MINISTRY OF ENERGY

eIN
Innovations for Energy

DIRECTIONS OF ENERGY INNOVATION DEVELOPMENT

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Energy
THE FIELD OF BREAKTHROUGH CHANGE

For several years, the energy sector has been subject to constant influence of technological and business trends, which cause its ever faster and deeper transformation. On the one hand, an increasingly central role in shaping its future is played by environmental and climatic conditions, and technological breakthroughs change competitiveness of many industry branches, and modify the map of global dependence on raw materials. On the other hand, the rapid increase in use of solutions based on information and communication technologies is observed. Progressive evolution in the field of the Internet, telecommunications and digitalization gives the end user the tools enabling him to play new roles in the field of production and optimization of energy consumption. The growing popularity of alternative fuels calls into question the undisputed supremacy of hydrocarbons in the transport sector. Political and social aspirations, and regulatory models compound on it, changing the traditional model of functioning of energy companies.

Main trends affecting the energy industry in recent years

1. The pressure to reduce the impact of the energy sector on environment
2. Emphasis on reducing greenhouse gas emissions and shift from carbon-based manufacturing technologies
3. Increasing social and environmental awareness
4. Development of technologies for production of energy from renewable sources
5. Constant improvement of grid energy storage
6. The growing potential of digital economy and the field of applications of information and communications technologies (ICT)
7. A breakthrough in hydrocarbon exploration and production technologies
8. The formation of a global infrastructure and LNG sales market
9. The growing popularity and cost efficiency of alternative fuels
10. Structuring role of energy in international relations and geopolitis

The cumulative impact of these factors in coming years may lead to a structural breakthrough in functioning of energy enterprises, energy consumers and in their relations. The funds involved in current energy assets may lose their value at any time.

We are already observing dynamic changes on markets of raw materials, in which the combination of geopolitical events and technological changes results in increasing fluctuations in prices of oil, gas and coal. The growing discrepancy between wholesale and retail electricity prices in the European Union, escalated by growing subsidies, makes it difficult to start new investments in production. Without clear price signals, investments in production, transmission and distribution are becoming more and more difficult, especially in the situation of bigger social expectations regarding accessibility, flexibility of power supply and its price. In many countries of the European Union, energy companies systematically lose their value, which is one of the reasons for their reduction of investments. New regulatory and business models harm the traditional way of operation of energy companies, but there is no guarantee that they will be able to provide a stable energy supply. The influence as well as values are edging towards the end user.

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The trends described above pose serious challenges to the Polish energy sector. They result both from the historically shaped structure of the energy mix, in which fossil fuels play a key role, as well as from the relatively low level of innovation in the economy. In addition, the need for evolution in the energy sector is confronted with low tolerance to risk.

At the same time, however, **Poland has not only ambitions, but also scientific and technological potential to take advantage of emerging opportunities resulting from the described trends**. Effective participation in the global technological race in the energy sector requires specification of key areas, where real success is in line with the strategic interest of the state, and it leads to the highest added value for the domestic economy by increasing its competitiveness and innovation.

Therefore, in response to the evident global acceleration of changes in the field of energy, the Ministry of Energy has prepared a document entitled *Directions for Development of Energy Innovations*. Its aim is to stimulate innovation and direct actions towards key and the most productive areas while increasing domestic, technological and industrial potential. The speed of changes in the world demands constant updating of the adopted assumptions. The document will be subject to periodic evaluation within the scope of adopted assumptions and achieved results at intervals no greater than 3 years. The Ministry of Energy conducts also constant monitoring of new technological, business and organizational trends in the energy sector. This will enable a quick response to the occurrent technological changes, and thus to pursuing an effective innovation policy.

A COHERENT IMPULSE FOR INNOVATION IN ENERGY

***Directions for Development of Energy Innovations* is a document defining a broad framework of innovative activity for the sector and its supporting institutions.** It allows to direct public spending to the most attractive and, concurrently, imperative challenges. It indicates to energy areas for potential synergies for companies. However, it is not an exhaustive document – the innovative activity, by its nature, requires the participants to be given the necessary flexibility. Its important complement is the framework of research and development activities for the sector, as well as research programs.

This program is designed to launch innovative processes in the Polish power industry, using public funds and involvement. It also gives a coherent impulse for innovative activity in the private sector. However, it cannot be a substitution for energy entities in making strategic choices or in allocating funds. Whenever it is necessary at the executive level, a clear division should be made, with regard to which activities and in which areas of research, development and innovation will be financed from public funds, and which should be taken over by enterprises. An important tool supporting this division is the private investor test. The evaluation of effects of spending funds and the need for public intervention should succeed at key moments, but not less frequently than at 2-3 years intervals. In particular, **it is important to activate the leading business entities operating in the Polish energy sector, and to increase their involvement, including the financial one, in research, development and implementation activities.**

Greater involvement of the business in giving an innovative impulse to the energy sector will also not be possible without the introduction **of rational mechanisms, i.e. based on reliable and feasibly advanced analyzes, limiting the risk aversion** in the decision-making bodies of companies. These are companies, which must prepare themselves in terms of **work culture, organization and procedures** for the **opportunity of implementing innovations**. Otherwise, the efforts of public administration and state agencies, established to promote innovation, will remain infertile – innovations will come into existence without their implementation and use for building the value of a particular enterprise.

Preparation of such solutions can be done with analytical work in the form **of a company's strategy in the field of research, development and innovation**, as well as an appropriate organizational and competence structure – **dedicating the innovation area to a member of the management body and putting emphasis on this topic by members of the supervisory body**.

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The model role of public administration in terms of use of innovative solutions is assumed. The task of administrative staff is to take a role of the promoter of best practices and, where possible, a role of the first customer. The public sector must set standards both in terms of technology and organization.

Directions for Development of Energy Innovations **serve to bring coherence and to correlate strategic documents at the level of government administration and state agencies** in the field of development policy and innovation in the energy sector. It will enable the effective use of existing resources and achievement of assumed economic and development goals, while providing an impulse to create regulations based on the most current assessment of trends and challenges for the sector.

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Goals
FOR DEVELOPMENT OF ENERGY INNOVATIONS

Directions for Development of Energy Innovations **have three main goals: to increase competitiveness of energy enterprises, to improve energy security and to maximize the benefits for the Polish economy, resulting from changes taking place in the energy sector.**

The Polish energy sector should increase its competitiveness by creating possibly the most attractive offer both in terms of energy price and its carriers, as well as technological and process advancement. Polish energy companies must be ready to compete with other companies from the European Union countries that have different production structures, frequently of a way bigger scale, and advanced business models based on modern technologies.

As the level of innovation at every stage of its production determines competitiveness of the final product, the Polish energy sector must be modernized in all parts of the value chain. Starting from extraction of raw materials through generating, transfer, distribution, sales, to managing energy consumption, it is necessary to constantly improve the technological level and to implement competitive business models, while optimizing the use of resources.

As a result, the cost of generating energy cannot burden Polish products, but it should give the Polish economy a competitive advantage. The share of energy costs in household budgets should be limited, contributing to the increase in disposable income and in the quality of life of Polish people.

In the context of growing pressure of environmental and energy-climate policy on conventional ways of generating energy, in particular on fossil fuels, ***Directions for Development of Energy Innovations*** **play a key role in the medium and long term in ensuring adequate share of technologies based on indigenous fossil fuels in energy production, and guaranteeing safety of the Polish energy sector**. It is necessary to maintain competitiveness of the national power generation potential, and to ensure access to strategic power raw materials and their derivative products at competitive prices. Concurrently, the dependence on imports of energy carriers and technologies should be limited. With the growing interdependence of European energy systems and in connection with the increasing overlap of information technologies on the work of these systems, it is necessary to ensure smooth operation and security of infrastructure of domestic energy systems, including the field of cybersecurity.

Investments in the energy sector, especially those of an innovative nature, can have a leverage effect for development of the entire economy, and they should be analyzed through the lens of **maximizing benefits for the Polish economy – not only in terms of standard economic parameters, but also from the perspective of their development potential for science and industry**. They can be an indispensable element of gaining a competitive advantage for Polish enterprises in various sectors. Between the energy sector and related sectors, such as chemical, ICT, transport and construction sectors, there are natural synergies and the use of which brings benefits for companies operating in these industries, and gives consumers new opportunities.

