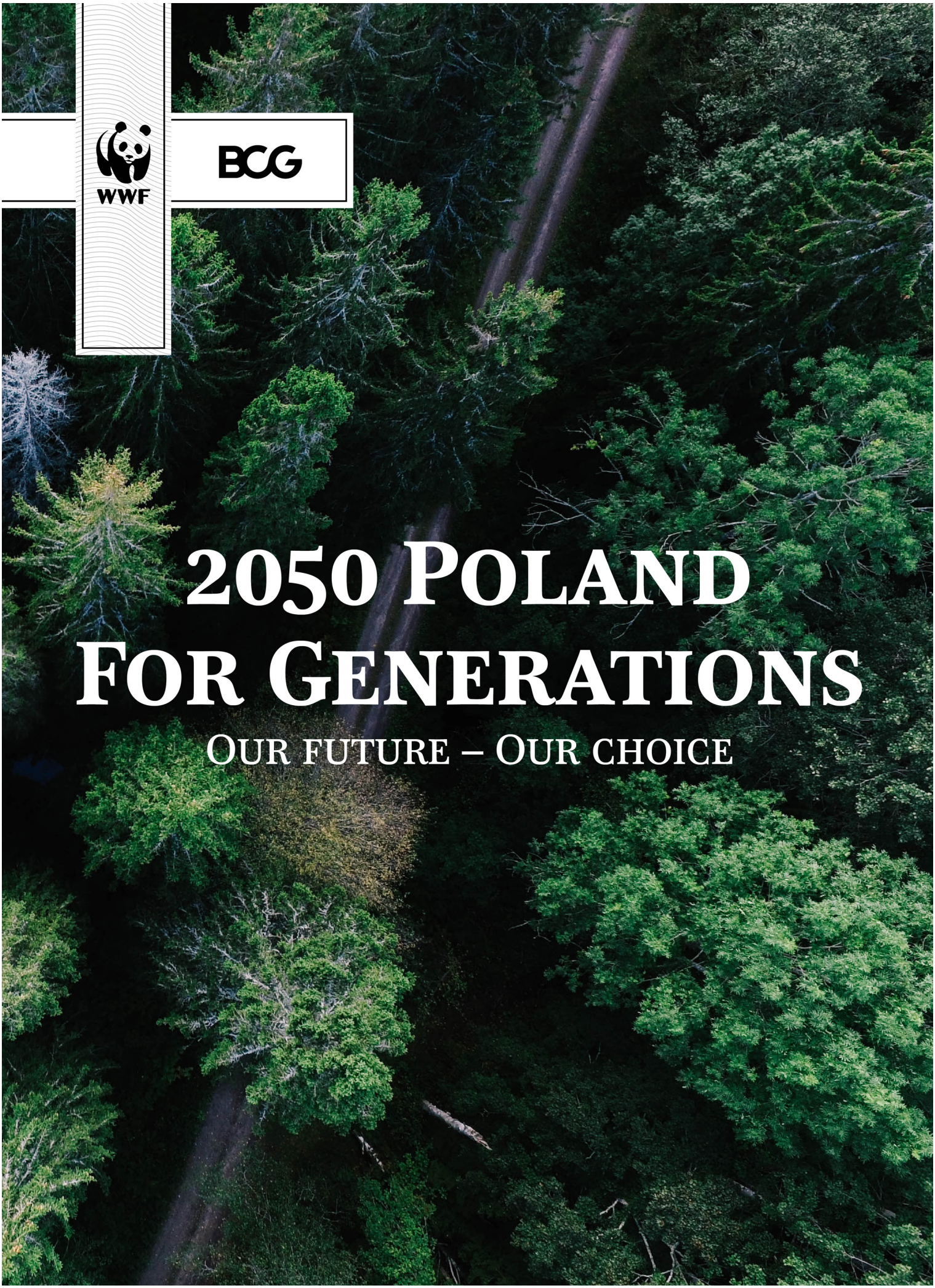

2050 Poland For Generations

Our future – Our choice

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Foreword

We are living in the Anthropocene era – a time when human activities change the functioning of global natural processes. They affect the climate, marine and terrestrial ecosystems, air quality, and freshwater resources. Mankind is consuming more and more and leaving a growing ecological debt towards future generations. We, Poles, also have influence over what the near and more distant future will look like. Are we going to continue to play a part in environmental degradation, or could we perhaps focus on sustainable development? The scientific world is ringing the alarm bells, and showing the trends and the scale of the needs.

This report was produced in a collaborative effort between The Boston Consulting Group (BCG) consulting firm and WWF Poland. The Report focuses on selected environmental issues – presented by the WWF team, supported by third party experts, in addition to which the BCG also provided economic modelling.

This report aims to describe how the Polish population and its future generations will benefit if people do business in a manner that is more sustainable and considerate of environmental protection needs. We have attempted to describe what impact the measures taken in the years to come will have on the surrounding environment and how this will affect the life of the average Pole with respect to prosperity, health and freedom. The report shows that environmental protection should not be pitted against civilizational progress in Poland. It illustrates clearly that in the longer term environmentally driven reforms could be a major factor leading to higher living standard in Poland. At the same time, the purpose of this report is not to present ultimate solutions for all of the issues raised, but to trigger a public debate on the need to combine economic development and environmental protection.

We hope that this report will set off a public debate on the future of Poland and that representatives of government bodies, the business sector, and society as a whole will be involved. We want this debate to be held according to the merits of the cases put forward, using objective figures on the state of the environment and their economic and social implications. We aim to present the consequences of taking or failing to take specific measures to curb the harm that man is doing to the environment.

To facilitate a public debate, we grouped our analyses into four subject areas: climate and air quality, rivers, the Baltic Sea, and biodiversity. Our analyses confirmed how crucial it is to take appropriate steps in these areas. The mean global temperature has been increasing at an unprecedented rate and failure to act may cause more multibillion losses due to weather anomalies. In addition, the air in numerous Polish cities and metropolitan areas is highly polluted with particulate matter, which causes more than 46,000 premature deaths per year.

Mismanagement of inland waters may lead to a greater risk of flooding, while local communities are frequently unaware of the real effects of river regulation and destruction of river ecosystems.

The maritime economy and coastal tourism depend on the good condition of the Baltic Sea. The declining fish stocks in the sea areas exploited by fish cutters may cause stagnation and later shrinkage of the fisheries sector. Cyanobacterial blooms represent a health hazard for tourists and bathing areas are consequently closed, leading to less growth in revenue from tourism. The loss of fishing nets by fishermen causes economic losses in the fisheries sector and increases uncontrolled by-catch of not just fish but also of other marine animal species.

Biodiversity is crucial to maintaining an appropriate level of ecosystem services (i.e. the contribution made by natural ecosystems to the general wellbeing of humans, such as oxygen production,

pollination, water treatment, soil protection, etc.) necessary to live on our planet. The value of ecosystem services in Poland is estimated to be PLN 120 billion per year according to 2018 prices. 70% of natural habitats monitored in Poland are in poor or unsatisfactory condition. The areas of greatest natural value in Poland are still not protected adequately. The last national park was established in 2001. National parks make up 1.1% of the area of Poland, which is three times lower than the European average.

The future of each of the above topics is depicted in two scenarios. The Base scenario is one in which the Polish economy develops according to the current trends and the present policies and strategies of public authorities continue. The For Generations scenario is one in which the recommendations made in this report are implemented, and the benefits produced by those recommendation materialize.

Executive Summary

Climate

- **Anthropogenic climate change is the key risk faced by humans. In recent decades, mean global temperatures have grown at a rate that has not been seen for at least several hundred thousand years. The direct cause of increase in the mean global temperature is man-made greenhouse gas (GHG) emissions.**
  - The suppression of global warming to safe levels will require reaching a net-zero emission economy by approximately the middle of the century.
  - Today, losses caused by weather anomalies in Poland total approximately PLN 9 billion per year (accounting for approximately 0.6% of GDP) and are growing year by year. Farmers are most affected.
  - Poland's greenhouse gas emissions are three times higher in relation to GDP and 18% higher per capita than the European Union average. One of the main reasons is the extensive reliance of the Polish power sector on hard coal and lignite. 82% of the greenhouse gas emissions in Poland are produced during fuel combustion processes mainly in the power, heat distribution, transport and household sectors.
- **Poland is among the European countries with air most heavily polluted with particulate matter emissions such as PM10 and PM2.5 and with benzo(a)pyrene. Air pollution contributes to many diseases and more than 46,000 premature deaths annually.**
  - 36 of the 50 cities in Europe with the highest PM2.5 pollution are located in Poland. The highest concentration of PM2.5 is recorded in the voivodeship of Silesia.
  - 50–87% of PM10, PM2.5 and polycyclic aromatic hydrocarbons in Poland (e.g. b(a)p) are caused by the inefficient burning of solid fuels (e.g. wood or hard coal) used to heat households in Poland. Households and road transport jointly account for 93% of the national primary sources of particulate matter emissions falling into the PM2.5 category.
- **Four key recommendation areas have been identified to support the decrease of greenhouse gas emissions and to improve air quality:**
  - Establishing and implementing an innovative development plan leading ultimately to a zero-carbon electricity generation system.
  - Real and tailor-made support for curtailing energy consumption by households, commercial buildings and industry.
  - Development of an electric and low-emission vehicle fleet.
  - Development of public transport, bicycle traffic and railway transport.
- **Our forecasts indicate that the implementation of recommendations made in this report in the years 2020–2050, could mean aggregate savings for the Polish population of PLN 447–462 billion, or about PLN 15 billion on average per year. Under the scenario with higher prices of**

CO_2 allowances these savings would amount to PLN 499–514 billion, i.e. PLN 19 billion on average per year. This may account even for 1% of annual GDP. This can be achieved by reducing energy consumption costs in households and commercial buildings. At the same time, thanks to capital expenditures to improve the thermal efficiency of buildings, an additional 24,000 jobs may be created.

- In the For Generations scenario, electricity consumption will be down approximately 10% compared to the Base scenario. It will also be structured differently (higher share of electromobility and railways).

- The optimization of the energy sector may lead to an increase in the output of energy generated by renewable energy sources (RES) from the current 13.36%[1] to 75% in the For Generations scenario. This will be possible thanks to the development of energy storage technologies for industry and households, as well as due to the forecast increase of costs of energy generation from hard coal. Under such a scenario, the level of hard coal consumption to generate electricity would go down to zero.

- Safeguarding the stability of a RES-based power system would require an increase of annual gas imports in 2050 by up to 9 billion m^3 under the For Generations scenario as opposed to 7 billion m^3 under the Base scenario. Another measure for grid stabilization would be a more efficient energy transmission infrastructure between prosumers and other countries.

- Under the For Generations scenario, the capital expenditures would reach PLN 200 – 350 billion. At the same time, the cost of generation of 1 MWh of electricity in 2050 would be PLN 578 or PLN 590 with higher prices of GHG allowances (PLN 516 or PLN 554 under the Base scenario).

- Under the For Generations scenario, carbon dioxide emissions in the power sector could fall by approximately 87% compared to 55% under the Base scenario in 2050. This would imply a decrease in CO_2 emissions from 991 tons/GWh in 2016 to 110 tons/GWh (and 333 tons/GWh under the Base scenario).

