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DECALOGUE

OF THE POLISH ENERGY TRANSITION

PARTNERS:

INSTYTUT JAGIELLOŃSKI

POLSKIE STOWARZYSZENIE ENERGETYKI WIATROWEJ

Forum Energii

RE-Source POLAND
Energia z OZE dla przedsiębiorstw

KE
KLUB ENERGETYCZNY

MSAP

SCIENTIFIC PARTNERS:

AGH

UNIWERSYTET ROLNICZY
im. Hugona Kołłątaja w Krakowie

UNIWERSYTET EKONOMICZNY W KRAKOWIE

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Warszawa, May 2022

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FOREWORD

ANNA KORNECKA

We present the "Decalogue of the Polish Energy Transition". The document describes ten areas where we have identified the need for an immediate action in order to exploit all opportunities given by the strive of the European economy for climate neutrality and independence of economic growth from fossil fuels. The measures we propose apply to **strategic management and planning** as well as specific areas, such as **RES and nuclear power** or **hydrogen technology development**. Furthermore, we identify the necessary measures with respect to **power grid upgrades** or **electrification** of our economy. We try to build the foundations of a green and innovative economy using all EU and national funds that could be obtained. We present **social aspects of energy transition and decarbonisation**, including the objectives and opportunities. We emphasize the role of **local governments by strengthening their energy independence** and the importance of **education and science** in a process as difficult as energy transition.

Energy transition is justified not only by climate protection but is a project likely to become the technological revolution of the 21st century. It is to foster development of broadly construed green economy, including green transport and industry. Poland wants to take part in the transition on equal terms with other European countries and to consolidate our energy security at the same time. Today, we are looking for areas where Poland as a country may enter the global supply chain and develop a domestic, local value chain, strengthening the drive towards transformation of the regions that need more effort in that respect. The transition must be just, must level the playing field and create new opportunities.

Furthermore, after 24 February 2022 the world is no longer as before. Europe faces even more difficult challenges — becoming independent from Russian hydrocarbons and adjusting consumption plans for gas as a transitory fuel. Today, when Russian military is committing crimes on civilian population of Ukraine, one cannot imagine Russian gas as a foundation of the leap forward our civilisation is taking. Together with growing inflation, the measures taken may harm those in jeopardy of energy poverty. Therefore, we should focus our efforts on improving energy efficiency of our homes and workplaces. Poland must start to make serious investments in zero-carbon, modern technologies that optimise energy consumption. Even with the longest possible exploitation of coal deposits and units, we have to be ready with new RES capacity — dubbed "energy of freedom" after the Russian aggression on Ukraine — and nuclear power alike. To make it happen, we must make certain decisions, take certain steps and specify ambitious milestones for Polish energy transition — today.

The document was prepared as a result of the complex geopolitical and economic situation to answer questions about the development of our country in the years and decades to come. Poland is a member of the European Union, which wants to become climate-neutral by 2050. We cannot fail to see the opportunity, yet we have to make some efforts to make the objective possible to achieve. Furthermore, the European Union allocates substantial funds to finance green investments. It is our job to use these funds wisely and not to lose this historic opportunity to have the cost of energy transition in Poland spread equally among all EU countries, rather than encumber only our citizens.

Together with a team of experts, we indicate the areas and specific measures that need to be implemented as soon as possible to successfully pursue the vision of economically developed, ambitious, competitive and sustainable Poland. We try to suggest where to seek new opportunities and which areas need particular support. Today, there is no technology that could make Poland energy-independent on its own. However, we should seek development directions and investments that would result in the most effective creation of the national supply chain; where we will provide competence, components, services and jobs to many new sectors of the economy.

We hope that our work will be used as a practical as useful guide to areas that require reforms and specific measures along the future path towards Polish energy transition.

We would like to thank all partners of the project — those who contributed to the creation of the document as well as those who encouraged and recognised our work.

Anna Kornecka
Director, Instytut
Stowarzyszenie Program Czysta Polska

CHAPTER 1.

A SOUND PLAN FOR ENERGY TRANSITION IN POLAND

Energy transition or, more generally, strive for climate neutrality of the European economy is not an invention of the Brussel's technocrats and officials, but an actual and civilizational need for a change. A change dictated by environmental, technological and social considerations.

To build its strength, European economy required vast amounts of energy necessary to power technological and industrial development and growth of the transport and services sector. Throughout the years, Europe was powered by fossil fuels — starting from coal, through oil, to natural gas, whose role has recently become increasingly important. To maintain its global position, Europe needs an increasing volume of energy carriers.

From the strategic and geopolitical point of view, energy transition is to make Europe independent from fossil fuel providers, who often exhibit values that are in fundamental conflict with ours in terms of human rights, freedom, freedom of speech or democracy.

POLAND FOLLOWS EUROPEAN PATH

Obviously, global challenges are also apparent in Poland. A state that for decades built its economic self-determination on coal must join the global transition of the energy sector and the entire economy alike. Prior to World War II, next to use for purely energy purposes, in the newly-reborn Polish state coal was also a currency in relations with other economies. Today, in the era of well-developed financial market, nobody is paying in coal. However, the fuel remains strongly embedded in our daily life. Irrespective of who we are, what views we present and what occupation do we have, we use coal every day — whether we want to or not.

Today, as much as 70% of electricity in our sockets is still produced from the "black gold". Moreover, many Polish citizens continue to use coal for heating their homes. Although coal-fired power plants provide a stable source of electricity, they strongly contribute to climate change occurring on Earth, and — in Poland — the economic fundaments of their use are becoming increasingly doubtful. For technological reasons, the lifetime of Polish coal-fired units is coming to an end. Most of them were built in the 1970's and 1980's in southern Poland.

Currently, Poland needs to import an increasing amount of "black gold". The reason are systemic issues of the Polish mining sector, increasing exploration costs or issues related to the quality of domestic coal. Coupled with progressing EU climate policy, aiming at full climate neutrality by 2050, this will result in our country resigning from coal much faster than expected by even the most ferocious defenders of status quo in the Polish energy sector.

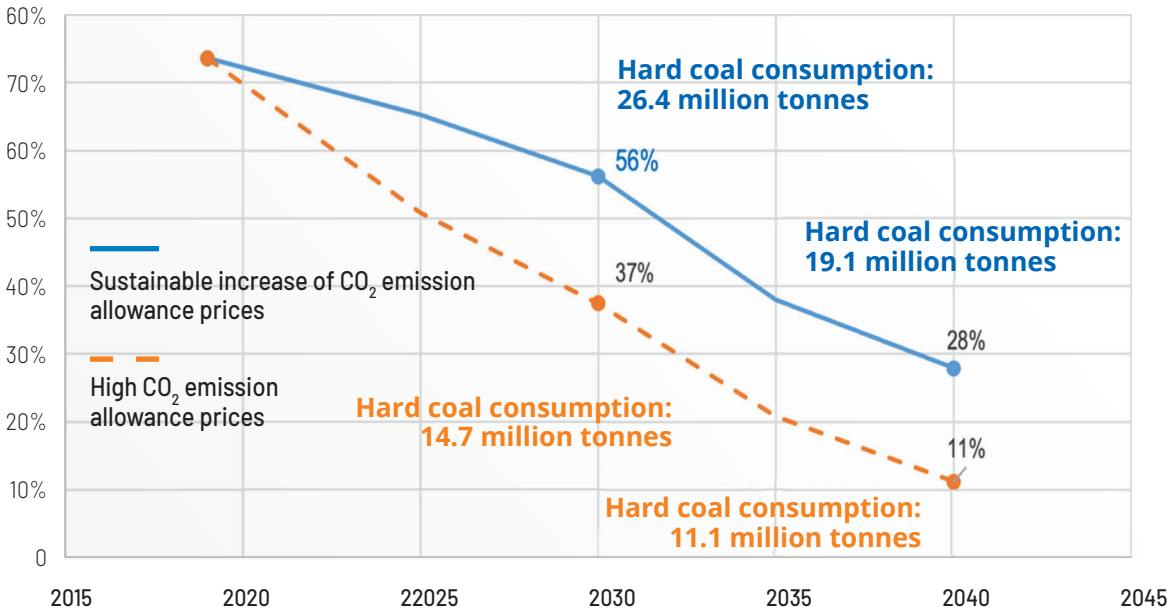
Therefore, Poland should commence a rapid march towards climate-neutral economy. It has to follow the spirit of energy transition, which, with all the challenges, brings a civilizational opportunity for development that must be used. The vision of Europe for the centuries to come is created today. Only those who have the ability to look towards the future with courage and conviction will end victorious. Those who insist on abandoning the reforms will find themselves not only at the end of the entire race, but also forgotten by history.

Next to purely economic elements, social awareness is a key element that gains importance. People want to live in a clean environment that is safe to their health. Such environment cannot be ensured by fossil fuels, in particular coal. Expectations of the population translate into political choices. In their campaigns, European political parties must take into account the expectations stemming from social aspirations. Political circles promoting climate and environmental protection are becoming increasingly popular in Europe.

THE HISTORY IS ACCELERATING

The era of stability and peace in Europe ended on 24 February 2022. A world based on respect for values and civilizational growth that has been build for years has collapsed. This is a great challenge for the entire energy sector. Plans we made on the basis of stable assumptions are no longer valid. The transition was to be based on RES and gas, used to stabilise the power grid. Today, when Russian military is committing crimes on civilian population of Ukraine, one cannot imagine Russian gas as a foundation of the leap forward our civilisation is taking.

FIG.1. **EXPECTED SHARE OF HARD COAL AND LIGNITE IN ELECTRICITY PRODUCTION IN POLAND BY 2040**

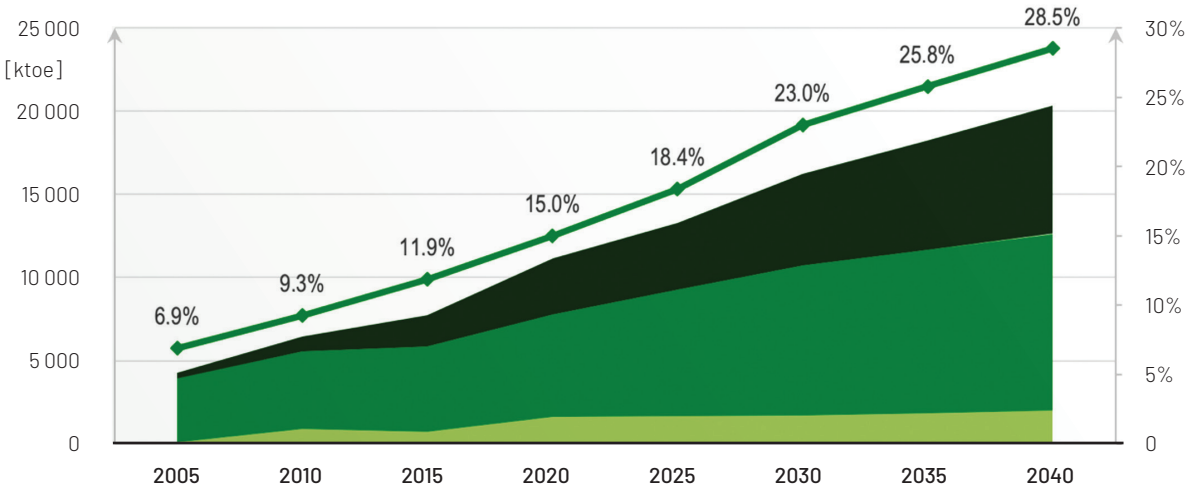


SOURCE: Energy Policy of Poland 2040

Poland saw the threat coming from Russia for years. We were preparing ourselves for the inevitable, building our capacity to diversify natural gas supply to Poland. Today, Russian gas contributes to approximately 40% of European consumption of the fuel. The lack of supply from Russia, coupled with insufficient supply from other global players and shortage of LNG offloading capacity in Europe, may result in prices of electricity produced from sources based on the "transitory" gas becoming dangerously high, both for the industry and the society. Therefore, the use of gas as a fuel for the transition in Poland becomes questionable.

The situation in the East coincided with the pending updates of the "Energy Policy of Poland until 2040". The document, adopted at the beginning of 2021, was long criticised for unambitious transition assumptions. One of the key examples of such conservative approach is the forecast of PV installed capacity. In accordance with the strategy in question, Poland was to achieve 5 to 7 GW in PV by 2030. The upper threshold laid down in the strategy was exceeded already in December... 2021, just a few months after the effective date of the Energy Policy of Poland.

FIG. 2. **EXPECTED RES CONSUMPTION FROM 2020 TO 2040 IN ACCORDANCE WITH EPP 2040**



SOURCE: Energy Policy of Poland 2040

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The new strategy must take into account both the plan to abandon Russian coal, oil or gas, and the expectations related to the European Green Deal. Therefore, the assumptions to the update to EPP 2040 included a provision on the intention to achieve approximately 50% of production from RES by 2040. Moreover, on the basis of connection applications for planned RES investments, Polskie Sieci Elektroenergetyczne also assume in their investments plans that renewable installed capacity will reach 50% in 2032. However, due to efficiency of particular sources, installed capacity differs from energy production. Eventually, in line with the law, the updated strategic document governing the Polish energy sector by 2040 is to be adopted by 2023. It has to be mentioned that the European Union already expects the average share of RES in the entire EU in 2030 to reach 45%, what poses a substantial challenge for Poland.

The Polish plan to resign from Russian fossil fuels assumes that Poland will abandon both Russian coal and natural gas by the end of 2022. Coal imported from Russia is sold primarily to households and small, local heating plants. In 2021 Poland imported 10 million tonnes of coal, of which as much as 8 million tonnes from Russia.

Resignation from Russian gas is no surprise. End of 2022 will see the expiry of a long-term contract for the supply of gas under the Yamal contract. The LNG terminal in Świnoujście and Baltic Pipe gas pipeline, which is to become operational at the end of 2023, will in January 2023 make Poland free from Russian, imported fuel. Today, the Russian gas contributes to more than 50% of domestic gas consumption.

Renewable energy sources, energy storage facilities, services and technologies related to the industry result in money that otherwise would have been spent outside the EU remaining in place and contributing to our economic power. The renewable energy industry already created more than 100 thousand jobs in Poland. The figures will increase every year, as spending allocated to transition will accelerate. For comparison, in accordance with the Industrial Development Agency, the mining sector — defended by some politicians and experts — at the end of May 2021 employed 78.9 thousand.

TRANSITION MUST BE DESIGNED AS EVOLUTION, NOT REVOLUTION

The transition has to be carried out wisely. It must be an evolution, not revolution. The change should start in the energy sector and spread to the entire economy. We should analyse the benefits, but also seek potential threats. The challenges cannot be blindly accepted. Problems most often and most painfully strike the society — those who may encourage the authorities to continue the process or influence them to suspend or hold it. We cannot have the people to bear all costs of transition — both in economic and purely human terms. Moreover, the design of transition must incorporate continuing technological progress. We have to build a model of the national energy sector that will implement each new technological or process solution without delay. This will enable us to follow a path leading to climate neutrality based on the most effective tools.

We also have to support local communities and local governments in grassroots measures leading to energy transition. The new energy model, based on distributed energy sources, empowers local governments with the feeling of subjectivity in the actions of the entire European Community and provides very practical economic benefits, stemming from, for instance, taxes and investment. Such a vision of the energy future requires strong coordination and cooperation on behalf of power utilities, companies responsible for electricity transmission, local governments and other energy producers' associations, for example energy clusters. It allows for maximisation of self-consumption of electricity produced locally while providing energy security to the entire country.

One of the last elements that require attention are funds to finance energy transition. Within the next several years, Poland will receive a broad stream of funds from the EU programmes aimed at supporting the transition. In accordance with the regulations applicable to the spending of European funds from the 2021–2027 budget, Poland is under the obligation to spend 25% of funds from the Cohesion Policy on projects that counteract climate change. For Poland, the Cohesion Policy Fund amounts to EUR 72 billion. Furthermore, Poland will also receive in excess of EUR 4.4 billion from the Just Transition Fund, which is to support regions most exposed to adverse effects of the transition. Additionally, revenues from the sale of CO_2 allowances are to supply the Energy Transition Fund, established to modernise the Polish energy sector. Currently, the funds just "dilute" in the state budget. The fund is to contribute almost half of the budget funds allocated to transition projects financed by the National Fund for Environmental Protection and Water Management.