Therefore, the criterion for assessing adoption of innovations in the energy sector should be the **maximization of domestic added value, particularly related to opportunity of obtaining technologically advanced products and services**. Taking a chance on the right energy innovations can contribute to increasing the overall efficiency of the economy, including reduction of specific consumption of energy and other resources, e.g. water.

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Implementation of Directions for Development of Energy Innovation will lead to strengthening the synergy effect within the field of innovations between enterprises, public institutions and science.

Goals for development of energy innovations

a) Increasing competitiveness of the Polish energy sector
   i. Constant improvement of technological progress and quality of operation
   ii. Implementation of competitive organizational and business models
   iii. Optimization of use of resources

b) Improvement of energy security
   i. Maintaining the domestic potential of energy generation
   ii. Ensuring access to strategic energy resources and their derivatives
   iii. Reducing dependence on imports of energy carriers and technologies
   iv. Ensuring the smooth operation of national energy systems

c) Maximizing the benefits for the Polish economy resulting from changes in the energy sector
   i. The use of energy innovations for industrial development
   ii. Reduction of specific consumption of energy and raw materials
   iii. The exemplary role of the energy area in building an innovation ecosystem between enterprises, public institutions and science

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Segments OF DEVELOPMENT OF ENERGY INNOVATIONS AND SCENARIO ANALYSIS

To fulfill the goals that the Ministry of Energy sets itself in the *Directions for Development of Energy Innovations*, it is necessary to define the selected areas of activity. It is not possible to stimulate the development of all technologies and solutions, therefore, based on the analysis of potential of the Polish energy and industry sectors, global technological trends and local resources ensuring energy security and enabling competitiveness of the Polish energy sector, four main areas of energy innovation development are distinguished. They will be adapted in tandem with progress made and changing external conditions.

Areas of development of energy innovations

1. An integrated and connected energy system that gives a central role to the user of energy
2. Effective and flexible energy generation, and acquisition of raw materials combining the reduction of environmental impact with energy security
3. Diversification of generation technology and efficient use of energy
4. An eco-friendly and energy-efficient city

Four segments of development of energy innovations respond to different scenarios of changes in the energy sector in Poland and in the world. Regardless of the direction and intensity of changes that will occur, maintaining competitiveness of energy companies and guaranteeing energy security, while maximizing the positive impulse for the Polish economy, will remain the binding goals.

Examples of scenarios for development of technology and regulations for the power industry

The following are four exemplary scenarios for the development of technology and regulations, which may be subject to development of the Polish energy sector. They are the response to the future evolution of two selected trends:

- **pressure to increase the costs of environmental protection and to limit opportunities for development of energy industry, based on fossil fuels**
- **increasing the role of consumer in the energy system,** caused by the cumulative compound of reduction of cost of energy generated from alternative sources and increase of opportunities of ICT applications.

As a result of overlapping of these trends, the following scenarios of development of the power system are defined:

Centralized system based on conventional technologies	Centralized system based on low-emission technologies
Decentralized system based on cooperating clusters	Distributed system based on individual user installations

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1 AN INTEGRATED AND CONNECTED ENERGY SYSTEM IN WHICH THE MAIN ROLE IS PLAYED BY THE USER OF ENERGY

GOALS AND CHALLENGES

> The goal of the project is to launch a combined and intelligent energy network (ISE) in Poland by creating technical, organizational, legal and economic conditions for the functioning and development of a system based on ICT solutions which is to intergate: actions of generation processes participants and transmission, usage and distribution of energy. The combined energy network is supposed to supply energy in a reliable, safe and economic way, taking into account requirements that are to protect the environment.[1]

> Thanks to the intelligent ISE network system, the electricity consumer will get additional tools and operational options to optimize energy consumption and to generate electricity. An intelligent energy network should also support the increasingly widespread use of Internet of Things solutions enabling every facility in the real world to automatically exchange information with other objects via the Internet.[2]

> Due to its strategic importance for the security of the state, power engineering becomes one of the key targets for cybercriminals. **Ensuring the security of the ICT network** is also **a prerequisite for the functioning of a modern economy and launching a fully intelligent network. It is especially vital to ensure the safety of the systems that are widely used in the power industry,** such as SCADA (Supervisory Control And Data Acquisition) or PLC (Programmable Logic Controllers).

TOOLS

The process of building the ISE should include strictly correlated legislative, legal, organizational and technical activities. Therefore, the optimal form of its implementation will be a dedicated programme, that is – a coherently implemented and managed set of projects. The coordinated implementation of this programme will bring an additional benefit. The scale in which IoT solutions may be applied is huge and not yet fully identified. Therefore, it is necessary to undertake a number of activities exploring various business models, regulatory standards and technological solutions.

A special role is played by solutions that interact with energy systems such as smart home appliances, building automation or infrastructure components of "smart" cities. Among other countries of EU, Poland is a significant producer of equipment that falls into the above mentioned categories. According to the data collected by CECED in 2015, in the Polish household appliances sector there are approx. 23 thousand employees working in 27 factories. The factories produce annually about 22 million pieces of "large and small" household appliances, which accounts for nearly ¼ of EU production of appliances and places Poland in the first four largest European producers of home appliances. Therefore, the implementation of ISE in Poland will open up a wide field for the implementation of the Internet of Things solutions which will communicate with it, and may also be an important factor in building Poland's competitive advantage.[3]

The 'constructing a smart power grid' programme will consist, in particular, of the implementation of **the reference system of the Measurement Information Operator** that will act independently of the distribution system operators. At present, the main barrier

Activity area 1.1

The use of the information and communication technologies (ICT) in optimizing the functioning of the power grid and enabling the implementation of the Internet of Things, as well as the protection of energy transport networks (especially power grids) in terms of providing cyber security.

1) ang. **Smart power grid.**
2) ang. **Internet of Things – IoT.**
3) CECED – Conseil Europeen de la Construction d'Appareils Domestiques (ang. European Committee of Manufacturers of Domestic Equipment) is a committee of manufacturers of household appliances. This organization is combined of many national committees and big concerns that produce domestic equipment in EU.

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in building an ISE in Poland is the lack of a system enabling the collection and processing of information from all participants in the process, providing them with access to reference information on energy consumption and generation.

In order to make the functioning of the smart power grid system efficient and effective, including the operation of the Measurement Information Operator, it will be **necessary to create an organizational and legal framework and reconstruct the communication systems in the power industry**, including the launch of a modern special communication system enabling efficient handling of emergency situations (to facilitate in particular removing the effects of the so-called blackout), and the creation of a framework for effective and safe communication of people and devices in the intelligent power grid and implementation of IoT solutions

There will also be support for the implementation by the DSO of advanced measurement infrastructure (AMI). At present, there is no intelligent metering of all energy consumption points. DSO estimates that in order to reach the state of saturation with meters for remote reading of energy consumption measurement points in tariffs C and G (approximately 17 million points) at the level of 90.0%, we need at least 5-6 years.

It will be necessary to support work in the R & D area that is related to the creation of innovative technical solutions (eg new generation electricity meters) that ensure the functioning of an intelligent energy network and fully exploit the potential benefits of its implementation. It is vital to analyze, among others, activities related to the implementation of the dynamic tariff system, crystallization of the potential of ISE cooperation with dispersed energy and to the use of electricity in transport.

Due to the important role that the power system plays for the functioning of our country and its economy, **an important tasks will also be issues related to the implementation of cyber security solutions in the ISE**.

Energy sector entities should implement anti-attack systems and early warning systems. An important element of this plan is the development and implementation of **model solutions for power block automation systems and distribution grids control systems**.

The cyber security must include the security of control and measurement systems responsible, among others, for controlling energy systems, security of data transmission and storage. The institution responsible for all of the ISE's digital security should be one entity. Within the structures of this entity, there should function the CERT (Computer Emergency Response Team) and CSIRT (Computer Security Incident Response Team) teams.

In addition to cyber security itself, it is important that electrical power systems are characterized by safety understood as resilience to threats related to weather and other natural factors that may cause power outages. This type of threat can be minimized by a properly designed and used ISE system. Another threat is tracking the customer behavior and lifestyle by analyzing data. The way to minimize this threat is **to implement the right policy regarding the collection and exchange of all customer data. Customer data should be their property and should be stored under the administration of OIP using secure ICT solutions that are not based on the so-called public cloud computing.**

One of the important tasks which the energy sector faces is the training of stuff working at the interface between the ICT and energy sectors.

