In Poland, carbochemistry was already being developed in the 1980s. I think that work on carbon materials or various types of carbon and polymer composites are attractive and have a future. However, they should be confused with commodity use of bituminous coal or lignite.

At the Clean Coal Technology Centre of the Central Mining Institute, we are currently looking into issues that are part of the policy of the European Green Deal. We are conducting research on hydrothermal liquefaction of cellulose biomass, sewage sludge, as well as lignite.

These studies are aimed at developing a technology to produce bio-oil and biochemicals. In this respect, we are implementing the European project "Direct hydrothermal catalytic conversion of biomass and lignite to liquid fuels and chemicals", which we are coordinating. We are also conducting research on the cogasification of coal and wood biomass to produce hydrogen.

Other issues we are looking into are related to the production of carbon sorbents for the remediation of polluted waters. And this is where we are implementing another European project – "Strategies for the purification of water generated in the process of underground coal gasification and other processes, based on carbon sorbents and bioremediation." In addition, we are participating in two projects aimed at capturing and storing carbon dioxide, i.e. "Strategic planning at the level of regions and areas of Europe supporting low-emission energy generation and low-emission industry through CCUS (CCUS-H2020 STRATEGY) and CO2 Geological Pilots in Strategic Territories — PilotSTRATEGY – H2020.

3W Idea

A space for collaboration between society, science, business and administration.

Today, we understand that development cannot occur at the cost of future generations.

That is why in the coming years and decades, there will be huge changes related primarily to the transition of the economy to zero emissions.

The 3W initiative, which is undertaken by BGK, development of technology in the areas of water, hydrogen and carbon. We will facilitate the flow of information between business, science, administration and society.

We will shape consumer attitudes, gather valuable knowledge and create tools to help implement 3W projects.

3W is starting out as an idea, but within the next several years, it will become a rapidly growing branch of the economy.

BGK is taking on the role of the project initiator and integrator – a link between different environments – to work towards the sustainable development of Poland.

3W • WODA • WODÓR • WĘGIEL

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