The money must be well-spent, without being wasted on unpromising and outdated projects. Never in the history of Poland we faced such a broad outlook for aid to redesign our energy sector and the entire economy. Funds spent on energy transition will not only make our energy sector less carbon-intensive, making the lives of everyone better, but will also build entirely new competences in industries and segments so far unknown or very rare.

Soundly designed transition must include all of the above elements. It opens an opportunity for a civilizational leap. We should plan it well, thinking about our children and grandchildren, who will reap the fruits of our work. The young generation is our future — but we have to take care of it today.

CHAPTER 2.

DEVELOPMENT OF RES AND NUCLEAR POWER

For many years development of renewable energy sources in Poland was motivated by the need to implement EU climate and energy policy. Next to wind, nuclear power is a source with the lowest lifetime CO_2 emissions. Both nuclear power and RES should complement each other to jointly create carbon-free economy of the future.

Subsequent EU regulations fueled the Community ambitions related to implementation of the climate and energy policy. Member States, including Poland, established dedicated support schemes necessary to finance investments in more expensive generation sources. However, few years ago came a breakthrough. First RES technologies achieved grid parity — the cost of production of electricity from RES equalled fossil fuels.

In Polish climate conditions, the first to achieve grid parity were: onshore wind, PV and offshore wind. Given the current electricity prices, most RES technologies have reached this breaking point.

Crossing the barrier means that — from economic point of view — the development of renewable energy in Poland should increase its pace, satisfying growing demand for electricity and displacing conventional generation units, whose lifetime comes to an end. Investment in new RES generation capacity is a win-win — it provides the system with substantial volume of inexpensive electricity free from carbon footprint while boosting the development of innovative economy.

The above is confirmed, among others, by Instrat estimates[1], in accordance whereof in 2030 RES installed capacity should reach approximately 52 GW, three times the current 18 GW.

ECONOMIC GROWTH

Creation of new energy mix based on renewable generation sources requires substantial investment expenditures. The majority thereof may be spent in Poland, contributing to the development of domestic industry. In accordance with industry analyses, by 2030 development of wind energy (onshore and offshore combined) alone may entail PLN 150 billion of investment (not counting investment made in industries supplying products and services for the wind energy sector). Add to this the benefits stemming from the development of the PV sector (both large plants and self-consumer installations) and other generation technologies, and the total investment in 2030 perspective will exceed PLN 200 billion (in generation sources only). Such an investment should leverage the development of not only Polish industry, but also science. It also should enable seamless adjustment of domestic employment structure from traditional sectors to high-tech.

1 Instrat — Achieving the goal. Departure from coal in the Polish power sector. Instrat Policy Paper. 01/2021.

The national economy will benefit not only from construction of new sources, but also from inexpensive, carbon-free electricity generated by them. In times of high electricity prices, observed since the second half of 2021 (peaking in December 2021, with weighted average monthly BASE price on the Polish Power Exchange reached 829.98 PLN/MWh), each generated unit of renewable electricity contributes to the decrease of the average price (by displacing expensive energy produced from fossil fuels). RES auctions held to date demonstrate that the cost of production of electricity from onshore wind amounts to approximately 200 PLN/MWh and 220 PLN/MWh for PV.

If we eliminate barriers to onshore wind development and enable installation of 5–6 MW machines, the costs should decrease even further.

The above relation — higher RES generation resulting in lower electricity prices — was particularly apparent at the beginning of 2022, when historically high wind output contributed to the decrease of average BASE prices on the Polish Power Exchange by several hundred PLN/MWh. More than 2.5 TWh were produced in January 2022, which means that, on average, wind energy operated with a capacity in excess of 3,400 MW — a capacity factor of almost 50 percent. At the same time the monthly average BSE price on PolPX decreased to 666.90 PLN/MWh.

The situation was even better in February 2022 — though shorter than January, onshore wind produced more than 2.6 TWh of electricity, resulting in average capacity in excess of 4,000 MW — a capacity factor of almost 55 percent. At the same time the monthly average BSE price on PolPX decreased to 525.89 PLN/MWh, more than 300 PLN/MWh less than in December 2021. The above relation should also be apparent in subsequent months due to increasing PV output.

Green energy is a must for the Polish industry not only because of its price, but also due to the very fact it is generated from renewable sources. An increasing number of customers in Western Europe consider reduction of carbon footprint a priority in making their purchasing decisions. Considering that approximately 80% of the Polish export is to the EU markets, it is necessary to accelerate RES investments to maintain competitiveness of the Polish industries in their current markets.

ENERGY SECURITY

In the context of the war in Ukraine, energy transition, which commenced as a result of climate change, starts to have a different meaning. EU emphasizes the need to accelerate the transition in Europe as the only long-term solution enabling complete resignation from external supply of fossil fuels. Faster reduction of our dependence on fossil fuels and elimination of supply from Russia must form the pillar of energy security also in Poland. Diversification of supply of fossil fuels — coal, gas or oil — will not guarantee full energy security. The latest history demonstrates that only domestic, distributed, renewable energy sources give full independence.

Redefinition of energy security from diversification of supply to development of domestic, distributed, renewable energy sources is in the best interest of the nation. It has to be emphasized that the force of nature, such as wind or sun, does not depend on geopolitical situation, and cannot be stopped by any external political

action. Moreover, a power system based on distributed energy sources is by its nature much more resilient to any military threats. Therefore, no time must be lost in eliminating all barriers to RES development and defining a clear state policy in that respect.

The EU climate and energy policy, aimed at departure from fossil fuels due to the need to curb climate change caused by their combustion, cannot be omitted. The increasing Community ambitions, expressed in the Fit for 55 package, which increased the original target for renewable energy sources development from 32% to 40% in 2030, needs to be reminded. In accordance with the latest announcements from Brussels, the target may be increased to 45% by 2030. It is very likely that the war in Ukraine will further accelerate energy transition at the EU level — following the outbreak of the war, particular Member States clearly indicate their intention to follow such a path.

Next to sun and wind, development of biomass and biogas is also worth supporting. As an agricultural country, Poland does not take advantage of its potential in production of these renewable sources. It has to be emphasized that both biomass and biogas may successfully stabilise the operation of weather-dependent sources and increase the profitability of agricultural production, using production waste to generate energy.

The purchase of electricity from RES is supported by an instrument known as Purchase Agreements. These long-term contracts for the supply of electricity from RES are usually concluded for 10–15 years directly between energy producer and industrial customer. Such an agreement secures a fixed price for the customer and gives the producer a guarantee that energy from renewable sources generated by it will be sold.

DEVELOPMENT BARRIERS

To enable rapid development of renewable sources, it is necessary to take urgent legislative action to eliminate artificial administrative barriers. To this end, we need simple solutions that will not result in excessively complex investment process and reflect the principles for minimisation of investment barriers related to the development of the RES sector adopted in the EU legislation (at the level of the so-called RED II Directive promoting the use of electricity from renewable sources). Bearing the above in mind, our proposals include, but are not limited to:

- Unblocking onshore wind investments (the so-called Distance Act, in force since 2016, brought development of onshore wind farms to a halt).
- Defining more areas available for offshore wind.
- Maintaining support for prosumers (including among business entities) and self-consumption.
- Introducing flexible incentives for RES investments with high capacity factor, such as biomass and biogas.
- Introducing incentives for sector coupling, in particular at household level.
- Streamlining decision-making processes at the governmental level and in local governments to decrease waiting time for administrative decisions as much as possible.
- Introducing more flexible grid tools enabling higher RES penetration.

NUCLEAR POWER

Nuclear power is a mature, fully tested and efficient electricity production technology. More importantly, nuclear power and renewable energy sources may and should complement each other to create zero-carbon economy of the future, taking advantage of mutual advantages. Next to wind, nuclear power is a source with the lowest lifetime CO_2 emissions — 12 gCO_2eq/kWh. For onshore wind, the figure is 11 gCO_2eq/kWh, for offshore wind — 12 gCO_2eq/kWh, whereas for fossil fuels — 820 gCO_2eq/kWh (coal-fired sources) and 490 gCO_2eq/kWh (gas-fired sources). Moreover, nuclear power provides stable generation, independent from variable weather conditions, what predisposes the technology as a baseline load in a carbon-free power system.

Considering the advantages of nuclear power, it is difficult to imagine a long-term strategy for sustainable development of a power system, aimed at climate neutrality, which does not assume basing the national energy mix on a synergy between renewable sources and nuclear power. Alas, the political and expert discussions often cannibalise both technologies, i.e. present an opinion where development of one precludes development of the other. This prevents energy transition in Poland from gaining sufficient momentum, giving advantage to producers of electricity from conventional sources.

Notwithstanding several years of activities aimed at construction of the first nuclear units in Poland, due to the scale of investment required for the development of the nuclear power sector, no binding decisions that would make the process irreversible have been made to date. In accordance with the update to the "Polish Nuclear Power Programme" (PNPP) published in October 2020, the first unit is to be commissioned in 2033, with subsequent six two years apart, to eventually achieve between 6 and 9 GW of installed nuclear capacity by 2043. Considering the pace of works on the nuclear power programme in Poland, the scale of works to be performed, and experience of other countries gained during implementation of such projects, the assumed commissioning of the first unit in 2033 is very optimistic. However, steps necessary to implement the project need to be taken.

In the context of time schedule of the nuclear power programme, it is crucial to ensure the necessary generation capacity in case of delays. The response should be based on further acceleration of investments in renewable energy sources to fill the potential generation gap. One should remember that the national strategy assumes implementation of two large — 1,000 MW — nuclear units in the first place, which means that delays will lead to a substantial generation gap. When nuclear units are commissioned, surplus RES may be used to produce electricity for green hydrogen purposes.

Poland is a country where relatively high part of the community supports or does not object to the construction of nuclear power plants, giving rise to hopes that the investments in question are feasible. However, further actions to maintain social acceptance at a high level should be taken.

SMR — Small Modular Reactor — technology, i.e. small nuclear reactors that could operate as distributed sources for the purposes of the Polish (energy-intensive) industry, will also play an important role in the context of the future decarbonisation of the economy and development of the nuclear power sector in Poland. Although not yet commercially launched, the technology is actively pursued in many countries. It is estimated that approximately in 2030, SMR technology will be commercially available, meaning that it could also be implemented in Poland. The largest Polish industrial enterprises have already expressed interest in the technology.

The combination of RES with nuclear power is the answer to the challenges related to energy transition faced by Poland. To effectively decarbonise the Polish power sector, we must take a number of actions accelerating investments in these sources. The investments will not only bring a qualitative change enabling efficient transformation but will also bring measurable economic benefits.

CHAPTER 3.
GRID UPGRADE

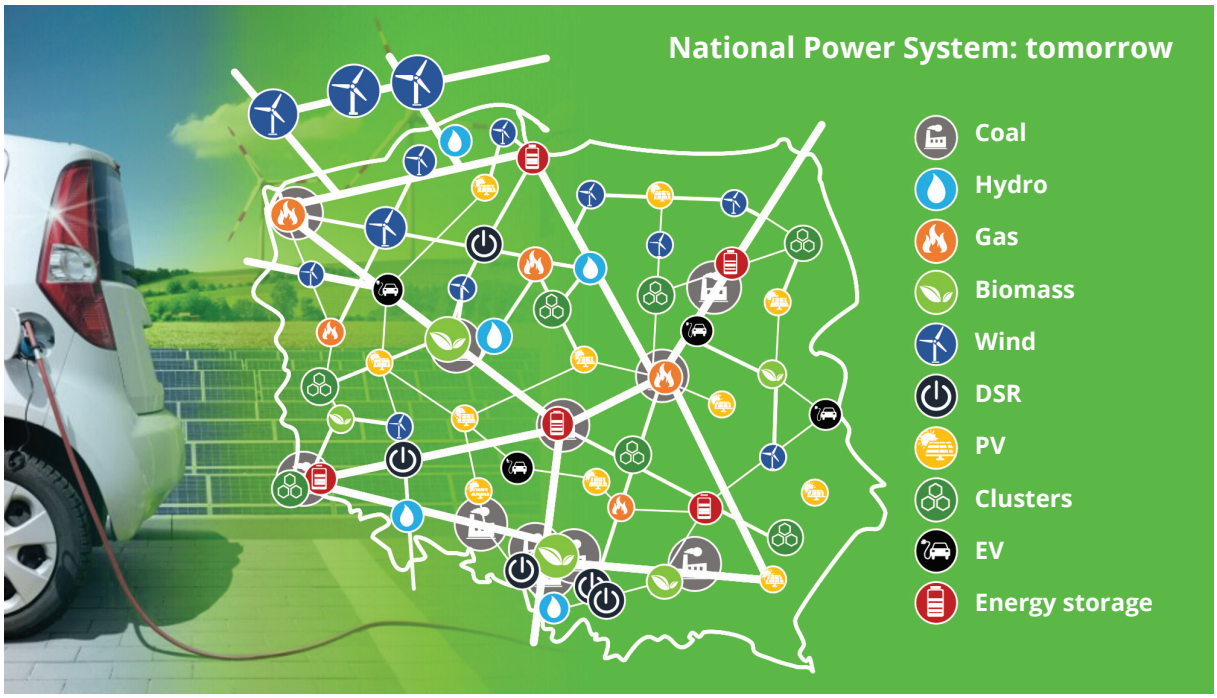
Power grid is a system of collaborating elements — cable and overhead lines, transformers and substations, other auxiliary — used to deliver electricity to customers and maintain appropriate quality, safety and continuity of supply. This means that the role of power grid is to provide services and enable performance of a contract between a customer and a producer — this crucial statement should demonstrate that all actions taken with respect to the power grid should be oriented on implementation of that fundamental function.

Energy transition, consisting in changes to electricity production structure and customer behaviour, not only entails necessary investments in generation sources, but also in power grid, which must be adapted to new conditions. Currently, the National Power System primarily comprises large, centrally-controlled generation units producing electricity from fossil fuels. However, traditional power sector is increasingly often displaced by small sources with a capacity from several to several dozen MW. Moreover, prosumer activity soared in the recent years, bringing the number of installations to more than a million. Such sources operate with substantially different characteristics, producing electricity depending on weather conditions. The changes occurring in the power system create substantial challenges that require innovative approach to the supply of electricity. They also entail the need for grid extension and upgrade as well as innovative approach to its operation through increased flexibility and smartness. Therefore, power grid should be equipped with modern digital equipment, enabling metering and communication between particular elements thereof using modern IT and telecommunication systems.

However, the change to the generation structure is not the only challenge in the context of investments in power grid upgrade. Energy transition that happens as we live also entails increased consumption of electricity, both in households and industry. More electrical appliances, development of electromobility, transition to electric heating to eliminate smog as well as electrification of industrial processes will entail a substantial increase in electricity consumption, necessitating major reinforcement of existing infrastructure.

Challenges are related not only to upgrade of the existing infrastructure, but also construction of new facilities that are necessary due to changing location of electricity generation sources. To date, due to available coal resource, the majority of sources were located in southern and central Poland. Currently, due to wind conditions, generation is shifting to northern Poland — yet geographic variability of demand remains unchanged.

The National Power System has to face the challenges at a time when a substantial part of transmission and distribution facilities is worn out. Certain parts of the grid "remember" the original electrification, and the majority of facilities owned by distribution system operators are older than 25 years. This makes the challenges related to adaptation of the grid to the new conditions much more complex.



Investments in renewable energy sources and nuclear power are necessary to eliminate carbon dioxide and other substances from the electricity production sector. To make this happen, we need to take a series of actions aimed at upgrading power grids, whose lack of adaptation to such generation creates one of the most serious barriers to RES development. Currently, the majority of grid connection applications for new RES is rejected, jeopardizing further investments.

IMPROVEMENT OF INFRASTRUCTURE EFFICIENCY

The scale of challenges and required investment expenditures related to grid upgrade is tremendous. However, the simplest and least expensive, available solutions, enabling increase in connection capacity, should be used first.