Activity area 1.2

Adapting power grids to be optimizing the user's Energy use.

GOALS AND CHALLENGES

- The aim of activities undertaken in this area is to provide the energy user (recipient) with the proper instruments to optimize their consumption (at the user level) and correlate consumption with the needs and capabilities of the power system.

- The important role is played by both the implementation of the necessary regulatory framework and the development of tools in the area of DSM (Demand Side Management) and DSR (Demand Side Response).

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TOOLS

DSM tools are a way to reduce demand, but only solutions in the field of DSR can introduce a fully active energy recipient, whose needs are correlated with the capabilities of the power The aim of activities undertaken in this area is to provide the energy user (recipient) with the proper instruments to optimize their consumption (at the user level) and correlate consumption with the needs and capabilities of the power systemsystem.

The key issue is to **increase the awareness and involvement of end users through affordable and intuitive services that allow monitoring the consumption of electricity and heat. Only at the second stage**, we shall decide on the implementation of comprehensive smart home solutions, mainly based on energy management. As the research shows, the mere provision of bilateral communication between the final consumer and household appliances does not induce the recipients to reduce or otherwise distribute the electricity consumption over time. **What is also needed here is education and financial incentives in the form of dynamic tariffs with a variable price during the day and throughout the year**. DSM should be developed jointly with the intelligent network and energy management systems in buildings (BMS) described in the "Ecological and economically efficient city" section.[4]

The development of DSR demand reduction services will be closely related to the implementation of functional solutions of the capacity market prepared by the Ministry of Energy. The power market creates conditions for the development of DSR services both through the participation of DSR in the processes of this market, as well as through the provision of DSR services to industrial customers in order to reduce their peak demand for power, and thus reduce the costs of the power market functioning.

The technologically neutral power market will create uniform competition conditions for all electricity generation technologies and the DSR mechanism, taking into account the degree to which individual technologies ensure the security of electricity supply. The capacity market rewards primarily those entities that provide power in periods of danger, i.e. periods in which there has been identified the risk of loss of continuity of supplies in the National Power System.

Activity area 1.3

Stability of transmission and distribution grids functioning

GOALS AND CHALLENGES

> The goal in this area is to improve the values of SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index), and thus to ensure stable energy supply.[5]

TOOLS

One of the basic tools (among innovations which lead to the increase of safety and operation of the transmission network and power grids) is the use of **failure detection, which separates and repairs failures** – FDIR (Fault Detection, Isolation & Restoration). It allows you to locate real-time network damage and its reconfiguration by isolating damaged sections and restoring voltage to recipients supplied from sections of lines not affected by damage. The most important element of this system is that it prevents failures from happenning and early detects them, isolating the failure site to ensure uninterrupted energy supplies to other recipients. The condition for achieving this status is remote monitoring of the most important devices and places in the network, which can be carried out, for example, with the use of drones. From these devices, the information is then collected and processed in remote monitoring centers.

Another tool is a **dynamic network load mechanism**. Modern measurement techniques using on-line sensor data and forecasting data are used for this purpose. To use this mechanism, it is necessary to introduce remote data transmission that allows their transmission in real time.

A regulatory tool that can be introduced to increase the safety and efficiency of energy supplies, motivating enterprises to invest in distribution, are **quality tariffs.**

4) **Building Management System.**

5) These indicators are the main indicators analyzed by Energy Regulatory Authority (ERA) while it verifies the quality of services offered by the network operator.

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2 EFFECTIVE AND FLEXIBLE ENERGY PRODUCTION AND USE OF RAW MATERIALS – COMBINING THE REDUCTION OF ENVIRONMENTAL IMPACT WITH ENERGY SECURITY

Activity area 2.1
Increasing the flexibility and efficiency of coal Energy production and alternative ways of using it

GOALS AND CHALLENGES

> The energy and climate package forces the Member States energy systems to undertake large-scale activities in the field of technological, regulatory and business innovation. In this context, maintaining the strategic importance of hard coal and lignite in the Polish raw material and energy balance, while reducing pollution from combustion and carbon dioxide emissions, requires **new coal technologies, which are highly effective, flexible and low-carbon. There is also a need for creating innovative business and regulatory models**. We shall consider, in particular, the adjustment of the Polish electricity production potential to multi-fuel combustion, using, among others, biomass and waste.

> The increase of the OZE share in the **power system makes it necessary to buster the flexibility** of power units.

> **The adjustment of conventional energy generation installations will also be more and more expensive** in the context of upcoming BREF-BAT standards.[6]

TOOLS

A key area of innovative activities is the **simultaneous improvement of the efficiency and flexibility of coal blocks**:

- We shall thoroughly analyze the **possibility of rebuilding of 200 MW** class blocks in biloblocks or supplying them with multi-fuel installations.
- It is necessary to **increase the flexibility in terms of fuels and working time of existing blocks.**
  Due to the challenging environmental standards, in particular BREF-BAT, there is a need for further development of the **denitrification, desulphurisation and mercury removal technologies**.
- An important element of the domestic energy sector development is to create also distributed systems for electricity and heat **generation in cogeneration, which activity requires support in the field of research and implementation**.

The development of coal technologies will be very difficult without new ways of managing CO_2. Technologies that reduce CO_2 emissions, such as carbon capture and geological storage, ie CCS technology, have proved to be very difficult to apply (at least at this stage). However, greater potential is recognized in the development of CO_2 processing technologies, in the management of this gas in carbochemistry and in the production of CO_2 fuels, including biofuels. Considering the above, it is advisable to develop CO_2 Capture and Utilization (CCU) technology.

One of the basic issues in developing the alternative use of coal in Poland is gasification. This allows for a multidirectional use of the resource – from high-efficiency electricity production to the production of chemical substances, including gaseous and liquid fuels.

In Polish conditions, the implementation of **large-scale coal gasification for the needs of chemical production and / or electric energy may be considered as an alternative**

6) BREF – Reference Document, BAT – Best Available Techniques.

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option for the use of coal. The technology mentioned above allows using the potential of the native raw material in the petrochemical area and in the production of materials such as ammonia, methanol and hydrogen.
Other areas of coal utilization in the field of gasification include **small-scale coal gasification (used to produce electricity and heat)** and **ground gasification (dedicated to low-carbon coals with high ash and moisture content)**.
It should be emphasized that Poland has not only its own hard and brown coal reserves, but also bears a significant scientific, research and technological potential in the field of new methods of using this raw material. Numerous universities, research institutes and analytical centers in Poland have large resources of knowledge and research potential that can contribute to the development of coal utilization technologies. **The global importance of coal provides a field for the development of knowledge and technology export on an international scale, especially as increasingly stringent environmental requirements in the energy sector will most likely also include the so-called developing countries.** The implementation of the Polish energy policy in the field of Clean Coal Technologies should take place with the full cooperation of the government, the scientific community and industry. This will allow to maintain a high level of energy security based on domestic fuels resources as well as to meet the requirements of the European Union's energy, climate and environmental package.

GOALS AND CHALLENGES

- Poland has an unused potential for methane extraction from coal seams. The exploitation of this potential can significantly contribute to increasing work safety in mining.
- Increasing the use of available deposits in Poland from conventional and unconventional deposits will allow for increased energy security and improved competitiveness of the sector.
- Geothermal deposits are a significant, and yet unused, source of energy.

TOOLS

Removing the methane from the coal seams on the surface is an opportunity to increase the safety of miners working underground, and at the same time for direct recovery of methane for commercial purposes. The methane balance resources in Polish coal seams are estimated at **85 billion m^3**. For comparison, documented reserves of natural gas in Polish classical deposits currently amount to 134 billion m^3. In Poland, methane is captured from coal seams during mining operations in the methane drainage process, so-called Coal Mine Methane (CMM) – in this way, 275 million m^3 of methane is obtained annually.
It is worth noting that, although hard coal production is declining, the release of mine methane is in an upward trend – **exploitation takes place deeper and deeper in the seams, which is associated with a larger amount of CH4 released from the deposits**. Considering that about 80% of hard coal resources in Poland is found in methane deposits, as well as the fact that the greenhouse effect of methane is 21 times higher than CO_2, it should be noted that skilful inclusion of methane in the transformation of the energy sector can make this gas an important raw material in the Polish energy mix, at the same time contributing to a significant reduction of greenhouse gas emissions in our country.
The energetic use of methane is an example of activity which is not only environmentally, but also economically (methane's heating value is more than twice as high as coal) and socially (improving the safety of miners) beneficial. The use of methane requires cooperation between various entities in the energy sector, which is why ME supports the involvement of Polish institutions and companies within the framework of the International Center for Methane Coal Improvement operating under the patronage of the United

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Nations Organization. At the same time, ME will take action to launch research and implementation projects in the field of methane development. These projects will be prepared by the Ministry of Energy together with interested entities.