- Modern heating systems and thermal efficiency improvement of buildings could generate PLN 79 billion of aggregate net savings and reduce annual CO_2 emissions by 18.3 million tons. At the same time air quality would improve drastically due to a reduction in PM2.5 and PM10 particulate matter emissions.

- Thanks to investments in railway and bicycle infrastructure and in public transport, the percentage of passenger cars in total passenger traffic could decline by 10 percentage points, down to 60% in 2050.

- In 2050, under the For Generations scenario, half of the vehicles driven in Poland could be electric vehicles (Base scenario: 36%). This process will be driven by falling prices of lithium-ion batteries, the development of new forms of energy storage, and support for infrastructure projects that are friendly to electric vehicles. The higher percentage of electric vehicles in road transport would translate into the reduction of greenhouse gas emissions in this sector under the For Generations scenario by 36% (Base scenario – 25%) and fuel consumption by approximately 5 million m^3 compared to the Base scenario. In the future, the development of hydrogen-powered vehicles is also feasible, especially in freight transport and long-haul intercity bus transport, for which today's energy consumption by electric motors would be too high.

1 **As cited in:** Eurostat – Short Assessment of Renewable Energy Sources https://ec.europa.eu/eurostat/documents/38154/4956088/SHARES-2016-SUMMARY-RESULTS.xlsx/97eeb23c-9521-45d6-ab30-578246f1a89d, download date 20 September 2018.

- The solutions envisaged under the For Generations scenario are still not ambitious enough for Poland to contribute towards combating climate change and keeping it within safe limits. An attempt should be made to develop a zero-carbon plan for the economy by around mid-century, taking into account the obstacles to a departure from fossil fuels (in the power, heating, transport and building heating sectors) and proposals for overcoming them.

Rivers

- **The main threats to the rivers and river valleys are irreversible changes in river ecosystems through planned development of inland waterway transport, regulation of smaller watercourses, incompetent flood risk management, excessive exploitation of floodplains, and the disappearance of riparian forests.**
  - Poland does not have the right conditions for developing inland waterway transport for freight transport, with the following major constraints being as follows: general climatic and hydrological conditions, morphological conditions of riverbeds, poor waterway infrastructure, and natural constraints for river development.
  - The construction and modernization of selected river sections, so that they are promoted to the category of international waterways, would cost somewhere between PLN 71 and 91 billion according to preliminary estimates. Investment outlays at this level would be enough for more than 2,000km of additional motorways in Poland (currently Poland has 1,600 km of motorways). Additionally, inland waterway transport requires constant maintenance, at a very high cost compared to road and motorway maintenance.
  - The extra costs related to the infrastructure investment projects vital to the development of inland waterway transport are estimated to be PLN 25–35 billion for ports, intermodal terminals, access roads and railway tracks, and another PLN 20–30 billion for raising the height of bridges along with the alterations made to the accompanying infrastructure.
  - The Ministry of Maritime Economy and Inland Navigation envisages international inland waterway projects in the billions. According to the Ministry, these projects would reduce the harm currently done to the environment by freight transport in Poland. However, no economic, social and environmental analyses of the impact the program would have in these areas have been produced. Meanwhile, improper development of the inland waterways may contribute to a higher flood risk and degradation of river ecosystems.
- **Due to inappropriate policy and the current approach to flooding risk management, at present approximately 4 million people are living in flood risk areas.**
  - A key issue is ill-managed spatial development policy and issuance of permits for investment projects located in flood risk areas. Additionally, farmers frequently risk high losses, using river valleys as arable lands, disregarding natural periodic flooding.
  - The regulations of cross- and longitudinal-sections of rivers have an adverse impact on ecosystems dependent on water and the river valley landscape, and increase the risk of flooding of the areas located downstream.
- **The analysis of two scenarios showed that:**
  - Implementing the transport optimization recommendations may generate an additional PLN 68

billion in 2020–2050, while also reducing the share of road traffic in overall transport from 83% to 70%.

  - Additionally, an appropriate water management policy and flood risk management policy may generate in the same period an additional PLN 530 million in income for local communities located in fluvial areas and reduce the population dwelling in flood risk areas.

- **Five key areas were identified for recommendations with regard to transport development, river management and flood risk management:**

  - devising and implementing a long-term investment plan for railway infrastructure as an alternative to the development of inland waterways,

  - change of policy on rail and road infrastructure access fees,

  - analysis of the development of inland waterway transport, taking into account its real impact on flood safety, the environment and the costs of that transport,

  - transfer of multi-billion spending from inland waterway transport to the development of railway infrastructure, road safety improvement and promotion of a diversity of means of transport,

  - implementation of a central management plan for rivers and floodplains aimed at more effective flood risk management, taking into account the wide restoration of rivers and their valleys.

The Baltic Sea

- **The Baltic Sea, one of the youngest seas in the world, is surrounded by nine countries, with a population exceeding 85 million people. The Baltic Sea is populated by over 2,700 species of fish, birds, mammals, invertebrates and marine plants. For many people, for example those working in the tourism and fisheries sectors, the Baltic Sea is their livelihood.**

  - In 2015, the Baltic fishing fleet caught about 613,000 tons of fish and seafood, worth approximately EUR 217 million, of which about 188,000 tons worth EUR 49 million were caught by the Polish fleet. The total headcount in Polish fisheries is estimated to be approximately 32,000 people, and the value of the Polish tourist market associated with the Baltic Sea is worth approximately PLN 6 billion[2], with a total headcount of 40,000 people[3].

- **Due to the specific geographical location and with the great strain placed on it by human activities, the Baltic Sea is facing a number of problems. The greatest environmental challenge is eutrophication. Among other problems resulting from anthropogenic pressure, attention should be paid to unsustainable fisheries and to the deepening waste problem. These threats have direct implications for human well-being.**

  - Eutrophication is defined as excess nutrients (phosphorus and nitrogen) entering the water, largely originating from farming. A large amount of nutrients causes an immense bloom of algae and cyanobacteria, which are potentially a hazard to human health. Closing of bathing areas may have adverse impact on tourism revenues. Eutrophication makes seawater less transparent and enlarges dead zones, where inhabiting organisms die out. In 2011–2016, as much as 97% of the Baltic Sea showed the impact of eutrophication. Poland is one of the largest suppliers of

2 BCG analysis based on data of the Polish Central Statistical Office and WTTC
3 BCG analysis based on data of the Polish Central Statistical Office and WTTC

nitrogen and phosphorus from the Baltic Sea catchment area.

- Another problem affecting the Baltic Sea is overfishing – both sanctioned and illegal. Overly intense fishing activities upset reproductive capabilities of the population, which leads to a decrease in fish stock populations, and, in conjunction with other environmental factors, may result in their extinction. Two fish stocks in the Western Baltic fished by the Polish fleet – cod and herring – are at risk today. In the last 12 years, their population has declined by 30%.

- The excessive amount of waste going into the Baltic Sea is becoming a deepening problem. It is estimated that there are already over 5 trillion tons of plastic particles in the sea waters around the world[4]. The plastic particles are absorbed by fish, and then ingested along with fish meat by human beings.

- The implementation of the For Generations scenario could generate as much as PLN 2.6 billion for the Polish economy and approximately 11 thousand additional jobs by 2050.

- The recommended actions will bring Poland closer to attaining the targets for the reduction of nutrient emissions determined by the Helsinki Commission. The condition of the Baltic Sea environment will gradually improve in the decades to come. This will reduce the number of days when blooms of toxic cyanobacteria will pose a risk to the marine ecosystems and human health, and the adverse effects of closed bathing areas will not affect the development of tourism. The rate of growth of tourism in the coming decades will range from 1 to 5% per year in terms of employment and generated added value.

- If environmental degradation continues, tourism development will fluctuate at around the inflation rate, and the number of jobs in this industry will decline in the early 2040s.

- If the catch limits continued to be too high, the fish stocks, key to Polish commercial fishing, would be severely depleted and some of them could become extinct. This would mean an insufficient number of jobs for today's fishermen: the number of jobs in this sector would decline by 50% by 2050.

- A sustainable fishing policy would lead to reproduction and maintenance of the fish stock population at a safe level, enabling fishery development at an average level of 0.7% per year, and 4,000 more jobs by 2050 relative to the Base scenario.

- **To ensure the stable development of both sectors, it would be advisable to apply the Blue Economy principles, including making changes in three key areas:**

  - Introducing legislation supporting, amongst others, farming activities and fishing in a way that mitigates their adverse impact on the environment,

  - providing subsidies and introducing incentives to encourage farmers, fishermen, and others to act in a more environment-friendly manner,

  - supporting the development and implementation of new fishing and farming technologies, that would help with marine environment protection.

4 **As cited in:** Marine Plastic Pollution and Seafood Safety, 2015 https://ehp.niehs.nih.gov/doi/10.1289/ehp.123-a34, download date 1 October 2018.

Biodiversity

- **Biodiversity is the wealth of nature around us. Nature is not only beauty – it is the foundation of our existence. Humans depend on nature – it generates oxygen; it supplies water and food. On the one hand this goes without saying and is common knowledge. On the other hand, if we look at how humans treat nature, one gets the impression that we do not fully appreciate how much we rely on it. Our economy depends on nature, on its resources and on the ecosystem services that we use. To ensure that there is no disruption to delivery of ecosystem services, biodiversity must be maintained at the appropriate level.**
  - The value of ecosystem services in Poland is estimated to be worth PLN 120 billion per year according to 2018 prices.
  - There are 80 natural habitat types in Poland that are protected under the Habitats Directive. Unfortunately, as many as 70% of habitats in Poland are in an unsatisfactory or bad condition.
  - Proper habitat protection – passive or active – makes it possible to preserve the natural value of sites key to Poland's natural heritage.
- **The most valuable natural sites should be adequately protected: national parks and nature reserves are the best solution.**
  - The most effective form of protecting the most valuable natural areas are national parks, while for smaller areas – nature reserves.
  - In Poland there are 23 national parks. The most recent national park was established in 2001.
  - The number and size of national parks in Poland is small compared with other countries – Poland is ranked at a remote 26th place in Europe, with an area covered by national parks being three times smaller than the European average. At present, national parks account only for 1.1% of the area of Poland, as opposed to the European average of 3.4%.
  - The Chief Inspectorate of Environmental Protection reports that habitats are in much better condition in national parks compared with the areas that are not protected this way.
  - Contrary to popular belief, national parks do not have a negative impact on municipality budgets in the areas where they are established. An analysis of budgetary revenues of 60 municipalities located within parks (and in the buffer zones) established in 1990–2001 clearly shows that the financial standing of these municipalities is at least as good or better than municipalities that are not within parks.
  - The areas under strict protection in the Białowieża Forest generate ecosystem services with higher value than the areas not protected in this way.
- **The implementation of our recommendations and guidelines for national spatial planning strategic documents would lead to the establishment of new national parks such as the Turnicki National Park, as well as the enlargement of the Białowieski and Bieszczadzki National Parks.**
  - Under this scenario, Poland does not deviate from the EU average in terms of the area occupied by national parks. Therefore, the level of preservation of habitats in the areas covered by

a higher level of protection has not deteriorated or is improving.

- **In order to ensure better protection of biodiversity, the most valuable natural areas in Poland should be incorporated into the national parks.**

  - By 2020 The Turnicki National Park should be established and the Bieszczadzki and Białowieski National Parks should be expanded.

  - By 2050 The Jurajski National Park, The Mazurski National Park, The Stobrawski National Park, The Lower Oder River National Park and The Middle Oder River National Park should be established.