Currently prevailing issues may be alleviated by implementation of legal solutions enabling the sharing of connection infrastructure by renewable energy sources producing electricity from different primary energy sources (so-called cable pooling). Cable pooling, in particular between wind and PV, will not only unlock the capacity to connect subsequent installations to the grid in areas with no available connection capacity, but will have a positive impact on power grid balancing by smoothing out production profiles in a given connection point in different periods. This will be achieved through negative daily and seasonal correlation between wind and PV — wind produces more energy during the night and in the autumn and winter, whereas PV — during the day, in spring and summer. Therefore, smoothing out production profiles by combining different generation sources in a given connection point should facilitate balancing for the operators, increasing available connection capacity.

Another effective solution that could be rapidly implemented is the construction of the so-called direct lines, i.e. separated power lines, not connected to the power system, connecting electricity producers and customers. Such a solution enables the construction of more RES in Poland without additional burden for the power grid, and requires no grid connection conditions. Moreover, it is sought by large, energy-intensive industries, which expect large volumes of RES electricity which, due to grid constraints, cannot be readily delivered. The solution is often undermined by power utilities, which claim that it contradicts the principles of a system; nonetheless, its impact related to decreased grid loads seems to be one of the measures to solve the current issues, related to lack of funds for grid extension and upgrade. Similarly to cable pooling, the solution provides an opportunity to build substantial RES capacity without the need to extend the grid, therefore may substantially contribute to decreasing costs related to the supply of electricity to final customers.

EFFICIENT ENERGY MANAGEMENT AT A LOCAL LEVEL

Due to insignificant unit capacity and distributed nature, renewable energy sources are primarily connected to distribution grids. This is a great advantage, enabling more efficient, local use of electricity produced from RES, without the need for transmission over long distances — without additional burden for the grid. The concepts of energy clusters, energy cooperatives, energy communities and other similar collective forms of energy production and consumption will in the future enable the creation of self-balancing areas, which by design will more efficiently use the existing grid infrastructure. Moreover, a high number of such entities may be centrally managed to take advantage of the offered benefits and provide effective and efficient power system balancing throughout the entire country.

Due to more efficient adaptation of generation sources to demand, power grid management at a local level, in energy cluster or energy cooperative, requires less expenditures. This means that expenditures on making local grids "smart" through investment in energy storage facilities and corresponding ICT tools — computers, software and equipment — are also lower.

Local grid management aspects should also include Demand Side Management (DSM) or Demand Side Response (DSR) solutions, used to manage and control demand for electricity. Common application of the schemes will facilitate power system balancing, adapting the demand to current system capabilities. Moreover, it is necessary to enable distribution system operators to apply such schemes.

INCREASE IN INVESTMENT EXPENDITURES

Next to legislative measures described above, improving efficiency of the use of the existing connection infrastructure, it is necessary to make substantial investment in further grid extension and upgrade, both at the transmission and distribution grid level.

The funds should be allocated to measures such as:

- Extension of 110 kV distribution grids to ensure stable electricity flows in DSO areas.
- Upgrade and extension of medium voltage power grids, MV/LV substations and low voltage grids.
- Application of new solutions to control the operation of distributed RES.
- Promotion of automatic control of grid operation inside the grid.
- Application of modern grid equipment and elements, controlled and managed through dedicated IT and telecommunication systems.
- Implementation of flexibility services by DSOs.
- Implementation of IT systems forecasting electricity production from RES and fast data transmission channels.

Investment expenditures should be accompanied by investment in energy storage facilities. However, storage should not be implemented by power utilities, but entities operating on the competitive market, to ensure services are provided at the lowest possible cost.

STREAMLINED GRID CONSTRUCTION

Currently, grid extension in Poland is a very lengthy and complex investment process, requiring numerous administrative procedures, decisions, approvals and opinions. Such investments clearly demonstrate all flaws of the administration system and legal framework. Therefore, construction of a single grid section just a few kilometres long may take in excess of a dozen years. To prevent such issues, it is necessary to introduce statutory solutions streamlining and simplifying development of grid investments. To this end, one may extend the application of the Act on the Development and Implementation of Strategic Transmission Grid Projects to construction of power grids of all voltages. The current solutions only support the construction of highest voltage grids. It is desirable to extend the coverage of the Act and implement a one-stop-shop procedure for the development and implementation of grid investments. Moreover, provisions imposing on municipalities obligations related to the preparation of the plans for the supply of heat, electricity and gas fuels should be extended to fully include grid implementation needs.

CHANGED POWER UTILITY OPERATION MODEL

Grid upgrade should be accompanied by a change to the operation model of distribution power utilities, which currently form part of vertically integrated energy groups. It is necessary to separate the DSOs from their structure and make them independent. Such a change will release funding for distribution grid upgrades and allow for a clear specification of the role and exact responsibility of these entities in energy transition.

Moreover, additional information obligations related grid load and available connection capacity need to be imposed on grid operators. This is particularly important in the context of RES connection. Current regulations make the connection process non-transparent and lead to many questions, often resulting in a waste of time and money for investors. A statutory obligation for grid utilities to provide reliable and transparent information on the condition of the grid and available connection capacity will substantially improve the efficiency of construction of new energy sources.

Furthermore, more opportunities for participation of entities willing to be connected to the grid in extension thereof should be provided. To this end, grid utilities should be obligated to apply uniform and transparent standards enabling producers to calculate extension costs of grid elements and its feasibility. Given the utilities' lack of funds on grid upgrade, such a solution would enable commercial investments in that respect, increasing and streamlining RES connection.

CHAPTER 4.

ENERGY INDEPENDENCE OF LOCAL GOVERNMENTS

Climate neutrality targets that European Union wants to achieve in 2050 bring a change not only with respect to resources used — departure from fossil fuels towards renewable energy sources, but also to the structure of electricity production and distribution. One of the biggest challenges of transition is the shift from a system based on large generation sources to a distributed structure, where local energy sources will play a key role in satisfying energy customers' demand.

Such a change cannot be implemented without active participation of local governments, which will face a tremendous challenge, but also a great opportunity to improve own efficiency, competitiveness and security.

Energy and its carriers are a core element of each activity pursued by a local government: street lighting, public transport, heating and lighting in public buildings or district heating are, from a local point of view, highly energy-intensive. A local government that has to purchase all energy carriers from external sources becomes utterly defenceless against the increase in their costs. Only between September 2020 and September 2021 the weighted average price of electricity increased by more than 91%, what for average-sized cities translated into several million PLN of additional expenditure — funds that could otherwise be spend on investment.

However, notwithstanding economic pressure, local governments' attitude to energy transformation continues to be passive. In accordance with Article 37 of the Electromobility and Alternative Fuels Act of 11 January 2018, a local government unit, with the exception of municipalities and districts with a population not exceeding 50,000, prepares, every 36 months, an analysis of costs and benefits related to the use of zero-carbon buses in provision of public transport services. However, an audit carried out in 2020 by the Supreme Audit Office demonstrated that only three out of 26 cost-benefit analyses disclosed during the audit indicated legitimacy of investments in carbon-free public transport.

The reasons should be sought primarily in the lack of funds for independent implementation of energy-related investments, but also in shortage of competences. A distributed energy production and distribution system causes local governments to become players on the broadly construed energy market, requiring support of experts in the field.

THE ROLE OF ENERGY CLUSTERS

A key role in supporting local governments on their way through energy transition could be played by energy clusters — local frameworks that may comprise inhabitants, entrepreneurs, public bodies, R&D units and local governments themselves. The purpose of the framework should be to reach local energy independence, where locally produced energy fully satisfies the demand of local customers. Competence base should be provided by cluster coordinator — an external, expert entity determining milestones of local energy transition.

Energy independence of local governments not only improves efficiency of the public sector, but also increases competitiveness in attracting external investors. Traditionally, competitiveness of a local government unit was identified with its key determinants: local economic activity, labour market and human capital. Recent years clearly indicate a new trend, where investors, lenders and asset managers throughout the world expect power utilities not only to be profitable, but also ethical. This in particular applies to environmental and social matters. For automated and computerised industry, the possibility to obtain clean energy from local, renewable sources is as important as availability of qualified personnel.

Therefore, to accommodate all needs of local stakeholders, local governments together with energy clusters and their coordinators should prepare Local Energy Transition Strategies, encompassing not only the next several years of the European Union's budget, but a longer horizon, reaching 2050, when climate neutrality may become a reality.

The strategy should be comprehensive and apply to all energy consumed on the area of a given local government — not only by public infrastructure, but also residential buildings and local enterprises. This will enable additional synergies to be achieved, bringing benefits to the entire local community.

LOCAL ENERGY TRANSITION

PV installations located on school rooftops are quite efficient during the holiday break in the summer, when educational buildings are practically shut down.

However, this electricity can be consumed by commercial or production facilities equipped with air conditioning systems that consume most electricity during hot, summer days.

Cogeneration is a very effective tool for the production of electricity together with heat, which may be used to heat buildings in the heating season. During the summer, the heat may be used for production processes in local enterprises or in trigeneration solutions, where excess heat can be used to produce cooling.

Distributed energy sources include not only small installations forming part of technical infrastructure of residential and commercial buildings, such as rooftop PV installations or community cogeneration plants, but also large, commercial investments — wind and PV farms — with a capacity that may exceed 100 MW. However, these are still unstable sources, whose efficiency depends on atmospheric conditions.

Therefore, it is necessary to combine wind and PV with solutions that smooth out their operation. Such solutions include energy storage facilities, but also water electrolysers. Hydrogen produced in electrolysers will be a clean and inexpensive fuel that may be used to supply hydrogen-powered buses used in public transport.

Transition should be comprehensive not only with respect to covered sectors, but also applied technologies. Electricity for street lighting, consumed during the night, cannot be secured only from PV installations that produce electricity during the day and — in Polish climate conditions — primarily during the summer. To satisfy such needs, one has to invest in energy storage facilities or stable renewable energy sources (such as biogas or biomass installations).

Such a comprehensive, local energy transition entails constant tracking of both sides of the equation. One the one hand, there is production capacity of energy producers. On the other — the needs of customers.

Therefore, next to investments in local energy sources one cannot forget to decrease energy demand among its customers:

- Comprehensive thermal efficiency improvement allows for decreasing consumption of heat in a building by as much as 60%.

- The use of energy-saving, LED-based street lighting allows for saving 40% of electricity and improves road lighting quality. Similar effects may be achieved for internal lighting in public utility and multi-family buildings.

- Recuperation systems allow for recovering 30–50% of heat that otherwise would have been discharged to the atmosphere.

A gradual decrease in energy consumption entails not only decreased consumption of fossil fuels and reduced greenhouse gas emissions, but also actual savings on costs incurred to purchase energy and its carriers.

LOCAL SMART METERING

Efficient management is a core aspect of operation of a sound enterprise. This should also apply to local government activity with respect to energy. Knowledge stemming from monthly settlements, electricity bills or information on generation capacity of a given energy source is insufficient to administer a rational energy policy, which should be based on data answering at least the following three questions:

- Where? — What facility consumes energy and what kind of energy (electricity, heating or cooling)?

- How much? — How much energy is consumed?

- When? — At what time (in particular, what time of the day) is the energy needed?

Only then one can determine what energy sources, distribution systems and energy storage facilities are needed to achieve local energy independence.

Next to investments in generation sources and decreased energy consumption by customers, energy transition requires a third leg — an energy management system based on smart metering, a solution providing much more data than a regular energy meter, and allowing for data processing in real time.

However, energy management system is not only a tool for passive acquisition of information. It provides an opportunity to actively manage the power system: adjust lighting intensity to atmospheric conditions, control heating and air conditioning systems depending on the number of persons in a room, or automatically start charging electric vehicles when electricity is least expensive. This is yet another component of energy efficiency that could be implemented and is economically efficient with technological solutions that are readily available.

One cannot forget about education and information on the way towards energy independence. Energy clusters may constitute an invaluable platform for exchange of knowledge between entrepreneurs, related to their experience in optimisation of production processes energy-wise.

Local generation sources, in particular based on renewable sources, and energy-efficient energy customers connected by an energy management system are core components of local energy independence that will ensure:

- Energy security and improved stability of supply of local customers.
- Independence from volatility of energy and fuel prices on global markets.
- Decreased use of fossil fuels and lower carbon dioxide emissions.

The achievement of local energy independence brings effects beyond the energy sector itself. Clean, inexpensive and locally-sourced energy constitutes an important element of investment attractiveness of a local government. Improvement in energy efficiency contributes to gradual reduction in CO2 emissions and fossil fuels use. Carbon neutrality of public transport and transformation of heating system from traditional, coal- or gas-based to a green one, using hydrogen technologies and heat pumps substantially contributes to the improvement of air quality. Therefore, beneficiaries of energy independence are not only energy sector entities or members of an energy cluster, but the entire local community.

CHAPTER 5.
ELECTRIFICATION OF THE ECONOMY

Electrification of the economy on the basis of energy from renewable sources is one of the core methods to achieve climate neutrality. High prices, fuel risks, war started by Russia, financing limitations will redirect investors' attention to clean sources of energy, free from many investment risks. The definition of what we see as expensive will soon change — energy storage or green hydrogen will prove commonly affordable compared to expensive coal and gas. Renewable sources, in particular wind and sun, having zero fuel costs, will be the most desired investment, both among the community and financial institutions. Some people already dub renewable sources the "energy of freedom".

On 24 February 2022 the world has rocked to its core — Russia brutally attacked Ukraine. The background lies not only in Putin's imperialistic designs, but also energy war. These events will affect the way we think about energy.

Last year fossil fuels contributed more than PLN 600 billion to the Russia's budget — approximately 1/3 of total revenue. For years, the sale of fuels allowed Russia to develop its military power and global influence. The prices started to soar in summer 2021, increasing pressure on European Union states. Certainly, Vladimir Putin is irritated by the EU's plan to abandon carbon-intensive fossil fuels. This is the core objective of the Fit for 55 package, which is to contribute to limiting climate change.

The attack on Ukraine caused Europe to commence analyses concerning possible resignation from the import of fossil fuels from the East. War in Ukraine will accelerate phase-out of such fuels in Europe. The question is: how to fill in the gap?

In 2019 the share of Russian fuels in European Union reached:
- oil — 26.7%,
- coal — 46.7%,
- gas — 41% [1].

In Poland, Russian fuels amounted to [2]:
- 67% of oil,
- 15% of coal,
- 47% of gas.

Cutting Russia from energy revenues is a must. However, it won't be easy or inexpensive. The market is very anxious, what results in high price volatility, mortal to investors.

1 https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2c.html#carouselControls?lang=en
2 https://www.forum-energii.eu/pl/blog/import-paliw-kopalnych

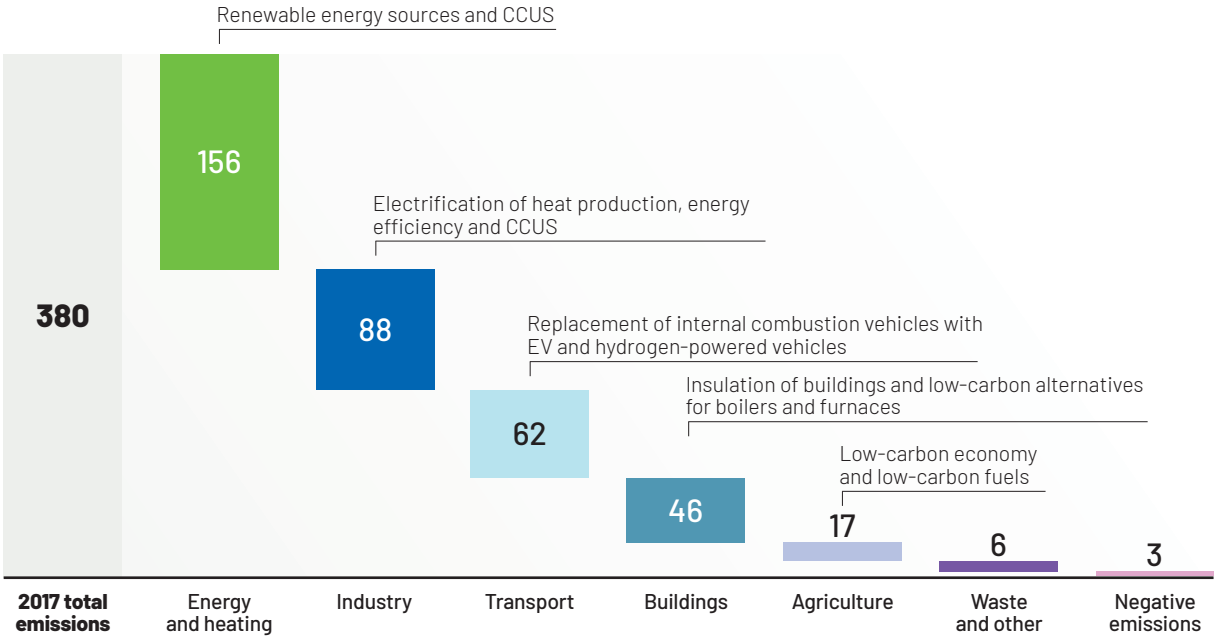
The future of energy sector lies in:
- Energy efficiency.
- Renewable energy sources.
- Electrification.
- Smart sector coupling.