Another prospective resource that can be used alternatively to coal and natural gas extracted in a conventional manner is a **tight gas**, present in concise, poorly permeable sandstones. According to the estimates of the Polish Geological Survey, its resources in Poland amount to 1.5-1.9 billion m^3 (based on the analyzed geological complexes in the following regions: Poznań-Kalisz, Wielkopolska and Silesia in the western part of the Baltic Basin). Another area is the **development of small gas deposits (often low calorific) containing hydrogen sulfide, without the need to build costly installations for gas treatment and transmission**.

What will also change in the coming years is the use of crude oil. The drop in the share of crude oil in the structures of primary energy use and the limitation of attractiveness as fuel fuel forces the refining industry to look for new market niches. These include, among others, the production and manufacture of additives for 2nd and 3rd generation fuels and the production of modern fuels, biodegradable lubricants, safe lubricants and operating fluids for mining, production of petrochemicals and specialized chemistry. A very important area is also the development of technologies limiting the impact of the refining industry on the environment, which may become a key determinant of the functioning of this sector in the future.

An important issue (from the perspective of the mining industry) is **the management of post-production waste, mainly coal sludge and the production of improved coal fuels, e.g. blue carbon or biocarbon**.

An important source of energy to be used is **geothermal** energy. It is a clean and environmentally friendly source that can solve the problem of air pollution in Polish cities which results from the use of inefficient individual heat sources. The use of **geothermal sources ensures the achievement of a health and environmental air without deteriorating Poland's energy security**.

Activity area 2.3

Improvement of exploration and production technologies of hydrocarbon

GOALS AND CHALLENGES

> Supporting the potential and knowledge of Polish companies in the field of hydrocarbon exploration and production in Poland and abroad will increase their competitiveness and increase the possibilities of obtaining raw materials by:

- more and more precise determination of areas of occurrence deposits of raw materials giving the greatest prospect of their economic development;
- improvement of deposit extraction indices (extraction factor);
- lowering the costs of extraction.

TOOLS

The use of domestic raw materials also means the development of modern mining and drilling technologies. Due to the shale revolution in North America, diagnostic technologies and modeling of deposits have developed strongly. In Poland, support for mining technologies in the oil and gas sector remains an important element of the research agenda in the energy sector, especially in the context of valorizing already invested funds in the development of exploration and exploitation technologies of hydrocarbons from shale formations. It will be important to support the development of directional drilling technology and controlled horizontal drilling, seismographic imaging technology and intelligent reservoir monitoring.

The improvement of the mining process – thanks to, among others, the automation of mining processes (ultimately in the so-called smart mine model) – will allow not only to reduce mining costs, but also to develop the existing mining sector for which global markets are the natural area of operation.

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3 DIVERSIFICATION OF ENERGY PRODUCTION AND USE TECHNOLOGIES

GOALS AND CHALLENGES

The expected gradual massification of electric vehicles in the world is a chance to gain a number of benefits for Poles and the Polish economy. These benefits include:

- the possibility of building a modern production branch;
- reduction of pollutant emissions in the transport sector through the introduction of low– and zero-emission transport, which results in a reduction of low emissions in cities and improvement of air quality;
- reduction of dependence on hydrocarbon imports;
- stabilization of the power grid by integrating vehicles with the network, reducing the so-called 'the night valley', and developing and implementing energy storage technologies;
- promoting Poland as a country of innovation and economic success.

TOOLS

It is essential to create an electromobility ecosystem, which will include manufacturers, users of vehicles and the energy sector that provides services for electromobility. This requires action on several levels – from raising the awareness of potential users by introducing a system of benefits for the user of an electric vehicle, stimulating the development of producers in the electromobility segment, creating regulations that determine the development of electromobility to the adaptation of energy networks to the needs of vehicles.

In order to take these challenges, the Ministry of Energy created a **Package for Clean Transport**, which includes the Electromobility Development Plan that creates conditions for the development of vehicles powered by electricity; the national framework for alternative fuels infrastructure development policy indicating the objectives and tools for the development of infrastructure necessary for using vehicles for alternative fuels and the Act establishing the Low-Emission Transport Fund, which aim is to support the development of alternative fuels infrastructure, as well as creating a vehicle market for these fuels.

Basing on the previous works, there was prepared a **draft bill on electromobility and other alternative fuels**, which is a response to the identified barriers in the development of electromobility in Poland. Defining the charging service, defining technical standards for the infrastructure and implementing a support package for electric vehicle users will allow to create a market framework and create an expectation of demand in the future. This, in turn, will contribute to the development of industrial entities operating in the area of electric vehicles and accompanying infrastructure.

An important tool for the development of electromobility will be the use of public funds in this area – in addition to the establishment of the Low-Carbon Transport Fund, research programs at NCRD dedicated to electromobility will play an important role and the creation of a program supporting the demand for electric vehicles under the NFEPWM. At the same time, the role of the National Fund may be to build awareness of future consumers of electric vehicles by launching pilot projects.

Activity area 3.1

Popularization of electric transport, development of electromobility industry and transition to a flexible energy network using energy storage systems

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What is essential for the success of the whole undertaking is to **define the role of the energy** sector in the process. The growing share of electric vehicles not only raises the challenge of covering the increased demand for electricity, but also constitutes a strong impulse for technological change that will affect the overall condition of the entire sector. The development of intelligent networks, energy storage networks or V2G (Vehicle-to-Grid) technology can become a lever that guarantees better adjustment of the energy companies' offer to the customer's needs, and consequently their competitive position on the energy market.

The development and implementation of energy storage technologies, including those that use the potential of electric vehicles, seems to be crucial for ensuring the positive impact of electromobility on the electricity grid. This network, due to the growing share of generation from renewable sources and difficulties in ensuring the receipt of energy from a stable generation in the base of the system for a similar amount of time, will have to maintain its efficiency and increase its flexibility at the same time. The scale of work in the world on energy storage technologies and the number of problems that this technology can solve in the future power system clearly indicate that there is a need to intensify research activities in Poland.

From this perspective, it is important to create synergies between the enterprises' activities, to reduce the costs associated with working on new solutions, and then ensure their implementation on an appropriate scale. An important tool for these joint efforts may be a special purpose vehicle dedicated to the development of electromobility or a private equity fund to develop projects of a horizontal nature.

If electrification is not technically possible or economically efficient in a given transport segment, the development of CNG / LNG vehicles and the related industry will be supported. In order to fully implement the above-mentioned objectives, in the Ministry of Energy there was established the **Steering Committee of the Electromobility Program. It coordinates activities in this area at the level of the whole government and it is the leading center in the field of electromobility**.

Activity area 3.2

"Polish nuclear power program" and high-temperature reactor (HTR) construction project

GOALS AND CHALLENGES

- Poland's involvement in the nuclear power plant construction project will be strengthened by the expansion of Polish research and industrial potential in the area of nuclear technologies.
- Construction of high-power nuclear power plants can increase the innovation of domestic industry by implementing special technological regimes in industrial production and operation of equipment.
- Creating the first high-temperature research HTR reactor of low power will create the foundations for the construction of a larger model supplying chemical plants with process heat.[7]
- Technological cooperation with countries that have developed reactor technology should support the construction of research and industrial potential in Poland which will enable us to construct and operate an HTR type reactor.

TOOLS

The experience of countries with nuclear power indicates that the construction and operation of nuclear power plants requires a well-developed domestic industry, especially in such sectors as the broadly defined heavy engineering, the electrotechnology and electronics, the chemical industry and related sectors. The construction of nuclear energy units will contribute to **the transfer of modern (new to Polish enterprises) technologies, and thus to a significant increase in the level of competence of some Polish enterprises**.

7) **High Temperature Reactors.**

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Supporting production processes for the nuclear sector through supporting investment processes (e.g. construction of new production capacity, improvement of existing production processes, support of the certification process and accreditation of production and management processes proper for the nuclear power industry) will be the most valuable for the Polish economy. The implementation of the "Polish Nuclear Power Programme" (including export possibilities) can be used to improve the level of competence and innovation of domestic enterprises.