Looking ahead – Poland in 2050

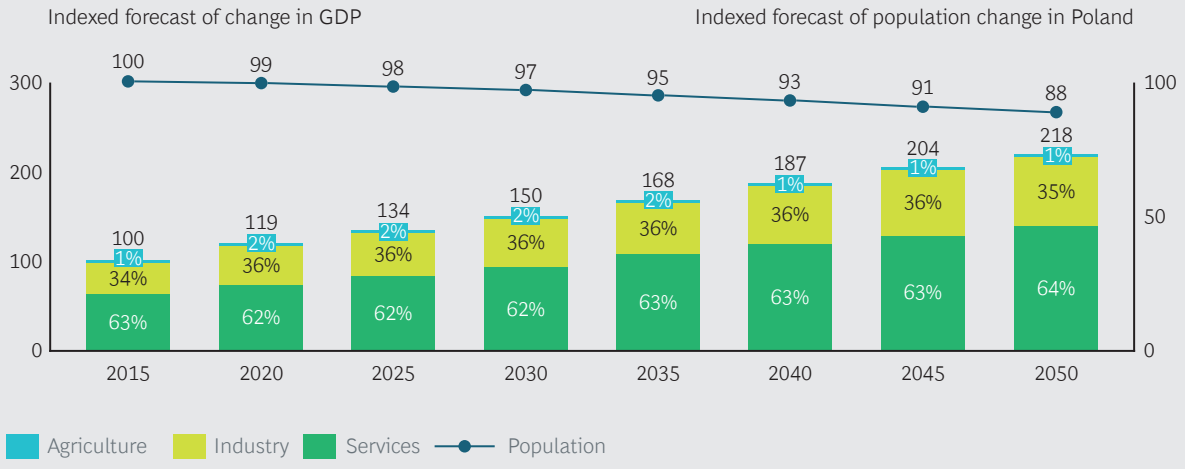
POLES IN 2050

Since the political transformation in 1989, Poland has undergone changes that led to an increase in GDP of 134%[5]. Poland has become one of the most rapidly developing countries in Europe.

According to forecasts, by 2050 the Polish economy will grow by an additional 118%. Over this period, according to analyses conducted by the Polish Central Statistical Office, the population in Poland will decline by almost 12%[6]– provided that there are no changes to migration policy. This implies that the population in Poland will shrink by as much as 4.5 million. The age structure of society will also change. In 2050, people aged 65+ will account for 36.5% of the population, up by 17% compared to 2015 (19.6%[7]). This age structure will represent a challenge for both the authorities and the working age population as well as for people who are just reaching retirement age.

BY 2050, POLAND'S GDP WILL GROW BY 118%, WHILE ITS POPULATION WILL DECLINE BY 12%

FIG. 1: GDP VS. POPULATION CHANGE IN POLAND



Source: Polish CSO, Oxford Economics, BCG analysis

Our scenarios for Poland in 2050

The following chapters present two possible development scenarios for Poland in four areas related to the natural environment: Climate and Air Quality, Rivers, The Baltic Sea, and Biodiversity.

The Base and For Generations scenarios use forecasts for the rate of growth of GDP and demographic

5 Economist Intelligence Unit (1989-1994), Polish Central Statistical Office (1995-2017)
6 **As cited in:** Polish Central Statistical Office, Table. A1. Population Forecast (in 1000), http://demografia.stat.gov.pl/bazademografia/Downloader.aspx?file=Prognoza_ludnosci_aneks.zip&sys=prognozy, download date 29 June 2018.
7 **As cited in:** Polish Central Statistical Office, Table A9. Population forecast according to traditional economic age groups (in %), http://demografia.stat.gov.pl/bazademografia/Downloader.aspx?file=Prognoza_ludnosci_aneks.zip&sys=prognozy, download date 29 June 2018.

changes in Poland developed by Oxford Economics and Statistics Poland. The development paths of more developed European countries were used as reference points for development phases of Poland in the coming decades.

In the period up until 2020, the For Generations and Base scenarios do not differ, and only vary from that time. The presented scenarios are based on available technologies, so they do not account for revolutionary technological changes that may occur in the period in question. No economic values are discounted (i.e. converted into the Net Present Value (NPV))[8] and do not account for residual values.

The Base scenario is based primarily on the activities announced by public authorities in official documents, and statements or interpretations of statements.

The For Generations scenario is the projection we devised, assuming the implementation of the recommendations we have proposed and estimates as to the probable changes that would occur in society and the economy as a result of these activities.

8 The exceptions are the analyses presented in the sub-section Thermal efficiency improvement of buildings, where the quantitative analysis was performed by Dan Staniaszek, Ph.D. from Building Performance Institute Europe (BPIE).

CLIMATE CHANGE AND AIR QUALITY

In recent decades, we have observed that the mean global temperatures have been growing at an unprecedented rate. Studies carried out by the Intergovernmental Panel on Climate Change (IPCC) show that the average global temperature in the decade 2007–2016 exceeded the average temperature of the Holocene period by approximately 1°C and has been the highest at least since the Eemian Interglacial that occurred 125,000 years ago[9] [10].

This is an issue of global relevance. 2016 was the hottest year on record, and almost all of the hottest years ever recorded were years after 2001[11]. In Poland in the last seventy years, the average temperature has risen by 1.7°C[12]. Unless all countries eliminate greenhouse gas (GHG) emissions by around the middle of the century and continue to follow the Base scenario, by 2100 the average temperature on the Earth's surface will exceed the average in the second half of the 19th century by 3.5–6°C[13]. During the next two centuries, temperatures may increase by twice as much[14].

The temperature differential can be compared with fluctuations occurring during ice ages – the difference in the average temperature on the Earth's surface between the last maximum of the ice age of 20,000 years ago, and a warm period that began 11,500 thousand years ago, is approximately 4°C. The currently observed temperature change is, however, much more drastic and occurred over a period of one century. It is caused by growing anthropogenic pressure of unprecedented scale and intensity, in particular, by greenhouse gas emissions.

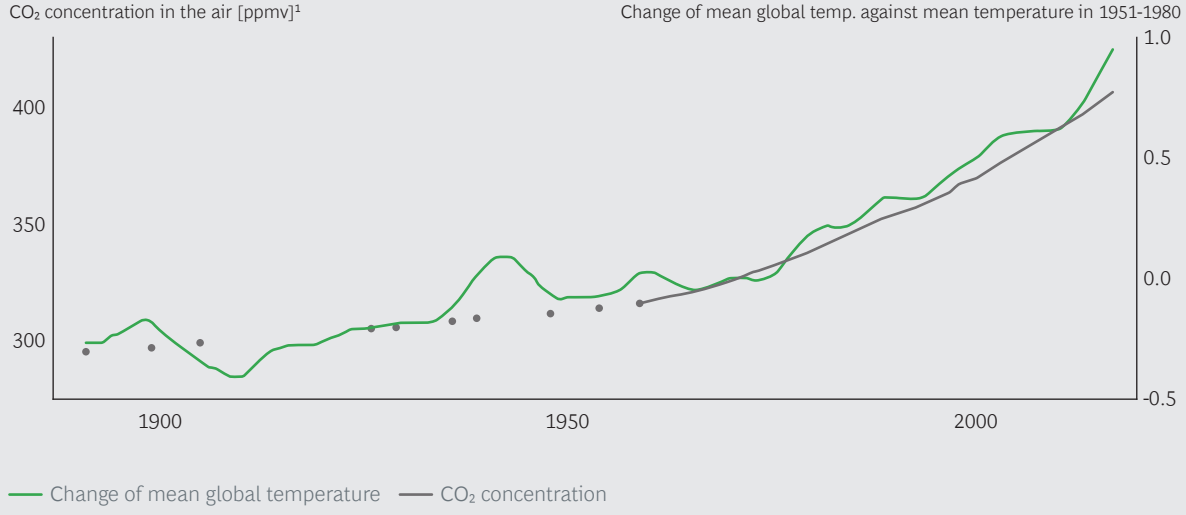
Climate change affects living standards of billions of people directly at risk from extreme weather such as droughts, hurricanes, heat waves, or heavy rainfall and flooding that often ensues. These weather events will not only be more frequent, they will also occur with greater force. At the same time, we will see a continued rise in sea levels. Sea levels are currently rising at a rate of approximately 4 mm per year, and this rate is increasing. By the end of the century, climate change could increase the global average sea level by 2 meters or even more[15] [16]. Total adaptation to the above-mentioned trends is not possible, whereas even partial adaptation by 2050 could cost more than USD 300 billion per year in the global south alone[17] [18].

9 **As cited in:** an article in the Nature magazine https://www.nature.com/articles/nature25464, download date 29 June 2018.
10 **As cited in:** IPCC https://www.ipcc.ch/report/ar5/, download date 29 June 2018.
11 **As cited in:** NASA https://climate.nasa.gov/vital-signs/global-temperature/, download date 14 September 2018.
12 **As cited in:** Institute of Meteorology and Water Management, National Research Institute, Climatic and oceanographic conditions in Poland and the South Baltic, 2012 http://klimat.imgw.pl/wp-content/uploads/2013/01/tom1.pdf, download date: 29 June 2018.
13 **As cited in:** IPCC https://www.ipcc.ch/report/ar5/, download date 29 June 2018.
14 **As cited in:** IPCC AR5 https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter12_FINAL.pdf, download date 29 June 2018.
15 **As cited in:** https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf, download date 29 June 2018.
16 **As cited in:** Dewi Le Bars et al 2017 Environmental Research Letters 12 044013 http://iopscience.iop.org/article/10.1088/1748-9326/aa6512/pdf, download date 29 June 2018.
17 **As cited in:** UNEP http://new.unep.org/climatechange/adaptation/gapreport2014/portals/50270/pdf/AGR_FULL_REPORT.pdf,
18 **As cited in:** WRI, http://www.wri.org/blog/2015/04/costs-climate-adaptation-explained-4-infographics, download date 29 June 2018.

The reason for the currently rising temperatures on Earth is the planet's energy imbalance, being a result of a growing concentration of greenhouse gases in the atmosphere, including primarily carbon dioxide (CO_2). Other greenhouse gases of anthropogenic origin contributing to global warming include methane (CH_4), nitrous oxide (N_2O), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6). Since the onset of the industrial revolution in the 18th century, the concentration of carbon dioxide in the atmosphere has increased by almost 50%, for methane by 150%, and nitrous oxide by almost 20%, reaching the highest levels for many millions of years[19].

A STRONG CORRELATION BETWEEN INCREASE OF CO_2 CONCENTRATION IN THE AIR AND MEAN GLOBAL TEMPERATURES

FIG. 2: THE CORRELATION OF THE CONCENTRATION OF CO_2 IN THE AIR AND THE CHANGE IN THE MEAN GLOBAL TEMPERATURE ON THE EARTH'S SURFACE COMPARED TO THE MEAN TEMPERATURE IN 1951-1980



Source: NOAA, Earth System Research Laboratory, Global Monitoring Division; NASA; BCG analysis

The current concentration of carbon dioxide in the atmosphere is 407 parts per million as of 19 August 2018)[20]. For comparison, a year ago the average concentration of CO_2 was 404 ppm, ten years ago it was 384 ppm, and prior to the industrial revolution it was approximately 280 ppm. Since records began in 1958, the annual growth rate of the carbon dioxide concentration in the atmosphere has risen from 0.7 ppm to 2.1 ppm, which is the level observed over the last ten years. Even if carbon dioxide emissions are limited in the coming decades, this gas will continue to play a role in the carbon cycle (CO_2 cycle between the atmosphere, land and oceans) for the coming millennia, maintaining the current effects of climate change in the future[21].