In this chapter we will focus on the last two issues, which are strictly related to energy efficiency and RES development.

PATH TO CARBON NEUTRALITY

Electrification means using electricity instead of direct combustion of fuels — coal, gas, oil. In the last decades we saw a number of waves within the process. At the beginning of the 20th century, 40% of all vehicles in the USA were steam-powered, 38% were electric vehicles, and 22% used internal combustion engine. Implementation of an efficient, four-stroke engine determined its mass application in transport. In the 1950's, due to low electricity prices and poorly developed gas network in the USA, the country promoted electrification of households. The next wave of electrification is observed today, in Europe, due to the EU's plan to achieve climate neutrality in 2050. As demonstrated by McKinsey, electrification is the key tool enabling the achievement of that objective. Fig. 1.

FIG. 1. **KEY DECARBONISATION MEASURES** [$MtCO_2e$]



SOURCE: McKinsey 2020.

Next to energy, most carbon-intensive and fuel-consuming sectors include transport, building heating, industry and agriculture. They will have to undergo a radical change — soon.

Electrification of subsequent sectors of the economy will increase demand for electricity. To ensure cost efficiency and avoid increased fuel consumption, it must be related to substantial improvement of energy efficiency and development of renewable sources, in particular carbon-free. Fuel used to produce electricity from wind and sun is free and is produced locally.

Development of renewable sources entails major changes for the operation of the power system. Customers will use electricity in a manner different than we know today.

Electricity will be consumed with increasing awareness — depending on the time of day and year, electricity prices will vary substantially. Smart meters will enable us to adjust consumption to costs — start equipment when the prices are low.

Electricity will be produced locally, for own needs, with surplus sold to the grid.

Household energy storage (including vehicles) will supply electricity to the system in times of shortage, allowing us to take advantage of high prices.

Aggregators will appear — electricity vendors that will support households and small enterprises in making profit on wholesale electricity market.

There is no doubt that the design and operation of the power system of the future will be very different from what we know today. Similarly to Internet, which changed the way we communicate with the world, or airplanes that changed the model of travel. Flexibility, construed as the ability to rapidly adapt to changing demand for and supply of electricity, will be key. To ensure stable supply of electricity, the system needs to act smart — create opportunities for active participation in balancing by reducing or increasing energy consumption.

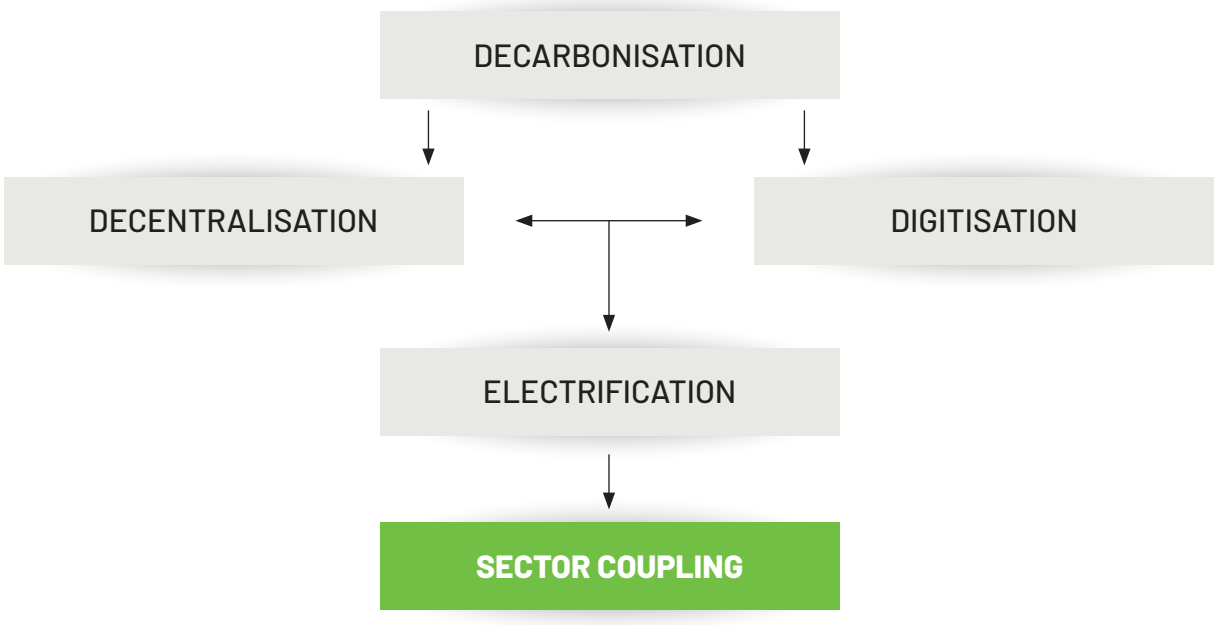
This is what the energy industry calls sector coupling — in other words, smart electrification. The goal is to have a power system that is not only low-carbon, but also cost effective and safe. Evolution of the power system is presented in Fig. 2.

Wise sector coupling and inclusion thereof in the energy sector is important for many reasons:

- Rationalisation of costs — for instance by combining energy storage with heating or electric trnasport.
- Increased stability of supply — stemming from increased flexibility of the power system, i.e. its ability to rapidly respond to variable supply and demand. Flexibility is the core feature of safe energy system of the future.
- Reduced CO2 emissions — through displacement of electricity produced by combusting fossil fuels by electricity from OZE.
- Increased energy security — by limiting fuel import.

The biggest potential for electrification — due to high fuel consumption and available technologies — is exhibited by heating, transport and industry. Let us take a closer look at these sectors.

FIG. 2. **THE FUTURE OF THE ENERGY SECTOR**



SOURCE: Forum Energii 2020[3]

TRANSPORT

Transport is responsible for approximately 15% of greenhouse gas emission in Poland. We are using more than 20 million of internal combustion engine vehicles. A substantial part of the fleet is older than 14 years. Emissions from the transport sector are fastest-increasing among all sectors of the economy.

Internal combustion engine will be replaced by electric or hydrogen-powered vehicles. They already became a common form of transport, with the number of vehicles increasing fast. In some countries — Norway for example — sales of electric vehicles are higher than vehicles using internal combustion engine. In accordance with the 2021 BNEF scenario, in 70% of vehicles sold in 2040 will be electric [3]. However, the scenario did not anticipate the war and additional regulatory incentives, such as the ban on the sale of internal combustion engines in the EU from 2035.

Analyses by Forum Energii (2020 [4]) demonstrate that in 2050 electric vehicles in Poland will consume 57 TWh. Today, total electricity demand in Poland reaches approximately 170 TWh. The total number of vehicles will decrease. Electric vehicles will constitute 82% of the fleet. Public transport and car sharing will continue to develop, in particular in cities.

3 https://www.forum-energii.eu/pl/analizy/integracja-sektorow
4 https://about.bnef.com/electric-vehicle-outlook/

ELECTRIFICATION OF HEATING

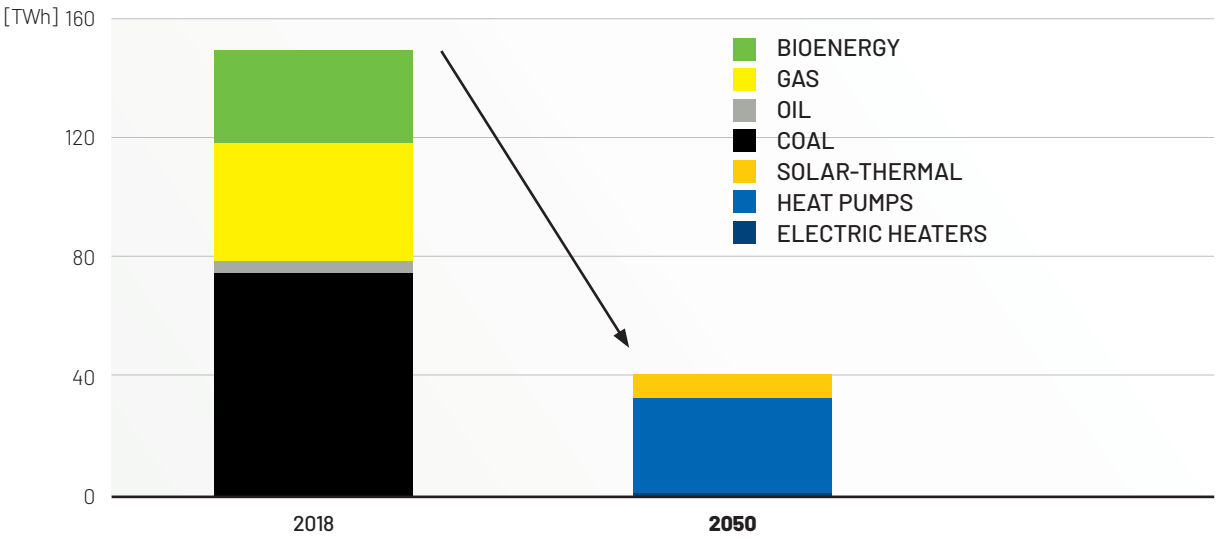
Heating exhibits even higher potential for electrification. The sector is responsible for approximately 11% of greenhouse gas emissions in Poland, with heat being produced from coal, gas, biomass and electricity. 60% of coal is imported from Russia. The decision to phase out that fuel, made by the government in March 2022, means acceleration of coal withdrawal — its prices will continue to rise.

This opens a new opportunity for Poland to accelerate the fight for clean air by installing more heat pumps. Currently, the equipment is expensive. Installation costs are rather high, too. Once it becomes more popular, the prices will start to decrease. Today, it is important to support the purchase of heat pumps from EU funds of the budget, using monies gained on the sale of CO2 emission allowances. Rational support for the development of the installation market through training and appropriate building codes will also be important to limit unprofessional conduct.

The core measure to electrify heating in Poland must be based on improvement of energy efficiency of buildings and better energy management. Analyses carried out by Forum Energii (2020) demonstrate that as a result of thermal efficiency improvement as well as warming of the climate, in 2050 the demand for heat in buildings will decrease by more than 70% . In 30 years 100% of heat will be produced form electricity and solar-thermal collectors used to heat water.

The same analysis demonstrates that demand for electricity in the heating sector will reach approximately 11–13 TWh. For district heating, the energy mix will be much more diverse. In 2050, green hydrogen and, probably, biomethane, biomass and large-scale heat pumps will prevail.

FIG. 3. **ANNUAL CONSUMPTION OF HEAT AND HEAT SOURCES IN INDIVIUDAL BUILDING HEATING**



SOURCE: Forum Energii 2020

ELECTRIFICATION OF INDUSTRY

Industry is responsible for approximately 20% of greenhouse gas emission in Poland. The sector generates 25% of GDP and provides employment for approximately 32% of workforce. For years it has been developing without any strategy, in particular with respect to decarbonisation. Increasing emission allowance costs and requirements for carbon footprint reduction will put an ever-increasing pressure on the industry.

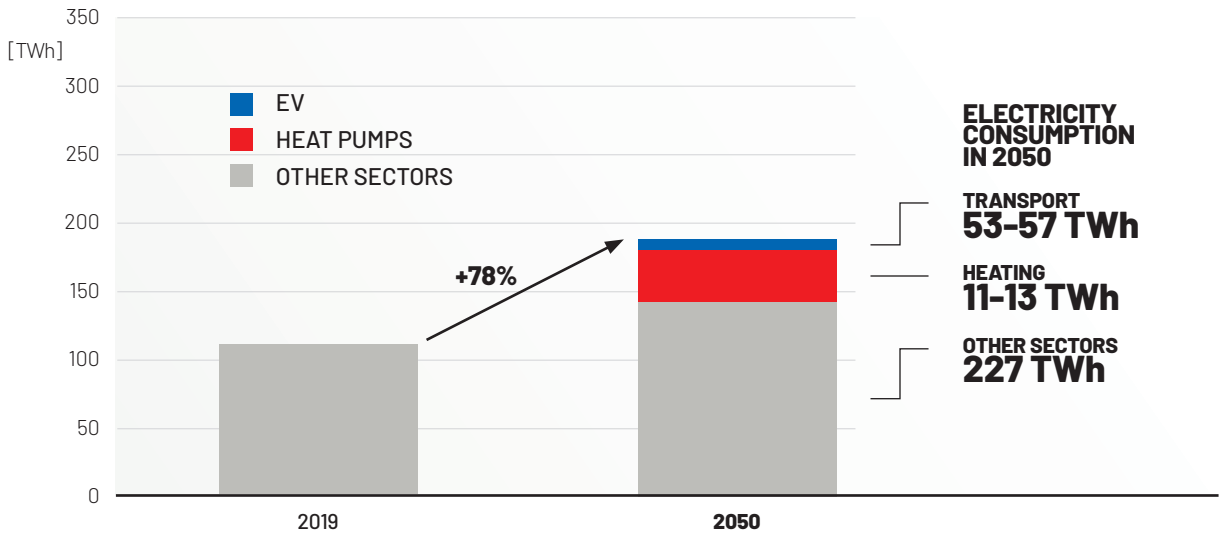
The majority of emissions are generated by the steel, cement, fuel and chemical industry. According to McKinsey (2020), a 97-percent improvement of energy efficiency, electrification of the production of heat, and carbon capture, utilization and storage (CCUS) technologies may bring a 97-percent reduction of greenhouse gas emissions from the industry by 2050.

Fundamental measures to decarbonise the industry and limit electricity costs include long-term PPAs with renewable energy sources — primarily wind. However, this would require elimination of the so-called 10 h rule (liberalisation of the so-called Distance Act), which currently effectively blocks onshore wind development.

ECONOMIES OF SCALE

Electrification of sectors means constantly increasing consumption of electricity. It may be expected that the consumption will increase from approximately 170 TWh currently to almost 300 TWh in 2050 perspective, depending on technological progress and improvement in energy efficiency.

FIG. 4. **ELECTRICITY CONSUMPTION IN 2050.**



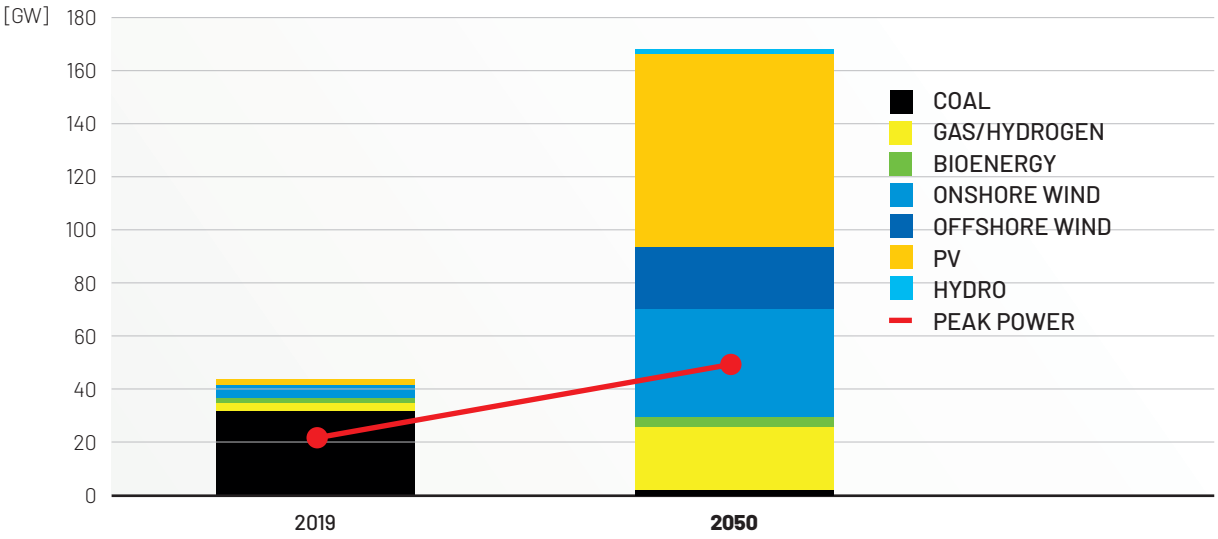
ŹRÓDŁO: Forum Energii, 2020

Electrification of subsequent sectors of the economy means that the power system will grow in size, in particular in terms of installed capacity in renewable sources.