For the efficient and safe operation of nuclear power plants it is also necessary to create our own research and technical facilities. Moreover, our own expert base is necessary to select the most optimal technology for the country and to determine the best specific solutions.

In almost all countries the research and technical facilities are based both on the own resources of nuclear power plant operators (research and development units operating within the structures of enterprises), as well as on laboratories with research nuclear reactors, hot cells and other advanced research equipment. In Poland, the National Centre for Nuclear Research (approx. 1100 people) together with the Central Laboratory for Radiological Protection (approx. 50 people) and the Institute of Nuclear Chemistry and Technology (~approx. 250 people) are prepared for such a role. Competences in the field of nuclear fusion are complemented by the Institute of Plasma Physics and Laser Microfusion (approx. 50 people). The NCNR's technical capabilities and competences also result in the research and export of radioisotopes to 80 countries for the benefit of over 2 million patients per year.

The currently implemented "Polish Nuclear Power Programme" also constitutes an opportunity for the development of new technologies, through associated research and development projects. As in the case of Great Britain, such projects should be of a dual purpose. On the one hand, it is a response to future power demand, and on the other hand, an activity aimed at the development of native competences, technologies and products.

The studies of the Sustainable Nuclear Energy Technology Platform (SNETP), which brings together the largest manufacturers and research institutions in Europe, have shown that **the most promising technology in the range exceeding 500 °C are the so-called high temperature reactors (HTRs)**. About a dozen research and industrial HTRs have been built in the world. So there are no major technological barriers.

The HTR should be constructed at chemical plants and fed them directly into the process heat (the largest heat consumers are refineries and other chemical plants). The HTR provides the investor with security in terms of heat supply and predictability of costs. Benefits on the national scale include: reducing the dependence on gas imports, reducing CO_2 emissions, acquiring new technologies and increasing the technological level of Polish sub-assemblies suppliers, exporting these sub-assemblies and helium to HTRs in other countries. The best way to reduce the risks associated with the HTR project is to construct a low-power research HTR. The next step in meeting the heat demand of the industry is to undertake research activities in the temperature range above 1000 °C. It is particularly important due to the production of hydrogen and hydrogen-based fuels. The development of HTRs into the so-called VHTRs (Very High Temperature Reactors) may evolve in this direction. To achieve this goal, **a Team for HTRs was established at the Ministry of Energy.**

GOALS AND CHALLENGES

Activity area 3.3

Support for the energy part of the circular economy (CE)

- The aim of the activities is **to increase power recovery from waste, especially in the combined production of electricity and heat**. It should be noted in this context that waste is a substitute fuel for fossil fuels.

- Using a closed circuit makes it possible to preserve the usability of products and materials on the market so as to reduce the need to acquire new resources, including due to the re-use of previously processed materials. Consequently, this leads to

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a reduction in the amount of generated waste while maintaining the desired level of production, reducing the dependence on the import of raw materials as well as limiting the impact on the environment. In professional and industrial power engineering, the issue of using the so-called by-products of combustion is essential as well.

TOOLS

On the side of enterprises and entities generating waste, one must focus on **the development of technologies and organizational tools that will enable obtaining waste that are better suited for thermal transformation (process changes at the production stage)**. These changes, however, concern not only the production process itself, but also the way of temporary waste storage, its transport and establishing cooperation between enterprises within the so-called new business models.

The existing experience of entities in the field of technology development should be used, e.g. in the area of processing of mixed municipal waste, use of municipal sewage sludge, thermal treatment of hazardous waste, including medical waste, biomass incineration / co-incineration, and disposal of waste in cement plants.

A circular economy in the power sector is a natural area of synergy between technologies and sectors – effective waste management is usually associated with the reduction of pollutant emissions resulting from the production of electricity and heat, as well as from transportation. Therefore, **a "self-sufficient city"**, that meets its power needs through energy produced from waste (e.g. electricity generated from waste, gas fuel for urban transport coming from a sewage treatment plant), should be an important project within the circular economy.

An important tool in terms of use of waste in the power sector is processing of local municipal waste (including sewage sludge) and industrial waste into synthetic gas with an average calorific value and into a carbon residue in a solid form. The aforementioned technological process can be supplemented with a module for producing electricity and heat (CHP) from from synthesis gas or a module for producing gaseous / liquid fuels or chemical products. Heat from the waste generated in the process can be used in heating systems. The carbonaceous residue produced in the process is suitable for many applications, e.g. for improvement of soil properties, for fillers in the rubber and plastics industry. The use of mixed waste without the need for expensive sorting and preparation is an advantage.

Support is also required for **multi-fuel systems using waste,** e.g. RDF or systems to recover heat from steam. Support for the development of technologies for the production of electricity and heat from waste can take place, e.g. by introducing the so-called "Heat From Waste Certificates". Such a solution is in line with the idea of a circular economy, meaning that it not only reduces the amount of generated waste, but also, primarily, rewards its recycling and use for power purposes.

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4 AN ECO-FRIENDLY AND ENERGY-EFFICIENT CITY

Activity area 4.1
Modernization of individual heat sources

GOALS AND CHALLENGES

> The aim is to significantly **improve air quality in Poland** achieved by eliminating low-quality combustion sources used in households that use low-grade fuels, and economic optimization of the policy in the field of heat production and distribution.

> In particular, the exchange and modernization of individual sources, the increase in the use of fuels with high calorific value and the introduction of alternative methods of individual heating will contribute to the reduction of low emissions.

TOOLS

The first step towards lowering the level of pollution emitted by individual heat sources is the **introduction of emission standards for solid fuel boilers with a capacity of up to 0.5 MW, regulating the problem of burning coal and other waste as well as installing individual filters on the chimneys of houses**. The introduction of modern types of fuels based on the blue coal (blue fuel) or mixtures with biomass (biochar) should be promoted.
The distribution of heat pumps will also be a future solution.
Environmental policy should be related to industrial policy – Poland is the largest manufacturer of solid fuel boilers in the EU, including class V (low-emission) boilers, while not being a significant manufacturer of gas boilers.

Activity area 4.2
Development of co-generation and heat / cold transfer networks

GOALS AND CHALLENGES

> Reduction in the primary energy consumption in the balance of a particular system, as well as of the entire country.

> Better use of produced electricity and heat, allowing to achieve environmental goals and increase the system economics while providing the customers with electricity and heat / cold.

TOOLS

Cogeneration is the most environmentally effective way of using fossil fuels. Therefore, **Poland should follow the example of countries such as Denmark, the Netherlands and Finland, increasing the share of cogeneration while taking care of the development of the domestic technologies in this area.**
The innovative potential applies especially to developing the electric and thermal energy technology (as well as network cold and cold from network heating), combined with gas and liquid fuel technologies, using the methods of fermentation or gasification of biomass, agricultural, animal, communal, sewage and other types of waste, which are low cost or virtually cost-free materials. The needs of the new solutions are related to i.a. cogeneration plants combined with biofuel production systems for local communities' or housing estates' energy centres, small installations including a cogeneration complex based on a multi-fuel pot and an ORC system, cogeneration installations for biomass processing plants with a gas generator, an internal combustion engine fuelled by syngas and providing heat recovery from syngas and exhaust fumes for drying biomass, using waste heat from the ORC plants as useful heat (heating pipes) and production of cold (chilled water systems and optionally – process cold for gastronomy), a multi-fuel polygeneration system with a power of 1-10 MW (in the fuel) as an element of dispersed energetics, for

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customers with the constant heating need or communities/cities having poorly developed heating network.

The development of the heating network combined with the elimination of individual heating sources should guarantee conformity with the provisions of the article 7b of the Energetic Law, according to which a building with the power not lower than 50 kW must be connected to the heating network, except for cases when an energy supplier refuses connecting because of its unprofitability. **Appropriate mechanisms of financial support of the heating network development may change the economic calculation of network investments, supporting the fulfilment of the environmental goals at the same time.**

It is also advisable to support the development of innovative technologies of producing cold from network heating (absorption refrigerators, installations in buildings) and creating appropriate mechanisms of commercialising this solution, which, apart from supporting the electroenergetic network on hot days and facilitating the work of cogeneration units in summer, will also support a change in the economic effectiveness of the heating network investment.