The international community is aware of the problem of the rise in the concentration of CO_2 and the implications this may have for future generations. During the Paris climate conference (COP 21) in December 2015, the representatives of 196 countries agreed that measures were needed to keep the increase in the average global temperature well below 2°C above the pre-industrial levels and to continue efforts to limit the temperature increase to 1.5°C[22]. By June 2018, the agreement had been

19 **As cited in:** http://www.sj.wne.sggw.pl/pdf/PRS_2017_T17(32)_n2_s244.pdf, download date 27 June 2018.
20 **As cited in:** NOAA, Earth System Research Laboratory, Global Monitoring Division, https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html, download date 4 September 2018.
21 **As cited in:** http://naukaoklimacie.pl/fakty-i-mity/mit-co2-ma-krotki-czas-zycia-w-atmosferze-68, download date 14 September 2018.
22 **As cited in:** Adoption of the Paris Agreement, UN FCCC, https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf, download date 29 June 2018.

signed by the 195 member states to the United Nations Convention on Climate Change (UNFCCC)[23]. Nevertheless, the National Determined Contributions (NDCs) declared by individual states and accepted in Paris, comprising targets to be achieved by 2030 are insufficient to keep the increase of mean global temperature below 2°C[24] [25] [26].

Climate Scenarios: The Base and For Generations scenarios.

The most recent IPCC report[27] shows that in order to reduce the global mean temperature increase by 1.5°C, greenhouse gas emissions need to be approximately halved by 2030 compared to today's levels and climate neutrality needs to be achieved by mid-century. If we do not reduce global emissions and the temperature rise remains at the current level, then between 2030 and 2052 the average global temperature will increase by 1.5°C and will continue to do so, resulting in a series of catastrophic consequences that will be felt worldwide.

This publication proposes measures that would enable Poland to reduce emissions to a degree closer to the arrangements made in the Paris Agreement[28]. It also sets out the areas in which changes can be made to inspire strategies for a zero-carbon (net-zero) economy by around mid-century. In the For Generations scenario, we assume that the proposed development model indicates the direction for the Polish contribution to climate protection, although this would still be insufficient. Therefore, in the textboxes, we have provided guidelines that should contribute to a net-zero path in compliance with the Paris Agreement. It also assumes that ambitious measures will be taken at the global level. The Base scenario assumes that both Poland and the rest of the world will follow a path where the abatement of the increase in average global temperatures will not be treated as a priority.

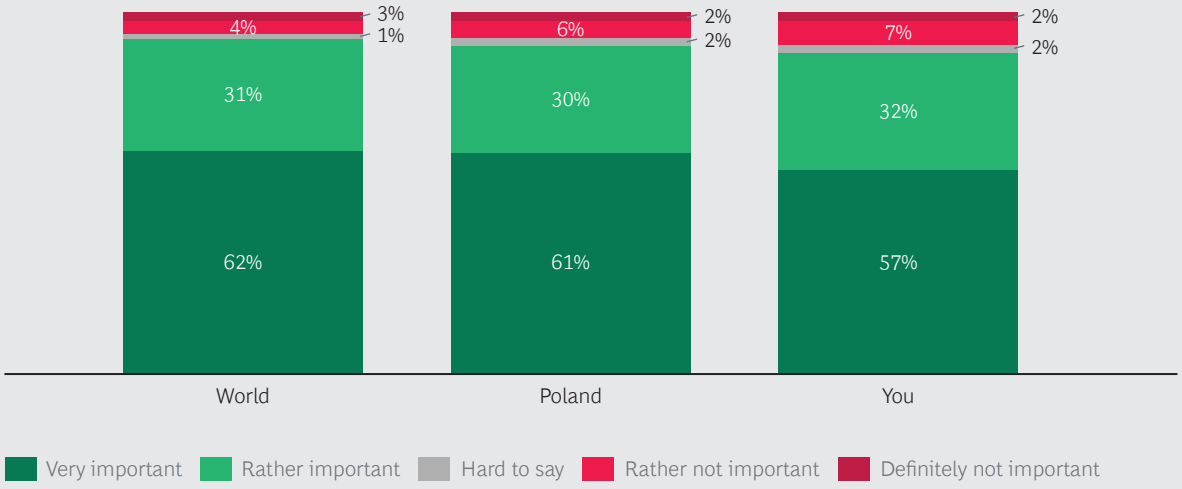
Risks related to Poland's high-emission economy

Poles declare that they are aware of climate change globally and in their country – as many as 93% consider anthropogenic climate change to be an important or very important issue for the world, and 89% consider it a major issue affecting them and their families. At the same time, however, Poles do not take significant steps and do not change their habits in order to improve the existing situation[29]. The passive attitude of Poles is partly due to the lack of sufficient awareness of the precise consequences that the progressive increase in average global temperatures is having and will have.

23 **As cited in:** Paris Agreement, United Nations Treaty Collection https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en, download date 29 June 2018.
24 **As cited in:** Fujimori, S. et al., 2016: Implication of Paris Agreement in the context of long-term climate mitigation goals. SpringerPlus, 5(1), 1620, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5028350/pdf/40064_2016_Article_3235.pdf, download date 14 September 2018.
25 **As cited in:** Rogelj, J. et al., 2016a: Paris Agreement climate proposals need a boost to keep warming well below 2°C. Nature, 534 (7609), 631-639, http://pure.iiasa.ac.at/id/eprint/13307/1/nature18307_proof1.pdf, download date 14 September 2018.
26 **As cited in:** Sanderson, B.M., B.C. O'Neill, and C. Tebaldi, 2016: What would it take to achieve the Paris temperature targets? Geophysical Research Letters, 43(13), 7133-7142 https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016GL069563, download date 14 September 2018.
27 **As cited in:** IPCC Report http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf, download date 29 June 2018.
28 **As cited in:** Adoption of the Paris Agreement, UN FCCC, https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf, download date 29 June 2018.
29 **As cited in:** Report on public opinion polls regarding energy in Poland, 2018 http://energiaodnowa.pl/wp-content/uploads/2018/03/RAPORT-Z-BADA%C5%83-SONDA%C5%BBOWYCH-OPINII-SPO%C5%81ECZNEJ-DOTYCZ%C4%84CEJ-ENERGETYKI-W-POLSCE-luty-2018.pdf, download date 29 June 2018.

HIGH DECLARATIVE AWARENESS OF CLIMATE CHANGE IN THE POLISH POPULATION

FIG. 3: ANSWER TO THE QUESTION: HOW IMPORTANT IS THE CLIMATE CHANGE FOR THE WORLD / FOR POLAND / FOR YOU?



Source: Report on public opinion polls concerning power sector in Poland, 2018 http://energiaodnowa.pVwp-content/uploads/2018/03/RAPORT-Z- BADA%C5%83-SON DA%CS%BBOWYCH-OPI N11-SPO%CS%81ECZN EI-DOTYCZ%C4%84CE!-EN ERGETYKI-W-POLSCE-luty-2018.pdf, download date 29 June 2018.

The key risks related to the high-emission nature of the Polish economy include:

- Environmental risks:
  - global warming caused by greenhouse gas emissions,
  - air pollution
- Socio-economic risks:
  - growing dependence on oil, gas and coal imports and related operating costs as well as energy price fluctuations,
  - weakening of energy security, i.e. the state of the economy in which the current and future customer energy demand can be met in a technically and economically reasonable manner in compliance with environmental requirements[30],
  - energy poverty (i.e. lack of funds in the household budget to maintain the appropriate temperature and satisfying basic energy needs at home). This, among other things, will affect mental and physical health, cause degradation of buildings, and result in social indebtedness,
  - blocking of the development of renewable energy sources,
  - hampering the development of energy efficiency improvement projects,

30 Art. 3 p. 16 Act of 10 April 1997 called Power Law (Journal of Laws of 2018, item 755).

– declining number of jobs.

Climate change and greenhouse gas emissions and the consequences for Poland

Because of weather anomalies Poles are exposed to multi-billion losses and major health problems

The last three decades were the warmest since records began in Poland. Since 1981, extreme temperatures have also been growing[31], which exacerbates extreme weather tendencies. More and more often we observe prolonged periods of heat and drought or violent thunderstorms. Due to climate change, each year Poles incur losses of approximately PLN 9 billion[32].

According to the 2013 governmental plan for adaptation to climate change, developed at the Ministry of the Environment, in the first decade of the 21st century Poland lost PLN 54 billion due to global warming. In the 2011–2020 period, the projected losses (if no adaptation measures are taken) are estimated at PLN 86 billion, and in the third decade of this century they may reach PLN 120 billion[33]. In 2018, from the second half of May, there was no rainfall and there were high air temperatures in some areas of Poland (mainly in central Poland) resulting in droughts on 53% of cropland, and severe droughts on 24% of cropland[34].

In the coming decades, the threat to crops caused by the occurrence of extreme weather events will increase, not only in the summer, but also in the winter (including late frosts). This will translate into lower profits for farmers, producers and distributors of food, and will affect consumers themselves, who will have to pay more for food. There is a wide spectrum of threats encompassing many sectors of the economy as well as ordinary people. In addition to disastrous global changes, in the coming decades, we will observe the direct impact of climate change in Poland:

- Losses to agriculture: The disruption of the seasons will extend the growing season, accompanied by frequent droughts, consequently lowering the level of groundwater. The intensification of the soil drying process is the biggest risk faced by farmers in the Wielkopolska voivodeship and Kujawy region, and - generally – in the central and western parts of Poland. Moreover, due to climate change, soil quality will deteriorate as a result of the decrease in organic matter used by plants to grow. Droughts, soil sterilization and other extreme weather events will have a negative impact on the quality and quantity of crops. Longer periods of hot days will also increase the risk of heat stress in animals, which will affect their health and, consequently, lead to losses to agriculture[35].

- Costs borne by local governments: Intensifying weather anomalies, such as floods, torrential rain or strong winds, are a challenge for local governments that have to adapt the country to the new conditions. This entails spending on adaptation of infrastructure, mainly in cities (including adjustment of roads and sewage systems to intensifying rainfall)[36].

- Higher insurance prices: One of many consequences of intensified weather events will be an increase in property insurance prices in in higher risk areas, by approximately 10–20%[37].

31 **As cited in:** Climatic and oceanographic conditions in Poland and the Southern Baltic Sea, Institute of Meteorology and Water Management, National Research Institute, 2012, http://klimat.imgw.pl/wp-content/uploads/2013/01/tom1.pdf, download date 29 June 2018.
32 **As cited in:** Strategic adaptation plan for sectors and areas sensitive to climate change by 2020, Ministry of the Environmental Protection, 2013, https://bip.mos.gov.pl/fileadmin/user_upload/bip/strategie_plany_programy/Strategiczny_plan_adaptacji_2020.pdf, download date 29 June 2018.
33 **As cited in:** Strategic adaptation plan for sectors and areas sensitive to climate change by 2020, Ministry of the Environment, 2013. https://bip.mos.gov.pl/fileadmin/user_upload/bip/strategie_plany_programy/Strategiczny_plan_adaptacji_2020.pdf, download date 29 June 2018.
34 **As cited in:** http://www.igik.edu.pl/pl/a/susza-rolnicza-2018-6, download date 29 June 2018.
35 **As cited in:** Strategic adaptation plan for sectors and areas sensitive to climate change by 2020, Ministry of the Environmental Protection, 2013 https://bip.mos.gov.pl/fileadmin/user_upload/bip/strategie_plany_programy/Strategiczny_plan_adaptacji_2020.pdf, download date 29 June 2018.
36 Development and implementation of the Strategic Adaptation Plan for sectors and areas sensitive to climate change, Environmental Protection Institute – National Research Institute.
37 Based on the current insurance price differentials in the high risk areas.