To balance the system in 2050 we need to almost four times the current installed capacity — it has to increase from the current 50 GW to almost 200 GW. Achievement of that target requires construction of 5 GW of renewable capacity eery year and a very economic space management. It will be necessary to streamline spatial planning to avoid development of areas valuable for agriculture or the environment.

In the future, natural gas will be displaced by green hydrogen. Coal, if ever used, will form cold reserves, launched only when the power system will not be able to balance itself.

FIG. 5. **M\INSTALLED CAPACITY: 2019 VS 2050 ESITMATES**



SOURCE: Own study

PROGRAM CZYSTA POLSKA

Common and rapid transition to renewable energy sources is a challenge, but also part of the solution. Wise electrification is the key to modern, zero-carbon and cost-efficient economy. Electrification of heating and transport will entail large-scale use of energy storage. This will substantially increase the possibility of flexible and safe operation of variable renewable sources.

Following the Russia's attack there were voices that Poland should return to coal. The myth of gas as a transitory fuel has collapsed. Perhaps we will use coal for 2-3 years longer — paying a high premium, for after many years of exploration its resources in Poland are starting to dwindle. However, the sooner we shift our energy sector to modern requirements, the less expensive and safer it will be for us. De-russification and decarbonisation go hand in hand.

CHAPTER 6.

DEVELOPMENT OF HYDROGEN TECHNOLOGIES

Russian aggression in Ukraine made public aware how much Europe, including European Union, depends on Russian fossil fuels such as gas, used in all sectors of the economy, from energy, through transport, to chemical industry. In these difficult times we increasingly often ask ourselves: how Europe may quickly become independent from Russian fuels? The answer is well known: "hydrogen". The gas may successfully replace fossil fuels in transport, energy or chemical industry.

Currently, hydrogen is usually used in the chemical industry. It is rare in transport, and almost nonexistent in the energy sector. Hydrogen used today is usually produced through separation from fossil fuels, such as methane or coal, and is commonly known as "grey" and "blue" hydrogen. Therefore, its production deepens our dependence on fossil fuels. To avoid this, it is necessary to produce "green" hydrogen, independent from fossil fuels. This type of hydrogen is usually produced by electrolysis, a process where the gas is released using energy from renewable sources, such as wind or PV. This method of hydrogen production brings two benefits: first, the process has minimum environmental impact, and second, it allows for accelerating energy transition and using renewable energy sources in the most efficient way, contributing to faster and easier integration of such sources in power systems.

Therefore, why green hydrogen is not commonly used today? The answer is simple: it is more expensive than hydrogen produced from fossil fuels. High cost is caused by imperfect electrolysis technologies, not yet used at a large scale. Nonetheless, current funding allocated to development of the technology will soon result in a rapid increase in the number of such investments, resulting in decreased production costs — an effect similar to what we observed with renewable energy sources. Originally, RES were incapable of competing with fossil-based energy. Now they are much less expensive. The decrease in technology prices is accompanied by a similar improvement in efficiency — today, certain RES are much more efficient than even the best coal-fired units.

GREEN HYDROGEN AND ENERGY TRANSITION

Energy transition is a process we are witnessing for almost thirty years, characterised by displacement of fossil fuels by energy from RES. As we all know, such sources are variable, which means that at certain times during the day and year they operate at (near) full capacity, but also periods with little to no energy from such sources. Therefore, from the perspective of the power system, desirable solutions allow for "harnessing" and stabilising these sources to enable the power system to use them on a continuous basis. These solutions

should accommodate surplus energy resulting from surplus production of electricity in low demand periods and allow for using the stored energy in the power system in times of shortage, caused for instance by downtime of renewable sources. Additionally, the entire process should be financially acceptable and bring added value for the economy. Therefore, the best solution combining all these elements is hydrogen, which perfectly matches the needs of energy transition and gives full synergy with the needs of the entire economy.

Furthermore, increasing number of RES in the system producing inexpensive, green electricity gives an opportunity to produce inexpensive green hydrogen (competitive with fossil-based hydrogen), which can subsequently be used to produce energy or in industry and transport. Therefore, a switch to hydrogen economy closes the entire transition cycle, causing it to fulfil its role not only in terms of ecology, but also economic efficiency of the entire economy.

DEMAND FOR HYDROGEN IN THE ECONOMY

In 2018, the global hydrogen production amounted to approximately 115 million tonnes. Poland is producing approximately 1 million tonnes per year and is one of the largest producers in Europe. Almost all production, in Poland and worldwide, is based on fossil fuels. Currently, the use of hydrogen in the economy may be termed as low. Hydrogen is used primarily for oil refining (approximately 33%), ammonia production (27%), methanol production (11%) and steel production (approximately 3%) — these areas will be the core hydrogen customers in the future. Nonetheless, the consumption structure will change, and the above core customers will also include dynamically growing transport and energy sectors. The demand presented above is fully satisfied by fossil fuels. However, it should be expected that in the future it will be fully satisfied by green hydrogen, produced in amounts sufficient to cover almost 100% of the demand. Therefore, as long as green hydrogen production is not launched at an industrial scale, the demand for hydrogen will remain relatively stable.

A breakthrough in demand for hydrogen may be caused only by large-scale production of its green variety. However, due to rather early stage of technological development, it is difficult to say when this will happen and what will be the demand for hydrogen in particular years. Certain guidelines in that respect can be found in the plans stemming from the documents published by the European Commission, including Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions dated 8 July 2020 — "A hydrogen strategy for a climate-neutral Europe". In accordance with the strategy, we may expect that in 2024, electrolysers with a capacity of 6 GW, producing more than 1 million tonnes of hydrogen, will be installed in the EU. In 2030, this will be more than 40 GW, producing more than 10 million tonnes.

The "Polish Hydrogen Strategy by 2030 with an Outlook until 2040", published in October 2021, assumes that around 2030 the production of hydrogen from low-carbon sources in Poland could reach almost 200 thousand tonnes.

A forecast of demand for hydrogen in the next 30 years has been presented by the Polish Wind Energy Association and the Lower Silesian Institute for Energy Studies in a report entitled "Green hydrogen from RES in Poland. The use of wind and PV for the production of green hydrogen as an opportunity to implement the assumptions of the EU Climate and Energy Policy in Poland". The report demonstrates that the demand will grow rapidly and may reach close to 1.4 million tonnes in 2030, 2.6 million tonnes in 2040 and as much as 3.4 million tonnes in 2050. Core customers will include industry, consuming almost 1 million tonnes in 2050, transport — approximately 1 million tonnes, heating — approximately 0.5 million tonnes and energy sector, which will become the largest hydrogen user, consuming in excess of 1 million tonnes.

Because almost all hydrogen will be produced from renewable energy sources, we need to take action to accelerate development of such sources. With the current growth rates, the values assumed above are unfeasible. Production of 3.5 million tonnes of hydrogen per year in 2050 perspective requires 112 TWh of electricity only for that purpose. This is approximately 65% of the current electricity demand in Poland, what demonstrates the scale of the challenge faced by the power system in Poland. It has to be emphasized that the 112 TWh should be produced from renewable energy sources. Assuming wind only, with average capacity factor of 40% (on the basis of operational experience onshore and offshore), this requires construction of more than 30,000 MW. Currently, wind energy contributes only 7,000 MW, less that 25% of demand for renewable sources for hydrogen production in 2050. The above demonstrates how important and necessary is to accelerate works on the construction of renewable energy sources in Poland.

MEASURES NECESSARY TO FULLY IMPLEMENT HYDROGEN ECONOMY

The future of the economy depends on hydrogen produced from renewable energy sources — clean, "green" hydrogen. To date, green hydrogen was perceived as an opportunity for faster integration of renewable sources with the grid. However, currently renewable sources are seen as an opportunity for transition of the entire economy and switching it from coal to hydrogen. Today, the role of hydrogen for the development of the economy becomes similar to the role of coal for early-industrial economies of the 19th century. Hydrogen is an opportunity not only for technological, but also ecological breakthrough. However, transition is not an easy task. It brings a number of challenges that require a number of measures with respect to technological progress and regulation.

Below are the key measures that should be applied:

- Support for R&D related to green hydrogen production.
- Construction of renewable energy sources.
- Construction of green hydrogen storage, in particular underground.
- Adaptation of infrastructure to enable transmission of hydrogen.
- Support for development of the hydrogen market.
- Development of technologies enabling the application of green hydrogen in the energy sector.
- Support for development of charging infrastructure for hydrogen-based transport.
- Elimination of legal barriers limiting the development of hydrogen economy.
- Development of support schemes enabling green hydrogen to compete with fossil-based technologies in the transitory period.

One of the more important measures specified above is the support for R&D, which opens an opportunity to accelerate the development of technologies used to produce green hydrogen and allows for seeking new, less expensive and more competitive technological solutions. To this end, it is crucial to rapidly commercialise technology. Therefore, similarly to renewable energy sources, it is necessary to introduce support schemes, in particular in the first phase of implementation, to eliminate the barrier caused by technology costs. A key role in the transition to hydrogen economy will be played by the energy sector, which — together with heating — will be responsible for almost half of demand for hydrogen.

Therefore, it is necessary to support technologies that will improve the efficiency of hydrogen use for energy purposes. Currently, the efficiency of such processes is very low — less than 30% — meaning that more than 70% of energy is lost. Without technological breakthrough in this field, the application of hydrogen for energy purposes is almost impossible. For that reason, we have to support Power-to-X technologies (for instance, Power-to-Gas) and technologies enabling efficient hydrogen combustion, including the application, in the transitory period, of technologies enabling combustion of methane together with hydrogen, enabling the use of currently existing gas-fired generation units. Moreover, development of hydrogen-based transport is a very important element of the support for hydrogen. Transport based on fossil fuels will soon see a price revolution, related to the ETS reform that will include also this sector and the rising global fuel prices. The latter element may particularly contribute to the acceleration of the transition, because Europe has no natural resources enabling security of supply, making it dependent on supply from outside — meaning Europe cannot influence fuel prices. Therefore, it is necessary to start hydrogen transition with support for the development of hydrogen-based public (municipal) transport, rail transport and heavy goods carriage.

However, the key to the development of hydrogen economy is to unleash the potential for the construction of renewable energy sources, in particular wind energy. Currently, onshore wind, whose estimated potential could satisfy hydrogen demand in the 2050 perspective, is blocked by the so-called Distance Act, which excludes more than 95% of area of the country from wind energy investments. Measures limiting the development of renewable energy sources may make the concept of making the economy hydrogen-based impossible to implement.

CHAPTER 7.

RESIGNATION FROM COAL, FOSTERING CARE FOR THE CLIMATE AND POPULATION

Coal is the main fossil fuel in Poland, combusted to produce 70% of electricity and more than 90% of heat. Decarbonisation means not only the need to build new generation capacity, but also to eliminate economic monocultures in areas where coal is currently mined and combusted. Hard coal from mines in Silesia and Dąbrowa Basin constitutes the majority of the fuel combusted in Poland. However, the largest power plant in Poland is lignite-fired Bełchatów, with installed capacity of 5 GW, satisfying 25% of electricity demand in Poland.

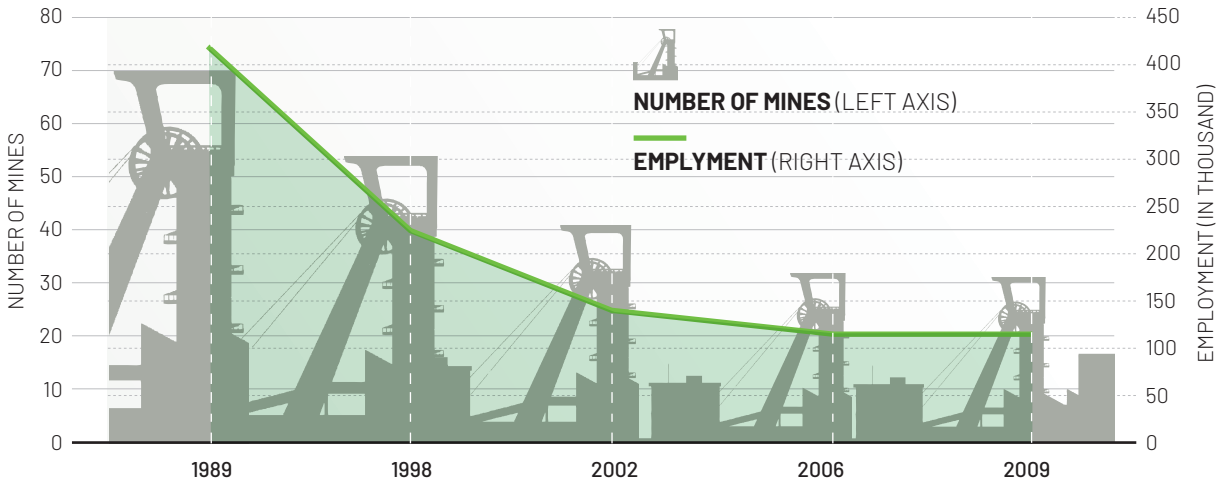
The Bełchatów Power Plant is the largest CO2 source in the European Union and the largest conventional power plant in Poland and the EU, and one of the largest in the world. Next to Bełchatów, lignite is also combusted in Pątnów-Adamów-Konin Power Plant Complex. The group, owned by Zygmunt Solorz, decided to phase out the coal-fired units and lignite mining by 2030. The Turoszów region is the last area where lignite is mined and combusted. According to plans, exploration of local deposits is to end around 2040.

However, the majority of electricity and heat is provided by power plants and CHP installations fired with hard coal mined in Silesia, the Dąbrowa Basin and Bogdanka mine in the Lublin region.

GOVERNMENTAL PLANS FOR RESTRUCTURING OF MINING

In accordance with the social contract concluded in 2021 between mining trade unions and the government, coal in Poland is to be mined and combusted until 2049. The mines in Silesia and the Dąbrowa Basin are to be successively merged and phased out — a process spread over three decades. Currently, there are 20 hard coal mines, employing approximately 78 thousand miners. Is 30 years to shut down 20 mines a lot of time? Indeed — Jerzy Buzek's government shut down 23 mines in 4 years, causing more than 100 thousand employees to voluntarily leave the mining sector.

FIG. 1. **EMPLOYMENT IN THE MINING SECTOR AND NUMBER OF HARD COAL MINES, 1989-2009**



SOURCE: Henryk Paszcza, *Procesy rekrutacyjne w polskim górnictwie węgla kamiennego w aspekcie zrealizowanych przemian i zmiany bazy zasobowej, Górnictwo i Geoinżynieria*, year 34, volume 3

Where in the Jerzy Buzek's times domestic mines provided excess coal and Poland exported produced electricity to our neighbours, today we are importing both coal and electricity. The current system is inefficient in many ways. More importantly, prices of electricity and heat produced by combusting coal are very high, not only due to increasingly expensive fuel, but also CO2 emission allowance prices within the EU ETS. This is a scheme established by the European Union to encourage Member States to abandon fossil fuels in the energy sector and industry.