An important project with huge environmental importance is also the replacement of gas and electric water heaters with the usage of domestic hot water provided by network heating. The system support of such solutions should include both heating suppliers (in matters of heating pipes development) and end users who, as the result of changing the method of providing domestic hot water, have to design and install the system in their objects, what is a significant cost. Apart from environmental and economic factors, it would also positively influence the level of users' safety.

Activity area 4.3
Decreasing of the energy consumption of buildings

GOALS AND CHALLENGES

- Decreasing the energy consumption of buildings by introducing energetic standards for construction materials and whole buildings, combined with development of the Polish energy-saving construction materials production industry.
- Introducing innovative business models and instruments motivating users to benefit from the potential of increasing the energetic effectiveness of buildings.

TOOLS

Buildings use 40% of the total energy used in the European Union. Therefore, energetic standards for buildings and materials and their heightening in next years will be crucial for the dynamic development of energy saving construction and the whole construction industry. Requirements related to energy efficiency are imposed on Poland by the provisions of the EPD and EE Directives (for the public administration buildings), which introduce rules of so-called eco-design. The construction sector should become virtually zero-energetic, namely it should minimise the needs of heating. It is assumed **that the highest potential and executional challenge for the EU in matters of improving energetic effectiveness of buildings is the sector of building renovation**.

Currently the Polish legislation indicates the obligatory values of the isolation factors and the regulations have been complemented with new, stricter sets of obligations. The above mentioned ambitious requirements will enter into force respectively in 2017 and then in 2021. It will be the target level resulting from the fulfilling by Poland (as a European Union member state) **the requirement of designing and constructing new buildings as so-called zero-energetic or nearly zero-energetic**.

Solutions such as Building Management System (BMS) will help optimise energy consumption in buildings. The easiest solution provided by BMS is the system facilitating passive unidirectional communication, which enables the user to read the current electric energy consumption value, to predict the sum of the bill and to desegregate the meter data in order to indicate the most energy-consuming devices. These solutions are relatively low-cost and have been tested in many countries. They increase the involvement of an end user and

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improve the energetic effectiveness of a household. In this case communication is provided by Wi-Fi or a cell phone network. The second type are more advanced BEMS (Building Energy Management Systems) class solutions. They enable bilateral communication with domestic devices via a domestic PLC network or wireless communication (ZigBee, Z-Wave, Bluetooth etc.). Systems of this class are more expensive but they provide a user with remote control of energy consumption.

Developed BMS as a comprehensive system of managing both energy and the user's comfort (heat, sold, water etc.) is complex and expensive in terms of installation and use. Therefore, it is used mostly in big buildings, especially offices, which are managed by professional suppliers and where the cost of the system control can be balanced by potential benefits. As the previous experience has shown, the barriers of this system's development are its price and the cost of use. A high cost of installation and then the necessity of long-term data integration and setting the whole system in order to obtain the parameters planned in the beginning, what may take even over a year, raise the cost of use. Therefore, it is necessary to develop solutions which will be **integrated with a building as much as possible, and will facilitate actions of a user, also by the means of automation**. It is going to be important to develop technologies enabling more and more effective collection and processing of information. It will lower the threshold of profitability and extend the range of buildings using such systems.

The objective is construction of energy-saving and intelligent houses, whose as many elements as possible are designed and manufactured in Poland. This task, leading to commercial integration of various technologies, could be the subject of a grant facilitated by institutions financing the development of Polish science and implementation of research results.

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Prime

MOVERS OF THE DEVELOPMENT OF ENERGETIC INNOVATIONS

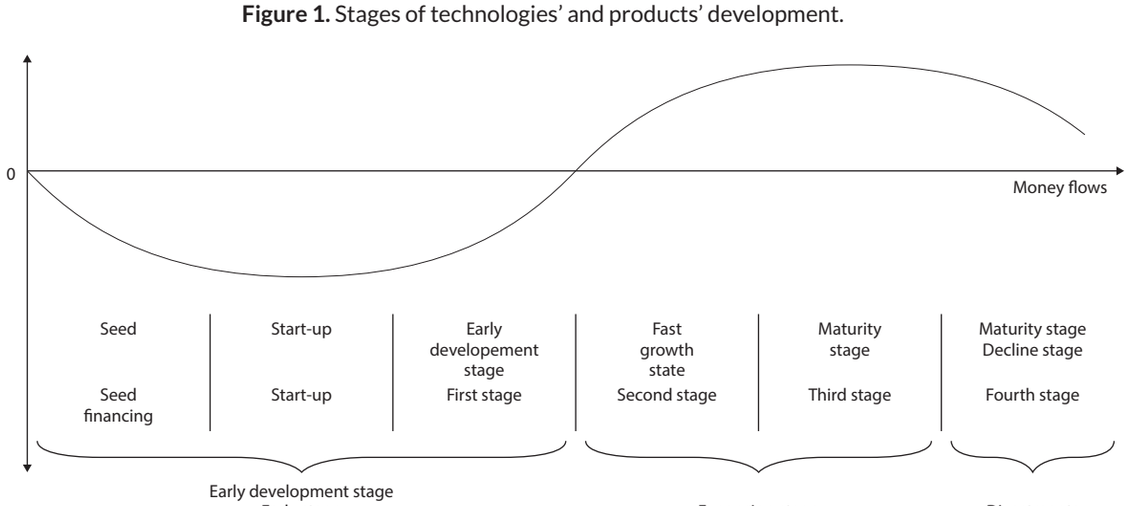
The development of innovation in the energy sector should be compatible with the development of the industrial sector and the general state policy in the field of science and research. Therefore, the Ministry of Energy monitors legal acts related to the innovation policy from this perspective, as well as the projects financed by the EU means, in order to make sure that they support the strategic objectives of the state.

1 ACTIVE ROLE OF ENERGY ENTERPRISES IN CREATING INNOVATIVE TECHNOLOGICAL SOLUTIONS AND BUSINESS MODELS

It is crucial for the development and implementation of innovations to understand specific types of innovation and stages of a particular technology's development. Innovations do not encompass only new technologies, but also organisational processes and structures. Therefore, in Directions of the Energetic Innovation Development we dedicate much space to subjects such as new business models, which are based on applications of technologies in a different way or in a different market segment. Apart from that, in order to understand the fundamental problem of so-called 'death valley', which not only Polish, but also other companies worldwide have to deal with, it is worth dividing innovations according to time and kind:

- Current projects – short-term incremental innovations (up to 2 years)
- Current projects – short-term incremental innovations (up to 2 years)
- Future projects – long-term critical innovations (more than 4-5 years)

Figure 1. Stages of technologies' and products' development.