- Harmful impact on human health and nature: long-term heat waves present the greatest risk to the elderly, the sick and the poor[38]. For the same reason, cold-weather species of animals and plants ill-suited to higher temperatures will also suffer, and will have to migrate in search of colder ecosystems, or will disappear from the areas in which they are currently found. For example, in Poland even today, the boundaries within which the spruce is found can be seen to be shifting northwards.

- Faster spreading of contagious diseases: Contagious diseases are spreading more quickly and easily due to fast demographic, environmental, social and technological changes. The number of cases of borreliosis transmitted by ticks has tripled over the past 10 years and tick-borne encephalitis has increased more than eleven times over the past 21 years[39].

- A threat to the stability of electricity generation and supply: recurring cases of extreme demand for energy at the height of summer during heat waves, with unfavourable hydrological conditions and low wind at the same time, increase the risk of power failures or at least the need to reduce power supply.

Poland emits three times more greenhouse gases per unit of GDP than the EU average

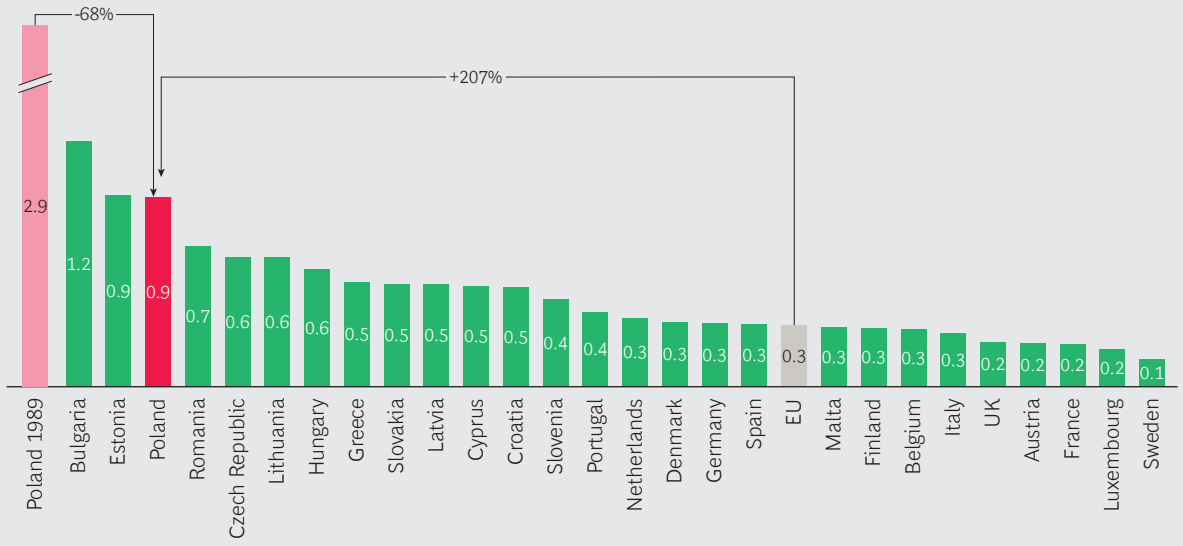
Poland emits 18% more greenhouse gases per capita and more than three times more in relation to GDP than the average for the European Union. This is the result of the high energy intensity of the Polish economy, which is based on fossil fuels, especially coal. This is largely due to its historical legacy. During the time of the Polish People's Republic, the Polish economy was based mainly on energy generated from coal-fired power plants, and despite industrial reforms carried out in the 1990s, coal still accounts for 78% of total primary electricity generation[40].

Over the last 27 years, greenhouse gas emissions per capita have fallen by 29%, and emissions in relation to GDP have decreased by 68%, but the transformation of the economy is responsible for most of the decreases in emissions. Since 1989, when communism collapsed in Poland, large inefficient industrial plants began to be closed, which caused a fall in emissions. Therefore, long-term goals and measures should be defined now in order to practically eliminate net greenhouse gas emissions (including balancing emissions through their absorption), that is, a zero-carbon (net-zero) economy.

38 **As cited in:** Climate Change 2014 Synthesis Report Summary for Policymakers, IPCC, https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf, download date 29 June 2018.
39 **As cited in:** World Health Organisation http://www.who.int/globalchange/climate/en/chapter6.pdf download date 10 September 2018.
40 **As cited in:** Eurostat, 2016, download date 29 June 2018.

OVER A PERIOD OF 27 YEARS, POLAND REDUCED GREENHOUSE GAS EMISSIONS IN RELATION TO GDP BY 68%, BUT RELATIVE EMISSIONS ARE MORE THAN 3 TIMES HIGHER THAN THE EU AVERAGE

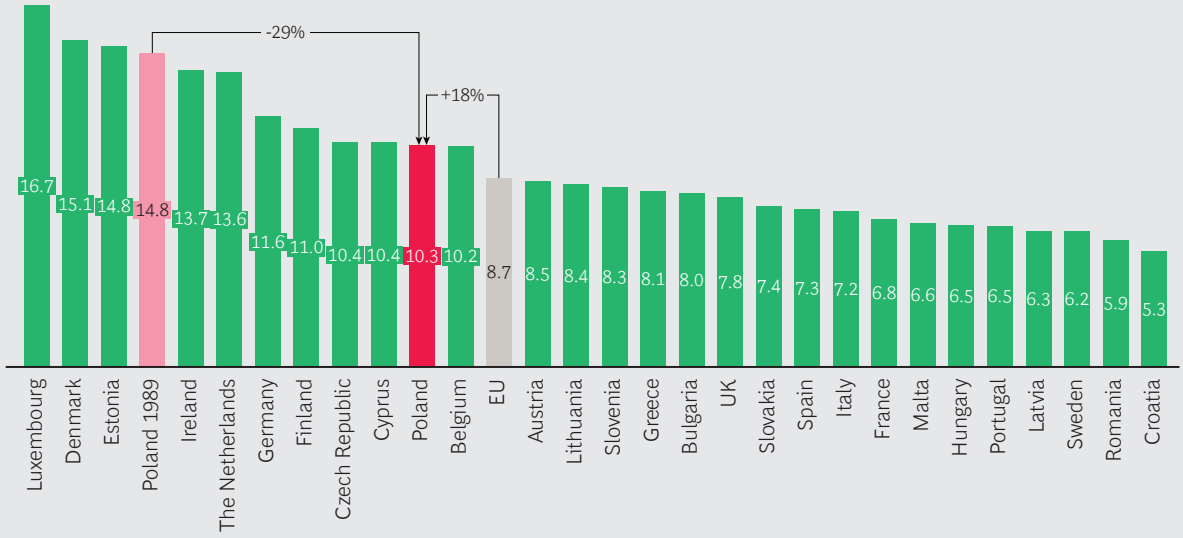
FIG. 4: GREENHOUSE GAS EMISSIONS IN RELATION TO GDP IN 2016 (1000 KG / M EUR)



Source: Greenhouse gases (CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent) — All NACE activities plus households, GDP current prices, Eurostat, 2016, BCG analysis

GREENHOUSE GAS EMISSIONS PER CAPITA ARE HIGHER AMONG INDUSTRALISED COUNTRIES SUCH AS POLAND, GERMANY OR THE NETHERLANDS

FIG. 5: GREENHOUSE GAS EMISSIONS PER CAPITA IN 2016 (1000 KG PER CAPITA)



Source: Greenhouse gases (CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent) — All NACE activities plus households; Eurostat, BCG analysis

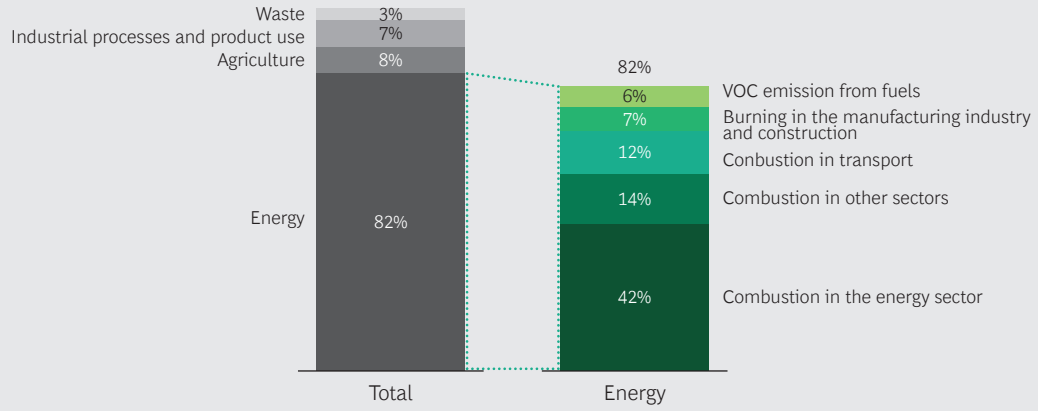
Fuel combustion is the main source of greenhouse gas emissions

Burning fossil fuels, i.e. coal, natural gas and crude oil, and the emissions of greenhouse gases as a side effect of mining, accounts for 82% of the total greenhouse gas emissions in Poland.

High emissions are the result of the use of fossil fuels in the power industry, industry and heating of millions of households. Transport is also a problem, now dominated by high-emission road transport. There is still too little usage of the more energy-efficient and low-emission modes of transport (freight and passenger transport) and public transport.