DEPARTURE FROM COAL

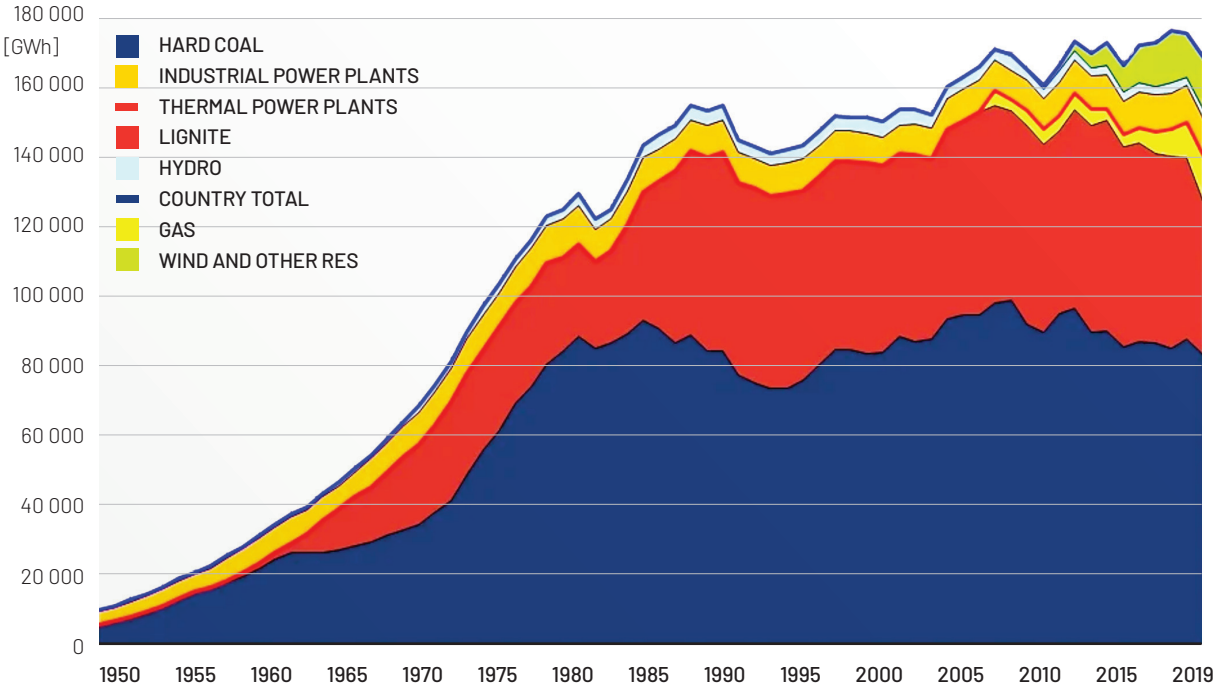
The social contract mentioned above, signed in 2021, assumes that hard coal will be mined in underground mines until 2049. Depending on deposits, lignite exploration is to end in mid-2030s to early 2040s — this is how long the currently explored resources will last. During the Glasgow Climate Summit (COP 27) Poland declared phasing out coal by 2040 — 9 years earlier than stipulated in the social contract with the Silesian miners.

The "State Energy Policy" adopted by the government in 2021 assumes that the share of coal in energy mix in 2030 will decrease from the current 70% to 56%, and in 2040 will be not higher than 28%. At the end of February 2022, in the face of the Russian aggression in Ukraine, the government announced an update to the energy strategy, in accordance whereof in 2040 the share of RES in the energy mix is to reach 50%, and the purpose of the update is to eliminate coal, oil and gas from Russia. A detailed update to the document is to be developed in the future.

Coal phase-out scenarios depend on a number of variables, including the previously mentioned CO2 emission allowances and the construction of new generation capacity. In accordance with Instrat Polska, Poland could phase out coal by 2030 if it builds enough capacity in renewable energy sources, such as PV, onshore and offshore wind.

How fast coal will be phased out depends on two factors — creation of new electricity generation units and the capability of the transmission system to accommodate this capacity. With such a strong dependence on coal to produce electricity, rapid switching to new energy sources is not possible for technical reasons — there is no sufficient new capacity that could replace coal-fired units.

FIG. 2. **ENERGY MIX IN POLAND, 1950-2019**



SOURCE: Polskie Sieci Elektroenergetyczne

PROGRAM CZYSTA POLSKA

Another issue is the so-called generation gap, which we may face in the next years — decommissioning of 200 MW coal-fired units built in the 1970s and 1980s. Their lifetime is coming to an end, and no sufficient new units capable of balancing decommissioning of old, coal-fired power plants have been built.

In 2021 electricity production in Poland amounted to 174 TWh, of which 127 TWh in coal-fired plants. Renewables (onshore wind and PV) contributed 30 TWh of electricity. Constraints in the growth of new RES capacity are caused primarily by legislative determinants — the so-called Distance Act (10 h) blocking onshore wind development, and by technical limitations, i.e. non-adaptation of the transmission grid to operation with distributed and weather-dependent energy sources, resulting in the lack of connection capacity.

Following Russian aggression in Ukraine, gas, which was to be the fuel of transition, may lose its role. In the update to EPP 2040 the government wants to phase out fuels imported from Russia as soon as possible. However, European market is lacking the additional 150 billion cubic metres of gas that could fill in the gap after phased-out deliveries from the East. This means that Europe will face shortage of gas, resulting in high prices. Therefore, the price of electricity and heat produced from expensive gas will also be high.

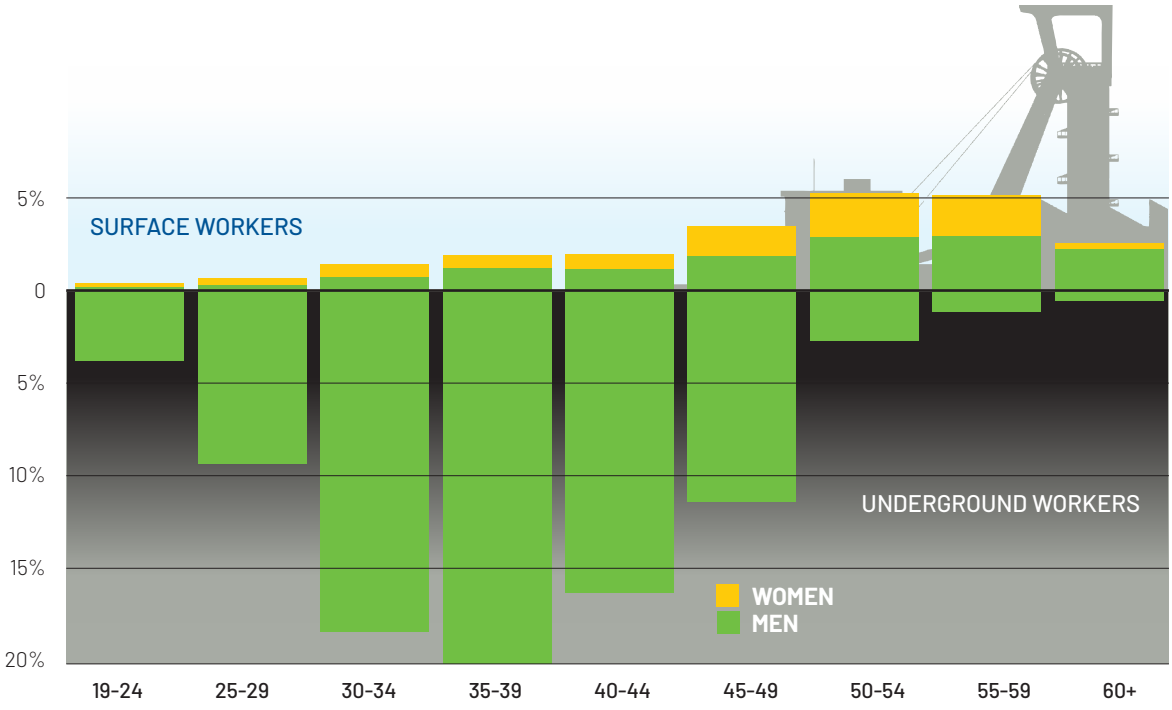
Coal-fired plants should act as a system stabiliser for RES electricity until nuclear units — both large and SMR — are built. In parallel we should work on solutions fostering hydrogen technologies, primarily on the increase in electrolyser efficiency, to decrease the price of hydrogen and energy obtained from its combustion in a gas turbine.

JUST TRANSITION

In the discussion on phasing out coal, we cannot forget that people should be in the centre of the transition. Whatever energy technology we will apply and whatever coalexit date we set, we need to consider the people that mined the coal and combusted it in power plants. The mine decommissioning programme mentioned above, implemented by Deputy Prime Minister and Minister for Economy, Janusz Steinhoff in 1997–2001 not only provided for generous severance pay for miners resigning from work, but also "miners' leaves", de facto allowing for early retirement with the right to the majority of salary.

Where in the times of Jerzy Buzek's government the miners found employment, for instance, in vehicle factories in Gliwice or Tychy, today those, who will decide to leave mines may count on employment in the broadly construed RES industry. This includes PV installers on the roofs of single-family hoses, through manufacture of electrical and electronic equipment managing the installations' operation, to construction of wind turbine components. The miners may also seek employment in other sectors. Industry is also evolving towards latest solutions basing on digital technologies. It is worth adding that 50% of currently working miners are younger than 40 — a workforce that can be trained and perfectly find their place in economy 4.0.

FIG. 3. **AGE AND GENDER OF EMPLOYEES IN THE HARD COAL MINING SECTOR**



SOURCE: IBS Research Report 01/2020

Silesia and the Dąbrowa Basin are regions with the lowest unemployment, located in the industrial heart of Poland, which requires highly trained personnel. The mining community is distinguished from other groups by labour ethos and high professional culture. However, in lignite regions we face economic monocultures. We should already create comprehensive transition and economic development plans for Bełchatów or Turów. An interesting example may be found in eastern Wielkopolska, where PV and wind farms are being built on areas adjacent to the current open-pit mines and coal-fired power plants. Moreover, projects related to hydrogen and production of electric vehicle batteries are also present in the region.

Another important factor that mining regions have to face is depopulation. In areas with economic monoculture and strong degradation of the natural environment, people — in particular young — are leaving for large cities to seek work and better living conditions. Therefore, local governments must create economic development plans for regions including not only investments in new jobs, but also in green spaces and recreation areas, cultural sites and social integration.

Post-mining wasteland is continuously causing harm. It should be rehabilitated as soon as possible. Funds for social and environmental measures have already been allocated in the Just Transition Fund. Poland is to receive more than EUR 4 billion from the Fund.

HEAT WITHOUT SMOKIES

Phasing out of fossil fuels will also affect individual heating. However, it is crucial to reduce energy demand. A broad thermal efficiency improvement programme for residential buildings needs to be launched as soon as possible. It will result not only in decreased energy consumption in buildings, but also economic growth through increased demand for construction materials, including insulation, and services.

Replacing coal-fired heat sources, people should consider technologies ensuring low operation costs. Paradoxically, the suspension by Polska Spółka Gazownictwa of the municipal gasification programme for the next two years is an opportunity for electrification of individual heating. With increasing gas, coal and electricity prices, the best solution is to combine a PV installation that will produce the necessary electricity with an electric heat source. Depending on the heating system applied, we recommend heat pumps as low-temperature sources for underfloor heating and electrode boilers for heating with heaters. Both purchase of a PV installation and replacement of a heat source may be co-financed by the National Fund for Environmental Protection and Water Management from the "Mój Prąd" and "Czyste Powietrze" programmes. Moreover, one may use biomass boilers, for instance pellet-fired, but this is a solution requiring more work to be used — the fuel has to be added to the hopper and ash has to be removed from the boiler on a regular basis. Furthermore, it has to be emphasized that the European Union is planning to cover individual heating with the CO2 emissions trading scheme, what in practice will entail taxation of installations producing exhaust gas in our homes.

Departure from coal will not only result in lower energy prices, increase in new RES capacity and increased economic growth, but will also contribute to the improvement in air quality and broadly construed quality of life. Coal mining entails emissions of methane — a very dangerous greenhouse gas — and causes a lot of damage, when buildings crack or roads subside as a result of shock. Moreover, exploration of pits produces millions of tonnes of industrial waste, which are very difficult to manage. Such areas face not only depopulation, but also lack of investments. In case of lignite pits, we face many square kilometres of highly degraded areas that will be very difficult to rehabilitate. Open pits resemble Mars landscape. Furthermore, lignite areas

face substantial water issues, as increasingly deeper pits drain water from neighbouring aquifers. Therefore, we need a wise plan for rehabilitation and regeneration of former mining areas.

The faster we abandon coal, developing new, carbon-free energy sources, investing in regional development and improving quality of life in former mining areas, the better chance we will succeed in carrying out a just transition.

CHAPTER 8.

REASONABLE INVESTMENTS AND DEVELOPMENT OF NEW TECHNOLOGIES

Green revolution is now widespread in Europe. Energy transition, zero-carbon, circular economy are not only slogans, but actual targets, whose implementation must be accompanied by substantial funding. It is capital-intensive, requires wise planning and effective supervision during implementation. Transition will involve all possible funds, including EU funds, public finance, debt and equity, as well as citizens' funds.

The pace of energy transition imposed in Europe is very ambitious. To achieve the desired goals, investments worth hundreds of billion EUR are needed, in particular in energy efficiency improvement, renewable energy sources, development of connection infrastructure and mitigation of transition effects in most affected regions. Investment challenges are related not only to delays in construction of renewable sources. The age of infrastructure, in particular generation units and grids, is a great challenge itself. Therefore, investments related to transition should be comprehensive and sustainable. Delays in transition require acceleration of measures to achieve the desired goals, what makes the actions taken in the recent years uncoordinated and chaotic. Therefore, today it is difficult to speak of sustainable and responsible transition, and the ambitious climate targets applicable to subsequent branches of the economy substantially affect economic and social costs. A long-term, stable transition strategy coupled with wise and efficient use of the EU funds will allow for avoiding unnecessary social costs and enable its implementation in the most efficient manner. It is particularly important to thoroughly plan spending of the vast budget allocated by the EU to achieve the targets set in the European Green Deal. It is time we took advantage of this unique opportunity.

FUNDS FOR TRANSITION

An efficient transition and development of a modern, ecological energy sector requires substantial investment expenditure. It is estimate that the figure may reach as much as PLN 1 trillion by 2050. Therefore, the process requires a stable and sustained financing.

Where to get the funds from? It is necessary to combine domestic and EU funds, resources of international and national financial institutions, institutional and individual investors (including households, in a manner similar to self-consumer installations).

The current economic environment, with rising inflation and substantial variations of currency prices, is not particularly friendly in terms of unleashing private investments at a larger scale. However, channelling equity to the energy sector, to be allocated to energy-saving solutions and "green assets", is an opportunity to mitigate the effects of inflation. Moreover, in times when money loses its value, it allows for achieving satisfactory return on equity.

Among domestic funds, the great amounts from the sale of CO2 emission allowances under EU ETS come first. 40% of these funds should contribute to the Energy Transition Fund. Depending on the actual amounts obtained from the sale (in 2021 the sale of CO2 emission allowances contributed approximately PLN 25 billion to the Polish state budget), it is estimated that by 2030 proceeds will amount to PLN 70–80 billion. At least some of these funds should be allocated to transition-supporting projects.

Public funds may also be used in the form of financial instruments enabling the effective launch of private financing. A crucial role in the support for green transition financing should be played by state-owned funds, such as the Polish Development Fund (PFR), which could support investors by granting the guarantees required by financial institutions funding such investments.

"Green" bonds, as a debt security, are another form of financing projects related to sustainable development. The range of projects that could be financed by bonds includes, but is not limited to:

- Renewable energy,
- Energy efficiency,
- Green building.

The above solutions, supported by debt financing provided by domestic and foreign financial institutions, will constitute a substantial source of equity required for transition. The use of financial instruments enables implementation of more projects with the same budget as well as higher economic profitability thereof.

EU funds will play a special role in the transition. EU allocated more than EUR 850 billion in funds and aids programmes for the next years, to be spent on transition in Member States. A substantial part of the funds may be received by Poland. Key financing sources include:

- Energy Transition Fund,
- Modernisation Fund,
- Just Transition Fund,
- InvestEU,
- National Recovery and Resilience Plan 2021–2023,
- Innovation Fund.