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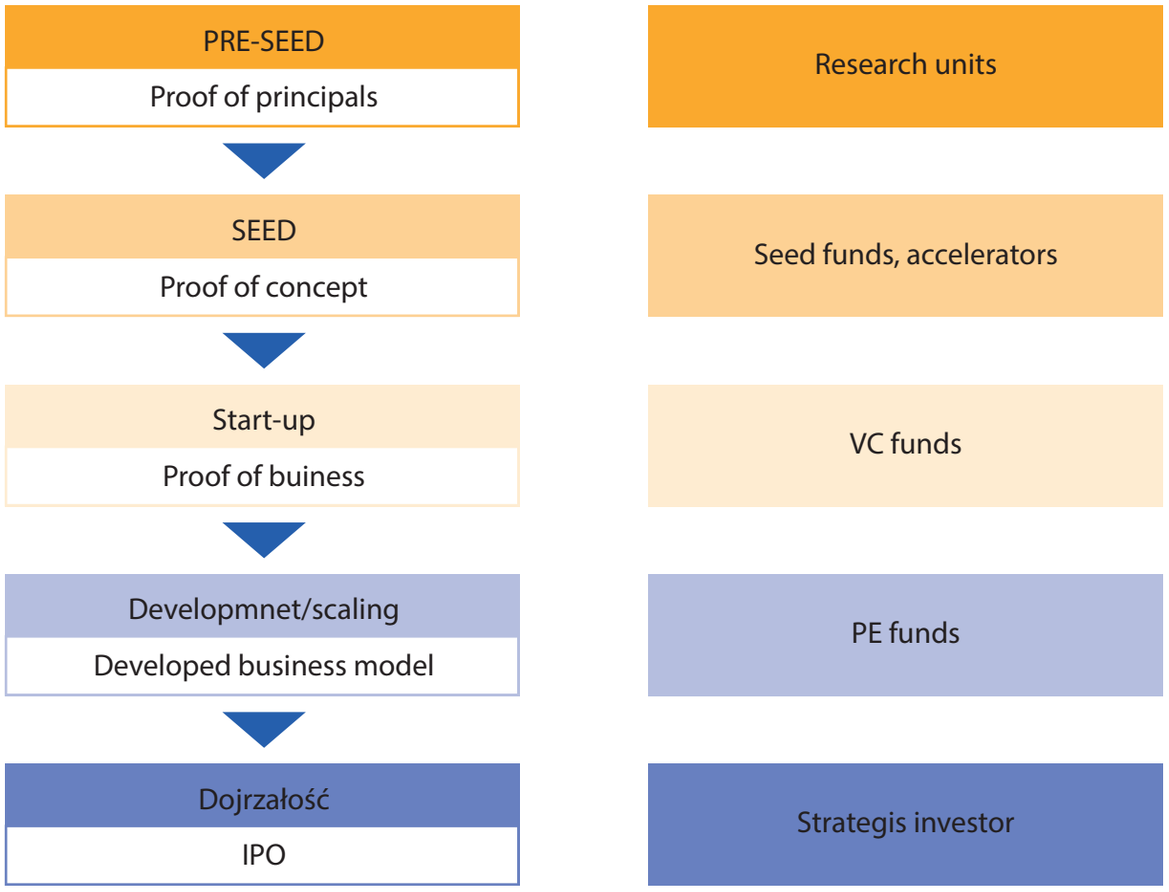
The vast majority of all innovations are incremental ones. Innovations, according to their type (incremental or critical), require different instruments, therefore the Ministry of Energy is planning to use the whole range of institutions and projects, starting from the research stage up to the implementation.

Figure 2. Stages of technology development versus mechanisms of financing.



In our opinion actions should be taken on **three levels**:

- supporting **new ideas and incubation**, where the condition of success is generating the highest possible number of highly risky projects requiring low financing, a short time of processing projects and creating the community of start-ups and innovation ecosystem;
- supporting **popularization and commercialisation**, where the condition of success is the involvement of venture type capital and large subjects as customers and product users;
- supporting **expansion and international development,** where the condition of success is cooperation of large and medium enterprises and supporting international expansion by economic diplomacy.

A weakness of the Polish system is undoubtedly the stage of technology development and implementation, which involves the necessity of pilotage and scaling of technology. Therefore, we stress these matters in functioning of presently operating or newly created institutions dealing with innovations in the energy sector.

An important element of the system is developing the **methodology of the assessment of enterprises' and particular projects' innovativeness and of measuring effectiveness in the innovation sector,** which will be common for the administration and for the business sector. Such methodologies are widely available and used, therefore this task requires mainly coordinating and adapting to the Polish conditions.

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2 COORDINATION OF RESEARCH AND DEVELOPMENT OF INNOVATIVE TECHNOLOGIES

To improve the work in the field of the innovation of the energy sector, coordination of work carried out within the scientific and analytical base is necessary. The aim is to optimize the use of funds allocated to research, development and innovation thanks to the co-ordination of the activities of various institutions. **Universities, research units and research institutes, especially those under the supervision of the Minister of Energy, could be strengthened by an entity which, upon the request of energy sector companies, would perform and commission (mainly to universities and institutes) research to verify technology.** The Electric Power Research Institute (EPRI), established more than 40 years ago, fulfills the role in the sector in the United States. It is currently one of the most known institutions of this type in the world.

The participation in the cost of maintaining the Polish EPRI counterpart should be maximized by a number of entities to minimize the burdens while providing access to test results that cannot be performed or commissioned independently. **One should be aware of the insignificance, on a global scale, of the funds possessed by Polish entities that can invest in development and innovation. Therefore, cooperation in the entire sector is a must.**

It is also necessary to review the needs for the creation of new bodies (e.g. Clean Coal Technologies Center) and improve the existing ones. The current formula of the research institute does not correspond to the tasks faced by our country. It is therefore necessary to transform institutes into national laboratories cooperating with energy sector entities, the industry, the Polish equivalent of the EPRI and administration.

Cooperation between universities and enterprises should lead to an increase in the number of patents, as well as the exchange of personnel between academic centers and industry. An important point is the increase of knowledge exchange with foreign centers and the implementation of internship programs for scientists in the energy sector entities. One of the tools can be curriculums sponsored and co-created by market entities, conducted by lecturers working permanently in the most renowned foreign centers and cooperation of Polish energy business with renowned foreign research and development centers.

Apart from scientists, the employees of companies from the sector, through study trips or education programs in the country or work in foreign subsidiaries should also have greater contact with foreign countries. This is particularly important for the creation and development of an **innovation ecosystem** which should also cover cooperation with the related sectors: the chemical, IT sectors and telecommunications, the automotive or arms industry.

We also propose that, **under the current regulations concerning both the energy sector (tariff system) and the cross-sectoral ones (Public Procurement Law), the entities investing in Poland in research, development and innovation should be rewarded**, e.g. by including expenditure on R & D and cooperation with local science centers. It is also an important task to create space for the implementation of new solutions. **Orders made by public sector entities should be a natural area for introducing new native technologies, products and services** whose effectiveness and safety have already been confirmed on the research path. The Best Value Procurement method and the separation of part of the budget for innovative activities (e.g. in the form of a special purpose entity) for projects based on procedures different from the standard in a given entity – facilitating the implementation of some previously non-functioning solutions or technologies – is one of the mechanisms corresponding to the specificity of activities in the area of innovation.

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3 FINANCING RESEARCH AND INNOVATION ACTIVITIES

NATIONAL CENTRE FOR RESEARCH AND DEVELOPMENT

The NCRD is a key state institution responsible for financing the research and development area in Poland. **From the perspective of the Ministry of Energy, it is a prerequisite for conducting an effective innovation policy to coordinate its work and programs with the strategic directions of the sector.**

In this context, particular attention should be paid to the II Axis actions of the Operational Program "Innovative Development" supported by the Center: Sectoral R & D programs. This axis is to be used to support the implementation of large R & D projects, significant for the development of particular industries / sectors of the economy. In this type of sector programs, the initiator (leader) of the joint venture is a group of companies that act on behalf of the industry (e.g. through a technology platform, cluster initiative, chamber of commerce, etc.), outlining the research agenda together with the specific demand of the sector for B + R work. Co-financing is granted for the implementation of projects that include industrial research and development works or only development works.

The increasing number and quality of projects submitted to two sectoral programs corresponding to the directions of innovation development in the energy sector are important activities. The ME's goal is also to increase the activity of energy sector entities in other NCR&D programs, including: BRIdge Alfa, BRIdge VC, BroTech and Demonstrator+. It is to ensure the growth of the innovation potential of large entities through cooperation with the field of science, small innovative companies and incubators of innovation. The involvement of energy sector companies in acceleration projects is expected to help SMEs increase and break the barrier of a small number of medium-sized companies.

Development of the described formula requires constant cooperation between the ME, NCR&D and entities from the energy sector. Ensuring it belongs to one of the tasks of public administration which is a natural integrator of efforts in the area of R & D & I. That is why the Ministry of Energy maintains a constant dialogue with energy companies about their innovation policy, including cooperation with such entities as the NCR&D. It would be an unquestionable facilitation in the cooperation between the energy sector and the National Center to supplement the NCR&D Council with a representative of the Minister of Energy.

NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT

The National Fund for Environmental Protection and Water Management has real tools for implementing new energy technologies, especially in the environmental aspect. Many of the tools significantly influenced the Polish energy sector. For the optimal, from the point of view of energy and environmental goals, using the funds held by the Fund, the Ministry of Energy submits its proposals for strategic projects having the greatest impact on the environment, and thus the life and health of citizens, with a significant technological and industrial component to the Fund. Important areas of support seem to be: Replacement and modernization of individual heating sources combined with the expansion of the heating network seem to be important areas, it shall help reduce pollution emissions while creating a market for domestic producers of modern furnaces; development of low– and zero-emission public and individual transport combined with the construction of infrastructure necessary for the popularization of low– and zero-emission vehicles; increasing the use of waste, building methane extraction installations before and during the operation of hard coal mines or coal gasification technologies on an industrial scale. Some of the above-mentioned activities have already been initiated under the NFEP&WM. However, they require not only continuation, but a significant extension of the scope and increase

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of the scale. **Energies A fast track for the most important project groups identified by the Ministry of Energy may be a good way to ensure their implementation.** To this end, the ME undertakes a dialogue and makes arrangements with the Ministry of Environment and the NFEP&WM regarding strategic directions in the area of energy and the environment and their operationalization.