COMBUSTION OF FUELS FOR ENERGY GENERATION PURPOSES ACCOUNTS FOR 82% OF GREENHOUSE GAS EMISSIONS IN POLAND

FIG. 6: BREAKDOWN OF GREENHOUSE GAS EMISSIONS IN POLAND



Source: Greenhouse gases (CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent, HFC in CO_2 equivalent, PFC in CO_2 equivalent, SF_6 in CO_2 equivalent, NF_3 in CO_2 equivalent), Eurostat, 2016, BCG analysis

Air pollution and smog

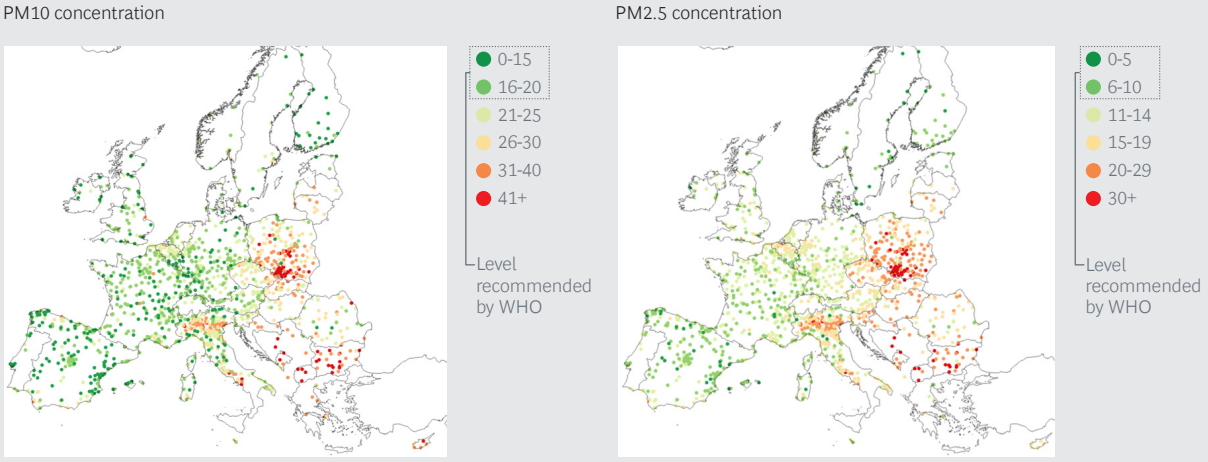
Poland is Europe's infamous leader in air pollution

According to the World Health Organization, Polish cities represent the majority of cities with the most polluted air in Europe, since as many as 36 out of 50 cities in Europe with the highest pollution are located in Poland. The residents of towns and cities such as Żywiec, Pszczyna, and Rybnik, and residents of large metropolitan areas such as Krakow and Warsaw[41], are most at risk. The problem also affects many other places, but air quality is not monitored for these places, and air quality data is not available.

41 **As cited in:** WHO, 2018 http://www.who.int/airpollution/data/cities/en/, download date 9 October 2018.

36 OF 50 EUROPEAN CITIES WITH THE MOST POLLUTED AIR ARE LOCATED IN POLAND

FIG. 7: MEAN CONCENTRATION OF PM10 AND PM2.5 PARTICULATE MATTER IN EUROPEAN CITIES [µG/M³] PER YEAR



Source: European Environment Agency, BCG analysis

In 2016, in as much as 39% of areas into which Poland is divided by the Institute for Environmental Protection, the PM2.5 air pollution limit was exceeded. The situation becomes even more alarming when we analyse the concentration of PM10 where the limits are exceeded, in 76% of these areas[42]. The limits for concentrations of benzo(a)pyrene in PM10 particulate matter are exceeded in as many as 93% of these areas. The legal target levels for average annual concentration of benzo(a)pyrene is 1 ng/m³.[43] In Nowy Sącz in 2015 it was over 11.9 ng/m³, in Zakopane – 8.9 ng/m³, in Krakow – 7.3 ng/m³, in Katowice – 6.0 ng/m³, and in Wrocław – 3.9 ng/m³. In Western Europe, concentrations were well below the limit: in Berlin – 0.41 ng/m³, in Paris and London – 0.21 ng/m³, in Barcelona – 0.15 ng/m³. In Poland, where there are listed cases of the permissible limits of harmful compounds being exceeded, the Institute of Environmental Protection recommends devising or updating the air protection program aimed at achieving acceptable or target concentration levels of substances in the air[44].

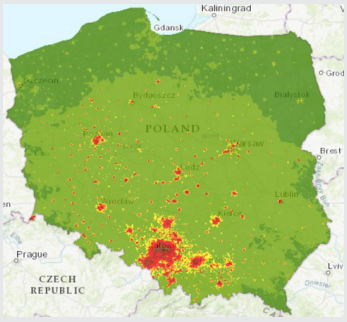
The poor air quality observed today is a consequence of many years of neglect. However, the level of awareness of the problem is growing. People on the street in masks protecting against air pollution, or people checking the status of air quality in mobile applications on a daily basis is nothing out of the ordinary.

42 **As cited in:** State Environmental Monitoring - Inspection of Environmental Protection. Prepared by: Institute of Environmental Protection - National Research Institute.
43 **As cited in:** Air quality in Europe — 2017 report, European Environment Agency, 2017 https://www.eea.europa.eu/publications/air-quality-in-europe-2017, download date 29 June 2018.
44 **As cited in:** Air quality assessment in zones in Poland for 2016, Inspection for Environmental Protection, 2017, https://powietrze.gios.gov.pl/pjp/content/show/1001097, download date 29 June 2018.

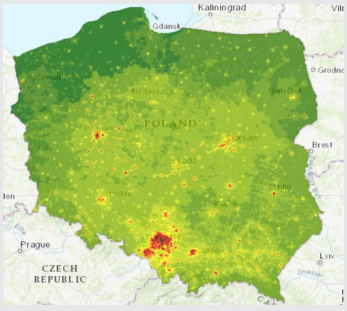
THE VOIVODESHIP OF SILESIA HAS THE MOST HEAVILY POLLUTED AIR IN POLAND

FIG. 8: MEAN-YEAR CONCENTRATION OF PM10, PM2.5 AND BENZO(A)PIRENE IN POLAND IN 2016 [µG/M³] PER YEAR

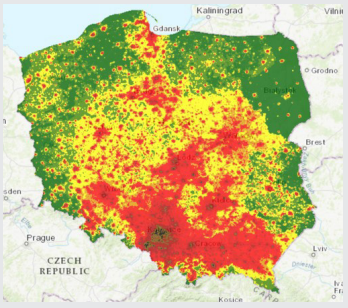
PM10 concentration



PM2.5 concentration



Benzo(a)pirene concentration



Source: Environmental Protection Institute

Polluted air causes deaths, diseases and huge losses

According to the European Environment Agency, air pollution of PM2.5 particulate matter causes over 46,000 premature deaths in Poland annually[45].

The most common harmful compounds found in the air are particulate pollution PM10 and PM2.5, and organic polycyclic aromatic hydrocarbons, including benzo(a)pyrene. PM10 increases the risk of respiratory diseases, of which the effects include wheezing, coughing and asthma attacks, chronic lung disease, and acute bronchitis. It can also indirectly raise the risk of heart attacks and strokes. PM2.5 is considered even more dangerous for human health. PM2.5 particles penetrate into the lungs, where they accumulate and from where they can enter the bloodstream, contributing, for instance to inflammation of blood vessels and atherosclerosis. Benzo(a)pyrene is a toxic carcinogenic and mutagenic compound that damages the adrenal glands, the liver, and the immune and the bloodstream systems[46] [47].

Air pollution also causes multi-million losses in the economy. One example is the 19 million working days that Poles lose due to sick leave every year. The health service is also exposed to additional healthcare costs exceeding PLN 350 million a year. In addition, there are losses incurred by farmers (when there is a loss of crops) estimated at PLN 1.1 billion per year[48]. Air pollution affects the development of plants and the so-called ecosystem services, which are the benefits that communities and the economy can derive from using natural resources. Plants are harmed by soil acidification and elevated levels of nitrogen compounds saturation caused by air pollution.

45 **As cited in:** Air quality in Europe — 2017 report, European Environment Agency, 2017,
46 **As cited in:** Impact of air pollution on health, We create atmosphere, http://www.tworzymyatmosfere.pl/uploads/files/Wplyw-zanieczyszczenia-powietrza-na-zdrowie.pdf, download date 29 June 2018.
47 **As cited in:** WHO, Outdoor air pollution, 2004, http://www.who.int/quantifying_ehimpacts/publications/ebd5.pdf, download date 29 June 2018.
48 **As cited in:** Review of the implementation of EU environmental policy. Country Report - POLAND, European Commission 2017, http://n-6-2.dcs.redcdn.pl/file/o2/tvn/web-content/m/p121/f/02f039058bd48307e6f653a2005c9dd2/3ae558c2-10a7-46eb-9959-be89f39534da.pdf, download date 29 June 2018.

FIG. 9: IMPACT OF AIR POLLUTION ON THE HUMAN BODY

Problems with memory and concentration, higher level of anxiety, depressive states, anatomical changes in the brain, accelerated aging of the nervous system, stroke

Breathing problems, irritation of the eyes, nose and throat, cough, runny nose, sinusitis

Myocardial infarction, hypertension, ischemic heart disease, arrhythmia, heart failure

Asthma exacerbation, lung cancer, exacerbation of Chronic Obstructive Pulmonary Disease, more frequent respiratory infections

Low birth weight, fetal death, premature birth

Source: Jakub Jędrak, PhD, Ewa Konduracka, Prof., Artur Badyda PhD, and Piotr Dąbrowiecki, MD *Impact of air pollution on human health*, Krakowski Alarm Smogowy (Cracow's Smog Alert), 2017

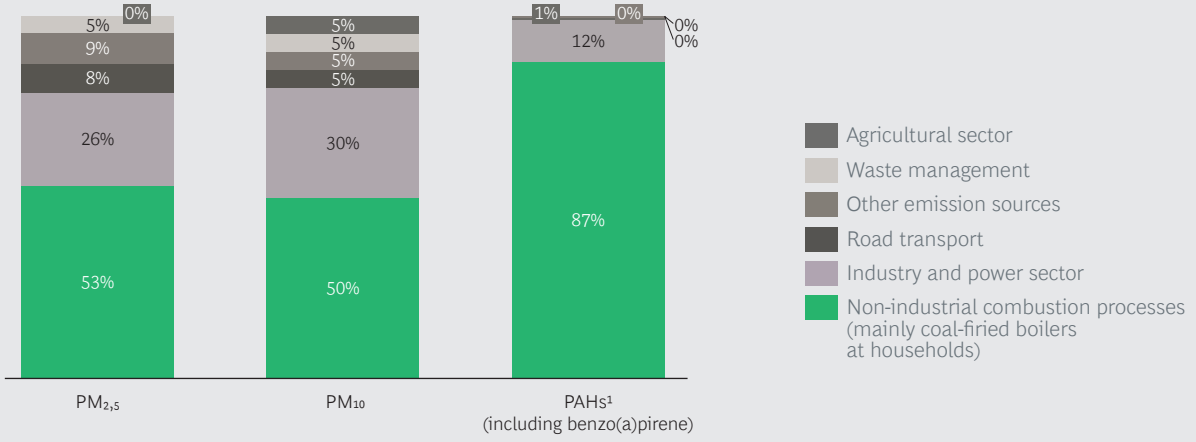
The most severe pollution is caused by single-family houses, industry and transport

In Poland, inefficient heating of households using solid fuels accounts for 50 to 90% of emissions (depending on the type of compound) of PM10, PM2.5 and polycyclic aromatic hydrocarbons (PAHs). This is a particularly dangerous source, as pollution is emitted directly in populated areas. Other important sources include the industrial, energy and road transport sectors[49]. Approximately 20% of PM2.5 concentrations come from cross-border emissions (originating from other countries) and natural emission from the land and plants, which is beyond the control of the Polish population, although cross-border emissions can be (partially) regulated by EU directives, among other things.

49 **As cited in:** National balance of SO_2, NO_x, CO_2, NH_3, Non-methane Volatile Organic Compounds, particulate matter, heavy metals and Personsent Organic Pollutant (POP) emissions in 2015 – 2016, National Emission Balancing and Management Centre, 2018 http://www.kobize.pl/uploads/materialy/materialy_do_pobrania/krajowa_inwentaryzacja_emisji/Bilans_emisji_za_2016-raport_syntetyczny.pdf, download date 29 June 2018.