The key purpose of these funds is to finance the upgrade of the National Power System and improvement of energy efficiency through support for investments in the production and use of electricity from renewable sources and support for investments in energy storage and power, gas and heating network upgrade as well as construction of cross-border infrastructure.

A combination of different kinds of financing with a stable strategy and predictable legislation will form an ecosystem enabling fast and efficient transition. Without such a coherent ecosystem, attracting private investors or equity engaged in other markets on a large scale will not be possible. One must remember that in order to be effective, financing schemes must always be fully adapted to regional or local socio-economic, legal and banking environment.

COHERENCE WITH STRATEGY

The stream of funds allocated to Poland is wide, and the effects that could be achieved — crucial for our country, therefore a clear, long-term transition strategy should form the core of their spending. The needs of the power system at a national level have already been identified and include:

- Development of RES (onshore and offshore wind, PV).
- Energy and heat storage facilities.
- EV/H2 charging infrastructure.
- Improvement of energy efficiency of enterprises.
- Nuclear power development.
- Modernisation and extension of distribution and transmission grids.
- Implementation of hydrogen technologies.

Top-down methodology — development of a general, state-wide strategy followed by ensuring coherence of particular regions through, for instance, regional plans — should apply to all provinces in Poland. It is crucial for the state to coordinate coherence of the plans to achieve synergy and eliminate conflicting, inefficient or market-distorting projects.

At the same time, ESG schemes need to be implemented at the national level to prevent financing of projects inconsistent with the transition strategy and — in particular provinces — with territorial plans. Supervision over investment consistency with territorial plans should be vested in a non-governmental organisation selected in a competitive procedure. National-level coordination could be performed by a dedicated committee established by the Council of Ministers. The following should be considered as system-wide solutions:

- Considering financing projects inconsistent with transition strategy or territorial plans as a breach of public finance discipline.

- Introducing certain energy efficiency indicators for new projects.

- Promoting contractors reducing CO2 emissions in public contracts.

- Introducing an obligation to purchase energy from renewable sources by public finance institutions.

Transition strategy and regional plans, with clearly specified targets, taking into account the satisfaction of needs of the people, region and the state, should be the ultimate solution, independent from current political objectives. Regional plans would form and incentive for local authorities to plan energy management (production, consumption and management) in an efficient manner.

To achieve optimum effects, the strategy and regional plans should be periodically reviewed (approximately every 5 and 2–3 years, accordingly). Moreover, transparent change management schemes should be introduced to specify the procedures for amending the documents.

MORE THAN INFRASTRUCTURE

Investments are more than infrastructure. They also, or maybe — primarily, include trained and competent personnel. It is necessary to retrain people working in sectors that will be phased out as a result of the transition, such as mining. They should be transferred to sectors that could take advantage of their competences, such as wind energy, which will soon need at least several tens of thousand employees. It is crucial for the transfer to be as seamless as possible. Moreover, one cannot forget to adjust the profile and methods of personnel training for the purposes of the modern energy sector and economy 4.0. To this end, curricula need to be adapted and adjusted accordingly, and new majors need to be created.

R&D investments and programmes fostering cooperation between business and science will also form an important element of transition. Institutions such as the National Centre for Research and Development and the National Science Centre may play an important role. R&D programmes have to be financed in a manner supporting the development of technologies particularly useful in the transition process. Additionally, similarly to other projects, this requires strong supervision and commercialisation pressure to ensure that the highest possible number of financed R&D projects enter the market. To this end, financing should be targeted at universities and R&D institutes cooperating with entrepreneurs, and their work should be maximally useful for the business.

TARGETED SUPPORT

Adoption of a uniform and long-term transition strategy enables specification of "transition accelerators", used to achieve the objectives laid down in the strategy. Such accelerators are to constitute the foundation and driving force of the transition. Without doubt, in case of the Polish energy sector such accelerators will include:

- Renewable energy sources,
- Energy storage facilities and investments in grid modernisation and extension,
- Hydrogen.

The above investments areas are inextricable. Energy transition in Poland will not succeed without construction of a large number of new renewable sources. Their construction depends on access to grid infrastructure and its connection capacity. Availability of the capacity is affected by energy storage or green hydrogen production facilities.

Implementation of the accelerators will require solutions facilitating and supporting investments, such as dedicated support schemes similar to the current RES or cogeneration support scheme or the capacity market. The schemes should respond to the market demand at any time. Therefore, they should be as flexible as possible. Currently, key areas to be developed include:

- A support scheme for RES installations coupled with a storage facility or electrolyser.

- Support for distributed energy, among others through full implementation of the Directive on the promotion of the use of electricity from renewable sources.

- Elimination of development barriers for particular technologies (e.g. the 10 h barrier for onshore wind, direct lines for large-scale ERS installations, etc.).

- A support scheme for investments in energy storage facilities for existing installations.

- Facilitations for grid infrastructure investment process.

- Facilitations for grid and storage infrastructure investments made by energy clusters and energy cooperatives.

- Solutions for local governments interested in increasing energy independence.

A SYSTEMIC APPROACH

Adoption of the strategy at a national level and plans at a regional level will enable efficient and effective planning and development of specific local programmes. This is very important, because a substantial part of the funds provided by the EU will be allocated by 2023. To use such funds, a quick development of a framework for investments is necessary, to be followed by specific terms and conditions for particular programmes. Spending of national funds should also be based on transparent programmes and consistent with the developed documents.

Implementation of energy sector investment strategy should follow the plan and maintain stable supply of electricity at a price acceptable to customers. Although in Poland the process needs to be substantially accelerated, it cannot result in energy poverty or harm certain regions or parts of the community.

CHAPTER 9.

DEVELOPMENT OF A GREEN ECONOMY

Energy transition will affect the Polish economy in many ways. Development of a green economy means not only reduction in emissions and energy intensity. One of inextricable elements of the changing Polish energy sector will be a long-lasting transformation of jobs, technologies and services as well as development of R&D competences.

Many energy production sectors appear as attractive in terms of the potential of Polish products and services. Construction of onshore and offshore wind farms, hydrogen, energy storage — these are just a few. The markets open opportunities for companies, employees and R&D units to participate in regional supply markets. Energy transition in Poland will require a number of decisions that should consider political, economic, social and technological issues. Polish economy will have to face a number of risks for the regions related to shutdown of power plants and mines, including increased unemployment, impoverishment of regions, decreased revenue of local government units, the need for industrial transition of suppliers and sub-suppliers and retraining of employees, and — in certain cases — increase in energy poverty.

To minimise these risks, a concept of the development of national economy should be at the core of energy transition. Next to creating new energy mix and fostering technological change, the reforms should consider social aspects and follow the idea of just transition. The construction of a green economy should be based as much as possible on:

- The concept of energy saving and circular economy,
- Development of national technologies (local content),
- Green innovation.

ENERGY SAVING & CIRCULAR ECONOMY

Energy is one of the core cost components of the economy. Industry, transport, commerce and services are branches with the highest share of energy consumption compared to generated value added. The price and volume of consumed electricity determines the competitiveness of the national economy. A decrease in unit consumption volume as referred to value added may ensure long-term competitiveness of Polish products and services.

Not every company has the know-how and competence to implement low-carbon transition. In particular, smaller companies may face issues. It is crucial to obtain funds for such investments. One of the possible solutions is to develop a market for ESCOs (Energy Service Companies), offering solutions settled on the basis of achieved cost reduction, implemented from own funds. Establishment of a coherent indirect support

programme, addressed to ESCOs, settled on the basis of reduction in emissions, is one of the ideas to ensure effective action towards energy saving.

As regards building refurbishment, the ideas of the Renovation Wave initiated by the European Commission should be implemented. As much as 75% of buildings in the EU is energy-inefficient, and only 1% of buildings is renovated each year. Today, buildings are responsible for 40% of energy consumption in Europe and 36% of greenhouse gas emissions. This is a huge challenge, also for Poland.

Ensuring know-how and access to resources in the circular economy idea will allow for balanced increase in competitiveness and development of new technologies in various industries. Access to alternative sources of raw materials by promoting the use of recycled materials — beyond production of energy — is crucial for many branches of the economy.

In the era of climate change, ever-increasing population of the planet and dwindling natural resources, counteracting production of waste is one of key tasks of the economy. Reduction of waste should start with decreases in production thereof, not only through conscious consumer choices, but also multiple use in business supply chains. Recycling of municipal waste, biomass, industrial waste or scrap metal determines long-term capability to implement circular economy and the position of the Polish industry. More materials in circulation create a substantial opportunity for sectors that are highly dependent on raw materials which can, for instance, use materials with lower carbon footprint.

Greenhouse gas emission reporting is based on corporate reporting and accounting standards developed by World Resources Institute and World Business Council for Sustainable Development (GHG Protocol — Corporate Accounting and Reporting Standard). The GHG Protocol classifies greenhouse gas emissions into three "scopes". A scope is an operational framework for existing greenhouse gas emissions (whether emissions are generated by the organisation itself, its affiliates or suppliers). Reporting — in particular for Scope 2 and 3 — will constitute a challenge for the Polish business, requiring identification of emissions of its partners.

Therefore, measures taken by Polish enterprises to "green" their supply chain and determine key objectives that will allow them to progress towards zero carbon should be substantially accelerated. International companies commenced the process several years ago and impose new requirements for their suppliers as decarbonisation trends become more apparent. If Polish companies fail to adapt to the new requirements soon, the carbon footprint reporting system will cause them to lose competitiveness.

DEVELOPMENT OF NATIONAL TECHNOLOGIES

Decreasing business costs through low-carbon measures is not the only aspect of energy transition. A green economy provides many firm market opportunities for enterprises to obtain new revenue streams. An example of such an opportunity may be the construction of wind farms in the Baltic Sea — an expenditure of several hundred billion PLN at the country scale. Potentially, this means tens of thousands of jobs (according to various estimates, from 50 to 70 thousand). Different sources estimate that today local content does not exceed 20%. However, it may reach as much as 40–45%. Another good example is onshore wind development in Poland, which already has a substantial impact on GDP, labour market and prospects for production facilities. It is estimated that development of this segment may contribute to the creation of 50 to 90 thousand new jobs.

The potential of local content in the onshore wind farm supply chain is currently estimated at 55–60% and may reach as much as 75% within the next 10 years.

Although it just starts the journey, hydrogen economy is yet another area that may substantially contribute to the development of competences in the Polish industry. Energy storage or PV are the segments of the new energy sector that will also find their place on the map of Polish technologies and production capabilities, in particular in the face of the geopolitical challenges for supply chains. In the field of the previously mentioned building refurbishment, Polish construction companies will have the opportunity to generate many new services.

GREEN INNOVATION

Polish economy deserved to be not only a sub-supplier, but also an innovator, a technology provider. Measures taken by Polish enterprises to "green" their supply chain should be substantially accelerated. Poland may become an important hub for electrolyser production. Baltic Sea could host innovative foundations featuring lowered carbon footprint. There is plenty of opportunities. However, their use requires appropriate competences. To transform the economy towards zero carbon, it is necessary to provide a systemic support for a modern labour market. Not every company has the know-how and competence to implement low-carbon transition. In particular, smaller companies may face issues. Many such companies struggle to obtain financing for this kind of investments.

Increase in the knowledge about energy saving, the share of national companies in the supply chain of the new energy sector, and green innovation will require simultaneous involvement and support for Polish enterprises in several fields. The most important ones include knowledge about the market and available solutions, and project identification and support, including large, strategic projects with fundamental importance for the creation of jobs and competence. It is crucial to develop a parallel support scheme for education to prepare Polish students for the new jobs.

Polish economy needs knowledge about opportunities for implementation of energy-saving solutions, but also about demand on the target market for Polish enterprises, goods, materials and services dedicated for specific branches of the energy sector.

To ensure maximum exchange of knowledge and experience, the leading Polish universities, together with think-tanks and industry organisations, may develop a list of good practices that could be gradually implemented by enterprises. A tool that will substantially aid entrepreneurs in building green economy based on energy saving and circular economy concepts is non-financial reporting, where companies present their achievements for the environment and local communities in line with ESG principles.

ESG reporting is a non-financial reporting specifying enterprises' involvement in the care for the environment, socially sensitive matters, green innovation and corporate governance. The European Commission introduced a uniform, European reporting standard. Regulators, customers and financing institutions are increasingly often interested not only in financial standing of Polish partners, but also in the ESG impact of their operations on their environment.

PROJECT IDENTIFICATION AND SUPPORT

Economy is not waiting and will not wait for final arrangements concerning energy mix. Polish entrepreneurs attempt to develop capacity for future market demand. However, considering the substantial international

competition (established supply chains in global markets) and imperfect knowledge about future demand, the companies are making higher-risk investments. Funds available for R&D are not always as flexible in terms of time and scope as required by the current business. Therefore, a programme or platform enabling companies to access the current best knowledge about technological and market opportunities along the entire supply chain would form a substantial support for enterprises. The Polish government may specify strategic industries of a modern and zero-carbon economy, where Polish companies may achieve a substantial success — and such companies should be supported by a special programme. Furthermore, a green economy means digitisation of many production and management processes as well as good practices implemented to administrative procedures.

Depending on the development scale of the Polish supply chain, it will be necessary to create a number of new competences, originating from our education system — secondary schools and universities. Comprehensive planning and coordination of human capital creation is key to full utilisation of the potential for the creation of supply chain in Poland. Coordinated action aimed at promotion of awareness among schools, launching new majors, active influence of the transfer of funds from the new EU perspective to education, establishment of education centres and other activities in this field will also be important for entrepreneurs.

State policy plays an important role in the development of support schemes and instruments that enable the economy and the entire community to fully benefit from the vast, unharnessed potential of the national renewable energy sector. A green economy means highly developed and economically efficient technologies and services, increasingly often provided by Polish entrepreneurs on the basis of already gained international experience. This is still a very attractive and insufficiently used area of economic activity in Poland. Green transition of the Polish economy — forced by very important changes related to transition to low-carbon economy — will not happen without targeted support schemes, exchange of knowledge and regulatory instruments.

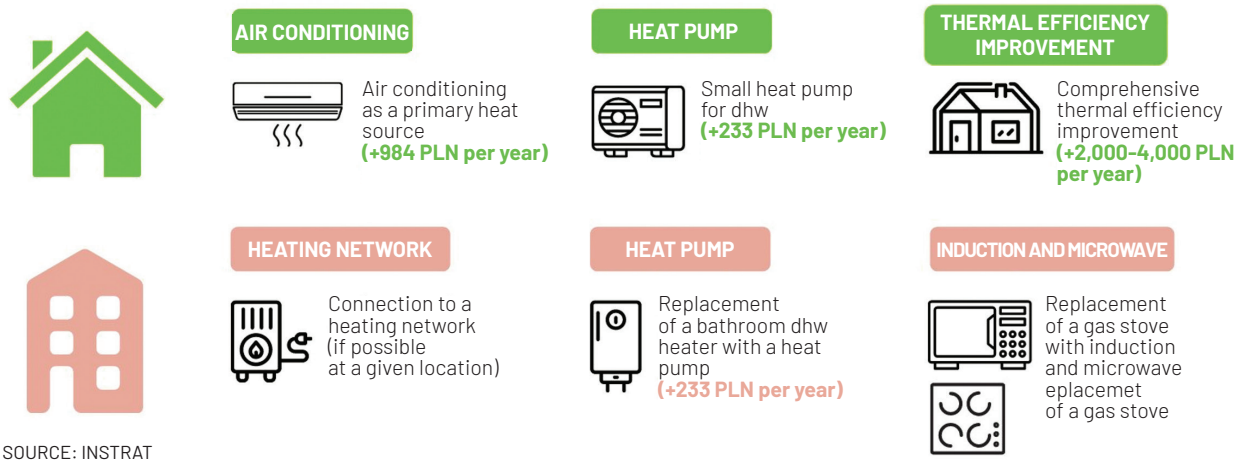
CHAPTER 10.
EDUCATION

Every substantial change, including energy transition, must gain social acceptance in order to succeed. No great social and economic reform will be fully possible without understanding and need to take action to foster the change. To make this happen, we need broad educational measures in schools, universities, and in public space.

Ecological education is needed already in kindergartens and needs to be continued in primary and secondary schools as well as universities. People should be taught not only what they can do to limit adverse impact on climate and the environment, but also need reliable information on climate change, the looming climate disaster and projects that need to be implemented in the coming years.