LOW-EMISSION TRANSPORT FUND

At the initial stage of the **development of the low-emission and zero-emission vehicles market**, the Low-Carbon Transport Fund will be an important element of the system. Its aim is to support, among others, producers of vehicles powered by electricity, compressed natural gas (CNG) and liquefied natural gas (LNG); research in the field of developing new technologies related to the use of electricity, CNG and LNG in transport; development of public transport powered by electricity as well as CNG and LNG. The fund **will reward the most innovative enterprises and institutions**, having at the same time the capability of implementing a given product or solution. The establishment of the Fund is planned for 2017, and the launch of funding for 1 January 2018.

SPV, TFI, CVC

The Ministry of Energy will support the establishment of institutions financing the development, implementation and commercialization of technology. The most popular tools that enable large enterprises to undertake innovation activities are Special Purpose Vehicle (SPV), investment fund companies in the form of a joint-stock company (TFI SA) and corporate funds – Corporate Venture Capital (CVC). The entities, apart from purely accounting and financial benefits, have a key advantage **– they constitute a mechanism that reduces risk aversion in corporations**. The selection of the instrument should depend on the needs of the given entity and the specificity of the projects being developed. The need for such institutions is, however, very clear. Currently, they seem to be an indispensable element of the development of innovation in the energy sector, both in the field of technology and new business models. The optimal solution is the **joint appointment and use of funds by several entities** located in one business area. It will make it possible to achieve the economies of scale, appropriate number of projects, as well as joint acquisition and sharing of knowledge in the new field, the functioning of CVC in Poland.

POLISH DEVELOPMENT FUND

The Polish Development Fund can be one of the most important instruments for financing development and innovation activities in the energy sector. The main path is its capital **commitment to the activities of energy sector entities**, as well as investments in innovative enterprises through **PDF Ventures sp. o. o**. The PDF Starter program seems to be very interesting. From the perspective of the Ministry of Energy, the **Local Government Investment Fund** remains an important element complementing the funds of the NFEP&WM and the Low-Emission Transport Fund, especially in the field of zero-emission municipal transport. The Ministry of Energy recognizes the **participation of energy sector entities** in the range of programs prepared by the PDF as a **very important element of building competences and the implementation path of innovative and development projects** in the sector.

INDUSTRIAL DEVELOPMENT AGENCY

The involvement of the IDA in the development of innovation in the energy sector should mainly focus on supporting technology transfer (capital and quasi-equity support for micro, small and medium enterprises) under **SG OP 2.2. Open innovation** as well as training programs for energy sector entities and combining them with innovative small companies, which is happening under the **IDA Innovation Pitch** program.

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4 PROMOTION AND EDUCATION

Social awareness is the basic factor in the dissemination of technology. Therefore, the Ministry of Energy considers its purpose to be, in addition to creating conditions for the development of specific technological solutions, the promotion and dissemination of knowledge about the benefits (financial, economic, health and environmental) resulting from their implementation.

The construction of a smart power grid and its connection to the electromobility project will not bring the expected results for the citizens as well as the power system if the clients do not see real benefits, thus triggering the mechanisms desired by the system designers. Similarly, the promotion of low– and zero-emission public transport or exchange of individual heat sources requires social actions that enable citizens get to know the most important facts about the causes and effects of the postulated changes.

All technological changes, especially those that are so close to citizens and have an impact on their lives, such as breakthroughs in the energy sector, must take place in conditions of full information, as well as understanding and internalizing the need for change. This requires a dialogue with citizens, non-governmental organizations and market players, and the ME is already undertaking it and the effects can be noted, among others in the case of the Electromobility Development Plan. Promotional and information activities will be continued with the use of the national and EU funds, so that citizens would not only be beneficiaries of technological change, but also their active participants and creators.

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5 DEVELOPMENT OF THE SECTOR AND INTERNATIONAL EXPANSION

The Clean Energy HUB program of the Ministry of Energy, supporting the development of innovative energy technologies, is an important element of building a modern energy sector.

The goal of the program is to help the development of Polish energy sector companies and their international expansion, and thus to **increase GDP and GNP through the development of the energy-related industry sector**. It consists of three components:

A. Acceleration of Small and Medium Enterprises – support for the development of Polish companies by providing them with appropriate tools, i.e.: training, promotion and foreign missions. The actions will result in improving the qualifications of companies from the SME sector, increasing the production volume, increasing employment in this sector, and creating a platform for cooperation and information exchange between Polish innovative companies and their promotion abroad.

B. Distinction for energy-friendly companies and local governments in Poland – development of the energy sector in Poland based on Polish and foreign companies that directly influence the development of this market through innovative activities related to the increase of energy efficiency, expanding their fleets with electric cars and using green solutions in their businesses. The development of infrastructure in municipalities that fosters the objectives set out in this document.

C. Innovative implementations in large Energy Sector Entities – supporting energy sector enterprises in implementing innovative solutions developed by the SME sector, in order to increase the business potential of both parties and promote the results of the implementations at home and abroad.

The growing role of the promotion of the national business abroad and the activities of international delegations show that the business component should be an inseparable element of bilateral meetings. **A map of international expansion has been prepared**, it will be verified in terms of the activity of the management of the ME. The next step is a guide for entrepreneurs, thanks to which we shall take care of the quality of statements, presentations and minutes of the energy sector entities during official missions and visits. In addition, before each trip it will be possible to participate in a meeting / consultations preparing all stakeholders to leave.

The component is to be a strong support for the management of the European Trade Union in bilateral talks and to **open opportunities for Polish energy business abroad** within selling its own technologies, purchasing foreign technologies, as well as developing cooperation in the field of innovation.

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Appendix – INDICATORS IN THE AREA OF RESEARCH, DEVELOPMENT AND INNOVATION

The following list of indicators is a proposal of the Ministry of Energy for the entities in the sector aimed at expanding knowledge about the processes happening in the sector in the area of innovation and development based on a common methodological basis for administration and business. The list is a guiding proposal, and the ME remains open to any suggestions regarding its completion or any changes. It will be updated with the document itself at specific intervals.

On-load – target for 2018	• Expenditure on R & D • Expenditure on R & D as a %: • total sales revenues; EBIT / EBITDA • Expenditure on innovation • Expenditure on innovation as a %: total sales revenues; EBIT / EBITDA • Expenditure indicator in relation to total expenditure on R & D & I • Number of full-time jobs in the field of R & D in relation to the total number of employees • Number of full-time jobs in the fields responsible for acquiring and implementing innovations in relation to the total number of employees • Number and value of external orders in the field of R & D • Expenditure on innovation-related activities (training, planning, market research, participation in industry events)
Process – goal for 2018	• Number of ideas in the innovation funnel broken down by the number of innovative projects possible to be implemented in a short (up to 2 years), medium (2-5 years) and long (over 5 years) time horizon • Employee innovation scale – the number of ideas and implementations versus the number of ideas and implementations of innovations from outside the organization • Number of exclusive rights notifications: including the number of patent applications; the number of international applications; the number of applications created jointly with external partners • Number of joint scientific publications with scientific units • Number of R & D cooperation agreements with external partners (research units, companies, incubators and accelerators broken down by the domestic and foreign) • Average time to market an innovative solution or technology (time to market)

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Effect – goal for 2020	• Revenues and profits from new and innovative products and services • Revenues from new and innovative products and services as a % of total sales revenues • Revenues from the sale of new and innovative products and services created in the internal R & D process in relation to expenditure on R & D • Operating result (EBIT / EBITDA margin) due to new and innovative products and services created in the internal R & D process in relation to expenditure on R & D • Sales revenues due to new and innovative products and services or the reduction of operating costs as a result of their implementation in relation to expenditure on innovations • Operating result (EBIT / EBITDA margin) due to new and innovative products and services or the reduction of operating costs as a result of their implementation in relation to expenditure on innovations • Profit from the sales of new and innovative products and services to external entities • Net profitability on the sales of new and innovative products and services versus net profitability on the sales of products and services in total • Revenues from license fees from own exclusive rights

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