COMMON USE OF COAL-FIRED BOILERS AND FURNACES (3 825 000 UNITS) AND THEIR POOR TECHNICAL CONDITION IS THE MAIN SOURCE OF AIR POLLUTION

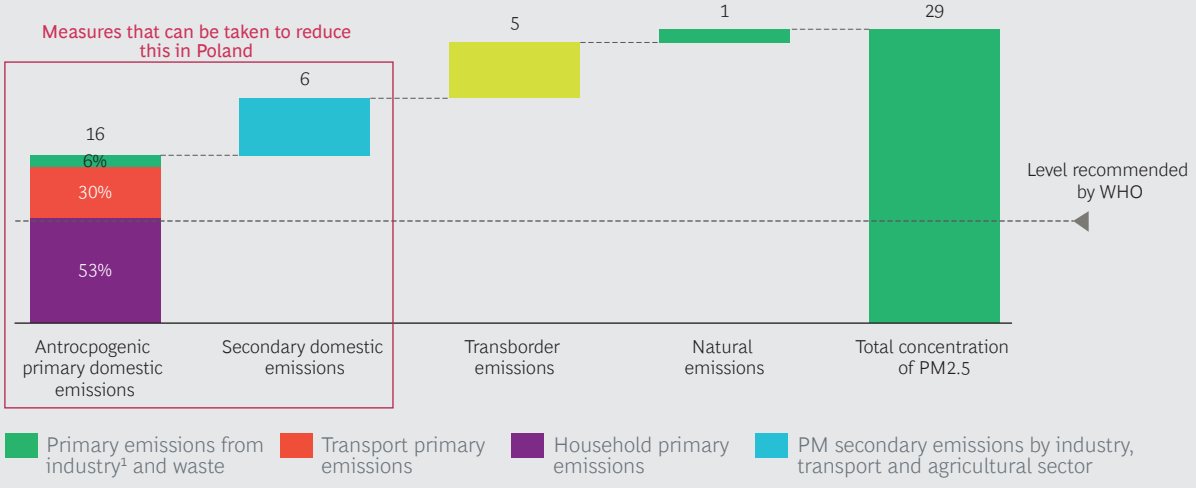
FIG. 10: BREAKDOWN OF AIR POLLUTION EMISSIONS IN POLAND



Source: KOBIZE Balance for 2014-2015, Institute of Environmental Economics "Economic Efficiency in Poland - 2015 Review", BCG analysis
[1]Polycyclic aromatic hydrocarbons (PAHs)

AVERAGE CONCENTRATION OF PM2.5 IN POLAND IS ALMOST 3 TIMES HIGHER THAN THE WHO RECOMMENDED LEVEL

FIG. 11: SOURCES OF MEAN CONCENTRATION OF PM2.5 IN THE AIR IN POLAND [µG/M³]



Source: Urban PM2.5 levels under the EU Clean Air Policy Package, TSAP Report #12, 2014, WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, WHO
[1]Including energy industry

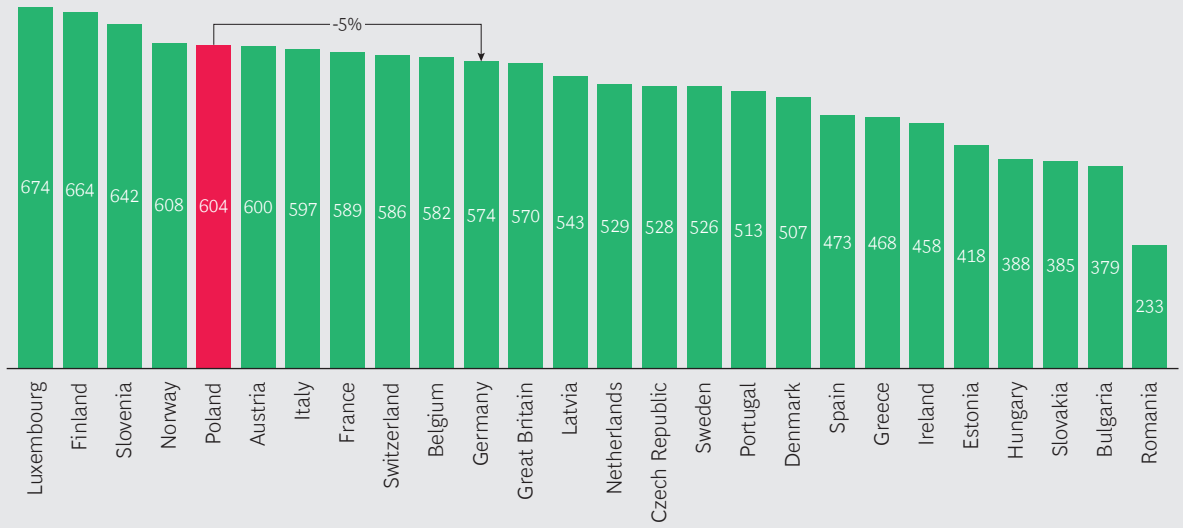
Many households emit significant volumes of harmful pollutants because they still use old and inefficient coal-fired boilers for heating purposes. According to statistics released by the Polish Central Statistical Office, 47% of Polish households use coal-fired hot water boilers in which not only hard coal is burned, but also biomass, coal dust, coal waste or even rubbish. Contrary to common belief, biomass and wood used in such a manner are not friendly to the environment or human health. Burning wood also causes emissions of significant amounts of pollutants and dust[50].

Road transport does not comply with standards

An additional source of air pollution is road transport in Poland. The average age of a car in Poland is 17.2 years, which is 6.5 years more than the average for the European Union[51]. Many cars do not comply with the current emissions standards for harmful substances required from new vehicles by the European Commission[52]. Moreover, the average number of vehicles per one thousand inhabitants in Poland is one of the highest in Europe[53].

POLAND HAS ONE OF THE HIGHEST CAR PENETRATION RATES IN EUROPE

FIG. 12: NUMBER OF LIGHT PASSENGER VEHICLES PER 1000 INHABITANTS IN EUROPE



Source: ACEA Pocket Guide 2017-2018, http://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2017-2018.pdf, download date 29th June 2018.

Furnace replacement and thermal efficiency improvement are required

Legislative measures aimed at improving air quality are being taken at the national and local government level. Many voivodeships in Poland already have the so-called anti-smog resolutions in place. To date, they have been introduced in voivodeships inhabited by approximately 60% of the population in Poland. For example, the Mazowiecki (Mazovian) voivodeship council adopted an anti-smog resolution in October 2017[54]. The main purpose was to eliminate the use of furnaces, boilers and

50 **As cited in:** United States Environmental Protection Agency, https://www.epa.gov/burnwise/wood-smoke-and-your-health, download date 29 June 2018.
51 **As cited in:** ACEA Pocket Guide 2017-2018, http://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2017-2018.pdf, download date 29 June 2018.
52 **As cited in:** European Commission, https://ec.europa.eu/clima/policies/transport/vehicles/cars_en, download date 29 June 2018.
53 IHS
54 **As cited in:** Official Journal of the Mazovia Provincial Office, http://edziennik.mazowieckie.pl/#/legalact/2017/9600/, download date 29 June 2018.

fireplaces that did not meet the requirements of the eco-design regulations[55] [56] and to prohibit the use of poor-quality coal in coal furnaces. Households with coal- or wood-fired furnaces that do not comply with the requirements have to replace them by the end of 2022 with models in line with the new standards. Despite these changes, it is likely that solid fuels will remain one of the main sources of heating in households.

In 2018, a pilot program of thermal efficiency improvement of thousands of households was launched in the 33 Polish municipalities with highest air pollution. The initially estimated costs of this program are PLN 750 million. It was followed up by the Clean Air nationwide program of thermal efficiency improvement and improvement of air quality launched on 17 September 2018[57]. The envisaged total capital expenditures under the entire program (including own contribution) are PLN 132,8 billion, of which PLN 63,2 billion will be subsidies and PLN 39,7 billion in loans[58].

Poland has also ambitious plans for electromobility development

In February 2018, the Act on Electromobility and Alternative Fuels came into force in Poland, which aspires to place a million electric cars on Polish roads by 2025[59]. The development of electric cars is to be an economic stimulus for the Polish economy and to be conducive to innovation development in the automotive industry. The Act removes barriers to development of electric car pooling, allowing them to be treated as a type of public transport. It also provides the legal foundations for building the infrastructure needed to charge cars with electricity and enables local governments to introduce "clean transport" zones, i.e. where only pedestrians, bicycles or zero-carbon electric cars are allowed.

Along with the bill amending the Act on Biocomponents and Liquid Biofuels[60] the Low-Carbon Transport Fund was established, with a planned budget of PLN 6,75 billion in the 2019–2027 period. Among other things, the Fund is to create a mechanism of fund redistribution among vehicles with engines fuelled with conventional fuels (additional PLN 0.08 fuel surcharge for each liter of fuel and diesel sold) and electric cars and cars that use alternative fuels (compressed and liquid natural gas, as well as biofuels).

Climate and air – Looking ahead

Our forecasts concerning Poland's future, where climate and air quality play pivotal roles, cover three issues:

- development of the power sector,
- change of transport structure (modal split),
- thermal efficiency improvement of buildings.

Changes in other sectors of the economy are also described briefly.

55 The eco-design requirements concern the reduction of pollutants emissions from solid fuel boilers and energy efficiency in buildings. Solid fuel boilers placed on the market and for use throughout the European Union will have to comply with the set requirements of seasonal energy efficiency and pollutant emissions for seasonal heating of housing units. The required emission standards relate to significant reduction of particulate matter (PM), carbon monoxide or nitrogen oxides.
56 **As cited in:** the Ministry of Energy, http://www.me.gov.pl/Energetyka/Efektywnosc+energetyczna/Ekoprojekt http://edziennik.mazowieckie.pl/#/legalact/2017/9600/, download date 29 June 2018.
57 **As cited in:** The Ministry of Environmental Protection https://www.mos.gov.pl/aktualnosci/szczegoly/news/rusza-nabor-wnioskow-w-programie-czyste-powietrze/, download date 29 June 2018.
58 **As cited in:** The National Environmental Protection and Water Management Fund http://nfosigw.gov.pl/czyste-powietrze/aktualnosci/art,3,porozumienie-na-rzecz-poprawy-jakosci-powietrza-w-polsce-podpisane-kluczowa-rola-nfosigw-w-walce-ze-smogiem.html, download date 29 June 2018.
59 **As cited in:** The Lower Chamber of the Polish Parliament, http://www.sejm.gov.pl/Sejm8.nsf/Przebieg%xsp?id=D06B7D40956323FDC125820C00486F9A, download date 29 June 2018.
60 **As cited in:** The Lower Chamber of the Polish Parliament, 2018 http://orka.sejm.gov.pl/Druki8ka.nsf/0/57E9FADFA6ACB5BCC125826C003358AF/%24File/2411.pdf, download date 29 June 2018.