In the face of the many challenges the modern society has to face — rapidly changing reality, increasing costs of life, environmental pollution or unstable geopolitical situation — social campaigns should focus on promoting ecological and economic lifestyle and work by proposing specific conduct. It is worth not only to explain how to segregate waste, but also teach why limiting the amount of waste is worth it. People should be demonstrated in an accessible manner why buildings need thermal efficiency improvement and how much can be saved, as well as what benefits stem from replacement of an old boiler with a zero-carbon heat source. Without education it is impossible to fight energy poverty. An example may be educational measures presented by Instrat, demonstrating how to quickly implement effective changes in the operation of households — seen from the perspective of a John Doe — to limit consumption of Russian gas.

FIG. 1. **HOW TO LIMIT CONSUMPTION OF RUSSIAN GAS**



SOURCE: INSTRAT

We need a broad social campaign on factors deepening the climate crisis, focusing not only on the macro scale, but primarily on the national picture. Next to fighting smog and waste-related campaigns, we should pay attention to water retention, deforestation and the need for sustainable production of food and counteracting food wasting.

Furthermore, the community should also be educated how to limit CO2 emissions and switch to zero-carbon sources of electricity and heat. We should create an educational campaign to explain to our citizens why coal phase-out needs to be accelerated and why we must bet on RES and nuclear power. Today, we focus on adaptation to climate change. However, we cannot forget about mitigating the change. Adaptation to climate change means adaptation of systems, both natural and anthropogenic, to the current or forecast effects of changing climate conditions. Mitigating the change is understood as limiting the impact of human activity on creation of so-called anthropogenic greenhouse effect on Earth.

The results of scientific analyses and climate scenarios clearly demonstrate that the global climate, including in Poland, is changing. The biggest threat to the economy and the community is posed by the increase in average yearly air temperature, and the frequency and intensity of extreme weather — strong winds, extreme precipitation and flash floods.

FUNDAMENTAL ROLE OF SCHOOL

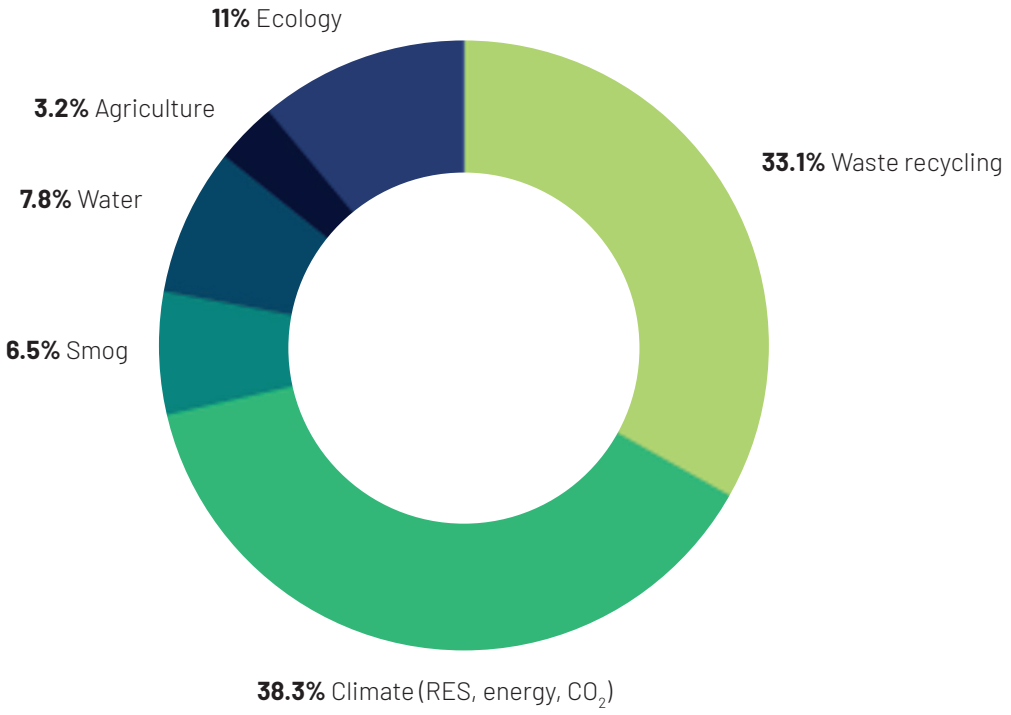
The adult population demonstrates high level of care for the climate. Deloitte studies demonstrated that 8 out of 10 Polish citizens are anxious about the condition of the environment. Cartoon Network studies carried out among school students have shown that 88% of Polish children are anxious about adverse effect of the changes occurring to our planet. After all, the youngest do quite care for the fate of the Earth and want to actively participate in processes that prevent climate change. Therefore, educational measures in that respect, aimed at developing proper attitudes and educating how to prevent adverse changes, should be implemented already at the kindergarten level. Kindergarten children are a very good target group for such measures, for a substantial part spend a lot of time with their grandparents — the age group that should often change long-established habits developed in times when environmental issues were not important. By educating the youngest generation, we may also affect the behaviour of the older part of the community.

A plan for climate education and care for the natural environment should be permanently included in the school curriculum. Due to current civilisation challenges, the teachers should not only discuss climate change, but actively promote social attitudes expressing in care for climate and well-being of the nature as a common good. Schools should actively participate in "Earth cleaning" and greening campaigns. They should participate in social campaigns promoting conscious and responsible use of the natural environment. It is important to create a platform for exchange of thoughts and ideas as well as innovation in that respect. Hackatons, knowledge contests and workshops should form a natural element of education in secondary schools.

The Youth Climate Council at the Minister for Climate and the Environment identified the thematic areas most interesting for today's young people already in 2020. These included waste recycling and individual change in the first place, and climate — understood as matters related to RES, energy sector or CO2 — came second. Broadly construed ecology (overall climate change or nature) was third. Next came water — its resources and retention. Clean air and smog were selected fifth. Agriculture and industry were sixth.

At the same time, climate protection cannot be based only on bottom-up and uncoordinated initiatives. We need a systemic education model in that respect and a trained teaching staff. It is teachers and tutors who shape the attitudes of their pupils in the first dozen or so years of their lives. Therefore, it is necessary to create an educational platform for teachers and tutors that will offer an insight into climate protection issues and propose ideas for educational measures in that respect. We also need all measures that could integrate business and education to create a number of new competences necessary in the development of a modern economy.

FIG. 2. **THEMATIC AREAS MOST INTERESTING TO YOUNG PEOPLE**



SOURCE: MŁODZIEŻOWA RADA KLIMATYCZNA

At later stages of education, it is necessary to support and promote majors related to energy, protection of climate and natural environment or climate diplomacy. It will be crucial to create and develop technical majors, giving specific tools to solve issues related to optimisation of energy use, energy management and creation of innovative equipment for production of carbon-free energy sources. To build and develop human capital to fully exploit the potential for the creation of a national supply chain, a flexible and quick adaptation of education to the market needs is a must. Moreover, scientists should actively participate in public debate and create opportunities for the broadest possible distribution of academic knowledge. Active cooperation between science and business is yet another important aspect of the transition. Polish universities carry out unique research and make unique technological discoveries that should be actively supported, implemented and commercialized. On the other hand, nothing but investments in R&D may bring great benefits to business and bring it to a higher development level.

OPPORTUNITY FOR LOCAL GOVERNMENTS

Education needs local government support. No one knows the needs of inhabitants of a given municipality better than their local representatives. It is them who should foster actions in their municipality that will be the best answer to the inhabitants' needs and current challenges. The current legal system already vested responsibility for the environment and cleanliness in the local government. Traditionally, inhabitants reach out to the local government when they see a threat to the natural environment. In the recent year, issues related to clean air became the leading theme of local governments' actions and cooperation with inhabitants. This trend must be followed through continued use of proven communication and public participation measures.

In the recent years local government supported individual investors (self-consumers) on the PV market. This direction should also be continued. The revolution Polish citizens made in PV deserves to be recognised. On the basis of new provisions, the market for clean, solar energy will open to residents of multi-family buildings and virtual self-consumers, who don't have the conditions to produce electricity at the location where it is consumed. This is a great opportunity, but also a job to be done. A job that may bring innumerable benefits to the local community.

Municipal authorities should already be aware how to exploit this opportunity and how to create municipal development strategies to fully benefit from the new possibilities. Local government employees should be proficient in distributed energy matters and local investments in that respect. They should have access to knowledge and share the existing opportunities and solutions. Funds for education or creation of education centres need to be secured. R&D in local governments should become a permanent item on the agenda of local government units.

A CHANGE IN EVERYONE'S DAILY HABITS

All measures taken towards energy transition are aimed at climate protection. However, it is not the ultimate goal. We protect our planet — Earth — for future generations. We are the ones that determine what the world will be like for our children and grandchildren. "A Lost Generation" — this is how young people, active in the School Strike for Climate, refer to themselves. Why so? They feel that consumerism of the last several decades put a stamp on our planet, and they will have to "clean it.

Therefore, we have to change our habits — gradually, yet decisively. We have to care for reducing waste and more sustainable lifestyle. Bet on effective and efficient management of energy consumption. We should take action to provide energy customers with feedback on its consumption — both in daily and mid-term perspective. This will foster effective adjustment of habits and influence human behaviour related to energy consumption and management. If energy will be rather expensive in the years to come, we have to focus on improving energy efficiency of our homes and the environment we live and work in. To this end, we have to educate to remain active in that respect and be the leaders of the change. The change in thinking and acting. Our activity should give a good example to others and encourage them to face challenges on their own and with initiative. Acting and living in harmony with the nature should be natural to us. To make this happen, we have to educate and share our knowledge with others.

Today, business must seek solutions that are sustainable and in harmony with the nature as much as possible. It needs to reduce waste, decrease energy and water consumption, and reasonably manage paper resources. Newly created products or services need to be delivered with the least harm for the environment possible. This means application of ecological packaging and reduction of carbon footprint in transport. Companies

should invest in R&D to increase innovation and pioneer nature of ecological actions and green transition. If we want to build Polish supply chain, we have to create new competences. This requires investments in education. Moreover, it is crucial to share good practices. Competition or recipients of one's actions may be effectively influenced only by knowledge distributed through experience.

We should seek the leaders of "green" change, who through their enthusiasm and consistent actions will seed ecological thinking in others. The transition — energy transition of the state and the community — requires consultancy and appropriate knowledge distribution. Today, information is a valuable commodity, and knowledge is a treasure that could bring specific, measurable and tangible benefits.

SUMMARY

MICHAŁ NIEWIADOMSKI

To keep up with the accelerating geopolitical and economic changes in Europe, energy transition must accelerate. Excessive dependence of Europe and Poland on coal, gas and oil from Russia made the public and decision-makers aware of the importance of diversification and energy independence of our continent. We should build a new safety paradigm based on renewable sources, which are unlimited. Paradoxically, the crisis caused by the Russian aggression in Ukraine may be an opportunity to make the transition more efficient and faster.

The key lies in a well-thought energy strategy accepted by all political forces, which should be based on a consensus of all parties — similar to the accession of Poland to NATO and the EU. Such a consensus is needed due to the importance of the power system in a collective security arrangement, as well as due to the scale of expenditures, reaching billions of PLN. An efficient transition will be possible only with continuation and determination of subsequent governments.

In order to reduce Poland's dependence on coal, oil and gas from Russia, which will be in great demand, causing their prices to rise, we have to reduce energy demand of both individual customers and enterprises — as soon as possible. Among others, a mass thermal efficiency improvement programme will reduce demand for heat in buildings by at least half. Seeking energy efficiency in businesses will allow for further reductions.

The process should be accompanied by a thorough remodelling of our energy mix. This cannot be done without immediate liberalisation of the so-called Distance Act, which block onshore wind development since 2016. Toady, wind energy is the least expensive in the market: it does not generate CO2 emissions and does not require complex investment procedures. Moreover, this is a technology which — together with PV — can easily develop a supply chain in Poland. Our country needs new sources of energy — renewables, but supported by zero-carbon nuclear units stabilising the operation of weather-dependent sources, such as wind or sun. A substantial role in stabilising the power system should be played by Li-Ion and hydrogen energy storage facilities as well as pumped-storage power plants. High electricity prices faced today may prove an opportunity to implement solutions based on hydrogen technologies. It is likely that with technological progress and high energy prices, projects rated unfeasible just a few years back will become profitable, becoming easily accessible.

Poland needs investment in new power grids, from low, though medium, to high voltage. Such grids need to be adapted to the new design of the energy sector. Increase in available connection capacity through cable pooling should be a priority, enabling development of renewable energy sources, which have to face increasingly more difficulties from grid operators, in the short-term. Moreover, it is necessary to "clean up" existing connection capacity in the power system to release capacity blocked by already issued connection conditions for investments that will never be completed.

The increase in new capacity and development of energy storage and hydrogen technologies should be accompanied by gradual phasing out of coal-fired plants. New, zero-carbon units are necessary to avoid so-called generation gap — decommissioning of 200 MW coal units built in the 200 MW coal-fired units built in the 1960s and 1970s, reaching the end of their operational lifetime. However, the pipeline lacks new, substantial and stable electricity sources, which means that system balancing issues may appear already in the middle of the current decade.

Poland needs nuclear power — both large reactor and small SMR installations. Today, the role of gas as "transitory" fuel is questionable. Where we could think of gas as such prior to the war in Ukraine, if the EU announces embargo on Russian gas, there may be insufficient fuel on the market, entailing rationing and — without doubt — high price. The situation may not be mitigated by attempts to increase the supply by the United States, Norway or Algeria. Therefore, combustion of expensive gas for heating or production of electricity will be illegitimate.

That is why Poland needs inexpensive energy from RES. Wind and PV, already dubbed "energy of freedom", are neither occupied by hostile troops or rationed by officials. This is the new paradigm of security — development of commonly available, zero-carbon sources. Fighting for energy independence, we cannot forget the climate objectives. If we want to achieve them, we have to re-electricity the economy. This means more common use of electricity instead of direct combustion of fuels — coal, gas, oil. We need to electrify all aspects of our life, starting from transport, through industry, building, to heating. In turn, electrification requires inexpensive electricity and smart technological solutions.

A substantial role in the distribution of the power system and encouraging citizens to achieve energy independence should be played by local government units — local communities are the impulse for effective and fast transition. Our citizens have already shown the initiative, massively installing PV panels on their rooftops. Local entrepreneurs also want to satisfy their electricity demand from RES. However, this requires numerous legislative changes, introducing regulations concerning direct lines, which could be used to transmit electricity from renewable installations directly to production plants and factories.

Energy transition will be accompanied by "greening" of the entire economy, including business. Non-financial ESG reporting encourages enterprises to adopt a holistic approach to production, sales, waste collection and disposal, as well as environmental issues or interests of local communities. The trend is also apparent in increasingly "green" supply chains and the business' drive towards zero-carbon.

Revival after the crisis caused by the COVID-19 pandemic, energy transition, "greening" of the economy, achievement of climate neutrality — European Union prepared earmarked funds, reaching trillions of euros, to achieve all these goals. Wise spending requires a very precise investment plan. We need a wise and well-considered agenda that will not only consolidate our economy, but also make it more resilient to further unpredictable events that may happen in Europe and around the globe in the future.

Just transition is a great challenge for everyone — central governments, regional and local authorities, business, media and non-governmental organisations. It is crucial not only to create appropriate conditions for people most affected by the transition (population of mining areas), but to ensure further social, economic and cultural development of these regions in the new reality. It is a crucial element of just transition. Our community and workforce needs to be prepared for new competences required to develop national supply chain for the modern energy sector.

The new strategy is key to specification of objectives and tools to achieve them. However, energy transition will not succeed without social acceptance. Emphasis must be put on education at all levels as well as in media and opinion-forming centres. The community not only needs to understand the processes that occur, but also to implement ecological habits at the level of each single citizen, enabling us to minimise adverse impact of our life on the environment and climate. It is our individual behaviour, multiplied and accepted by all our citizens, that will give the desired effect — a healthy, aware and sustainable society.

PROGRAM | CZYSTA | POLSKA

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DECALOGUE

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