Power Sector Development

Electricity consumption in the National Power System

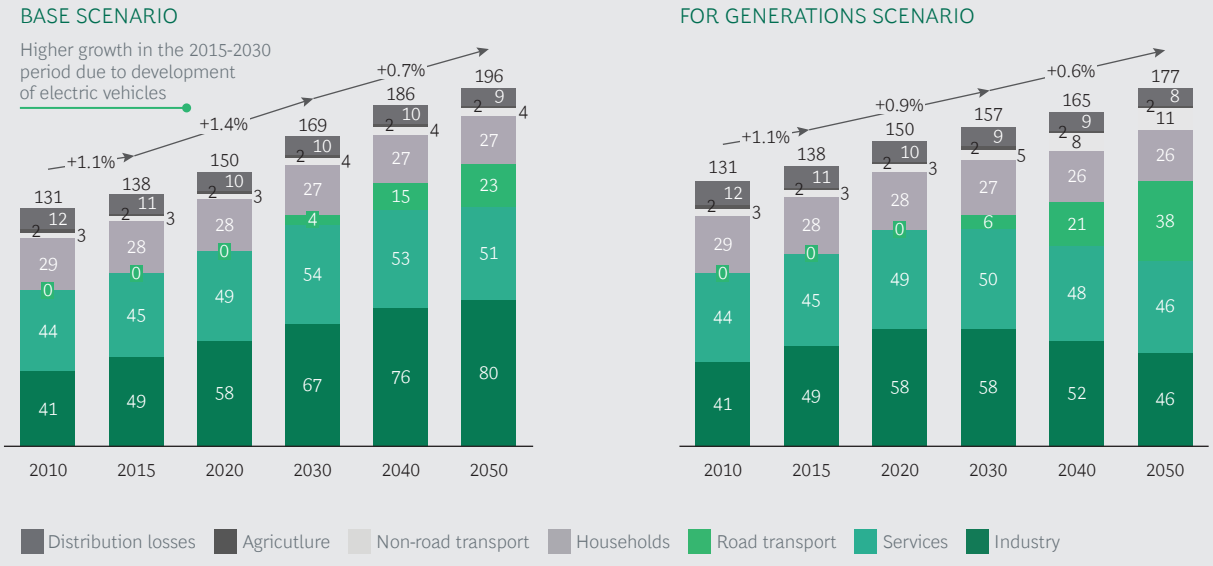
Regardless of the adopted scenario, we predict that in the coming years electricity consumption will grow in Poland, but at various rates depending on the chosen path. In the most conservative Base scenario, the increase in electricity consumption between 2015 and 2030 will accelerate due to the growing use of electric vehicles. Under the For Generations scenario, increasing electricity consumption resulting from more rapid development of electromobility and railways (greater share in the modal split and electrification of the railway lines) will be compensated for by increased energy efficiency, mainly in industry. We predict that industrial power consumption under the For Generations scenario will be lower by 34 TWh in 2050. The decrease in this scenario results from the fact that the Polish economy aims to achieve an energy consumption level in industry in relation to GDP the same as that currently seen in Denmark.

The 10% (19 TWh) decrease in total energy consumption in 2050 under the For Generations scenario as opposed to the Base scenario results from the different growth rates in the number of electric cars in Poland under the two scenarios.

Under both scenarios, the modernization of the power transmission system in Poland will reduce distribution losses to a similar extent. This is because these distribution losses will be balanced out by connecting medium and low voltage lines when supplying electricity.

UNDER THE FOR GENERATIONS SCENARIO THE POLISH ECONOMY MAY CONSUME 10 TWH ELECTRICITY LESS MAINLY OWING TO SAVINGS IN INDUSTRY AND SERVICES

FIG. 13: TOTAL ELECTRICITY CONSUMPTION IN THE NATIONAL POWER GRID [TWH]



Source: Eurostat, BCG analysis

Electricity demand

Poland 2050 Base Scenario

- Industry: Under the Base scenario, we assume that measures have been taken to enhance the efficiency of the industry. However, the measures will not be as extensive and fast as those presented under the For Generations scenario. As a result, in 2050 Polish industry will reach the level of electricity consumption per unit of added value generated in industry similar to that recorded in the Netherlands in 2016. Despite electro-energy intensity improvement by 30%, the total energy consumption in industry will increase by 60% from 41 to 80 TWh. This will be a consequence of the increase in industrial output. The rudiments of the Demand Side Response (DSR) system will be implemented only partially, and Polish industry will realise its potential only to a small extent. The natural consequence of these tendencies will be demand for electricity remaining high at peak times. Polish companies will not get a stimulus from the government that would force them to develop renewable energy and industrial energy storage technologies. Most of the technologies related to obtaining energy from renewable sources will be imported from Germany and China.

- Households and services: Households will reduce electricity consumption. This will be a result of energy efficiency enhancement, equipment availability on the market, and the replacement of conventional light bulbs with energy-saving ones (e.g. LEDs). The growing demand for electricity will be due to the growing number of air conditioning systems used in the summer season. By 2050, total electricity consumption in households and services will increase by 5 TWh, reaching 51 TWh. One of the reasons for this will be that commercial buildings will comply with stricter energy efficiency requirements. This will happen due to tighter EU and national standards in this area.

- Transport: Electric cars and buses will contribute to the increase of electricity consumption by 23 TWh. In 2050, total consumption in rail transport will increase from 2.9 to 4.2 TWh. This will be a result of gradual development of rail transport and its electrification.

Poland 2050, For Generations scenario

- Industry: the recommended scenario assumes that intensive measures to increase the energy efficiency of industry will be undertaken in Poland. Sustainable development will be promoted with an emphasis on energy efficiency. Over the span of 34 years, electricity consumption per unit of added value generated in industry will fall by 59%. As a result, total energy consumption in industry will go up by only 12% (from 41 to 46 TWh), with more than a twofold increase in generated added value. Thanks to the lower output of hard coal and lignite, energy consumption by energy-intensive mines will be reduced. Appropriate systemic solutions will enable implementation of energy recovery solutions from waste gases and heat in the steel industry and reduction of fuel consumption in the petrochemical industry (due to car electrification), which will also help to reduce energy consumption. In many manufacturing companies, Demand Side Response (DSR) systems will be implemented. The total potential for reducing power demand in Poland is 3500 MW – this is the amount by much it will be possible to reduce domestic demand for power at peak times. In addition, it will be possible to reduce energy consumption by about 200 GWh per year.

- Households and services: Households will reduce electricity consumption due to the increasing energy efficiency of used equipment and the replacement of conventional light bulbs with energy-efficient solutions (e.g. LEDs). Thanks to the regulatory requirements, many new buildings will be equipped with intelligent systems for managing the consumption of electricity. On hot days, when the air-conditioning is activated and energy demand usually reaches peak levels, Demand Side Management (DSM) systems will be used in high-consumption buildings to optimize the demand

side. The largest customers will use solutions such as the Virtual Power Plant[61]. This will help to reduce electricity consumption by 1.3 TWh above the assumptions made in the Base scenario. New commercial buildings will be more energy-efficient, and consequently total electricity consumption will increase by only 2 TWh in 2050, reaching 46 TWh. At the same time, some of the electricity generated by photovoltaics will be produced directly in households and the services sector through prosumerism, i.e. the consumption and generation of electricity by one entity.

- Transport: The development of electric passenger cars, buses, light commercial vehicles and lorries will contribute to the consumption of an additional 38 TWh of electricity. Due to the total electrification of the railway network and significant increase in passenger-kilometers and tons-kilometers, the electricity consumption on the railway will increase from 2.9 to 10.5 TWh.

Electricity supply

Poland 2050 Base scenario

The assumption with the greatest impact on the shape of Polish electricity generation is the upholding of the decision to build a nuclear power plant. We also assume that coal-fired power plants built in recent years will operate in the baseload power system (comprising Bełchatów B14, Kozienice B11, Turów 2, Jaworzno III, Łagisza B10, and Opole B5 and B6 power units) until at least 2050. According to the government's announcements, Ostrołęka C will be the last coal-fired power plant in Poland. Coal-fired power units will most likely be treated as energy sources that must run to preserve their place in the system. The development of wind energy that has slowed down in recent years in Poland will be accelerated thanks to the construction of offshore wind farms. According to declarations made by PGE and Polenergia, investment projects with a total capacity of 2,200 MW will be implemented by 2030.

By 2050, coal-fired power units will account for 13% of the capacity installed in the system and will be responsible for 29% of the total electricity generation in Poland. In 2016, these rates were – 72% and 78%, respectively[62]. The energy system will be supported by three new nuclear units with a capacity of 1,500 MW each, which will require funds (including indirectly public funds) of PLN 65–105 billion. Under this scenario, in 2050, nuclear energy will be responsible for 17% of national electricity generation.

The current laws, which are not conducive to modern solutions, will result in the increase of installed capacity of onshore wind farms by only 3 GW compared to today, and their total installed capacity will reach 9 GW. Offshore wind farms will grow faster – by 2050 facilities will be built of an installed capacity 7.5 GW.

The total power of photovoltaic panels installed on the roofs of households and commercial buildings will only be 7 GW. This is just under 30% of Poland’s maximum potential estimated at 25 GW.

By 2050, the share of RES[63] in the electricity output will rise to 36% from the level of 13.36%[64] recorded in 2016. This means that Poland will continue to stand out from other European countries in this respect and will not meet the target of a 32% share of renewable energy in the economy in 2030.

Poland’s energy system may be partly based on renewable sources, if new, flexible gas-fired power units are built of which the total generation capacity should increase to 17.9 GW. Due to the speed with

61 A system of connected dispersed renewable energy generation units with ICT networks, a management system and market mechanisms
62 Energy Market Agency
63 Wind, solar, hydro energy and biomass
64 **As cited in:** EUROSTAT https://ec.europa.eu/eurostat/web/energy/data/shares, download date 27 June 2018.

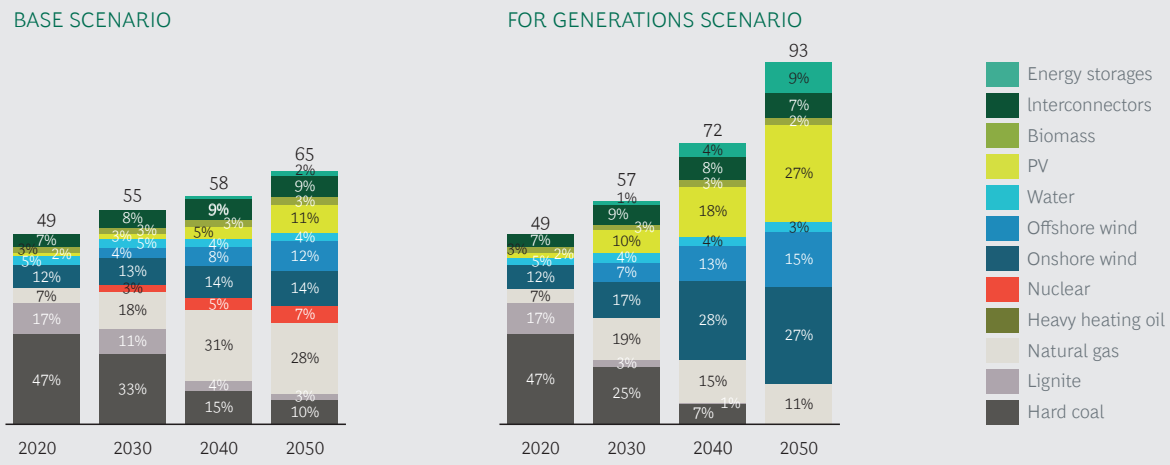
which they can be started up, the gas-fired power units will be able to replenish power shortages in the system when there is not enough solar energy or wind to generate electricity.

The additional mechanisms stabilising the system will play an increasingly important role in covering the demand for energy, especially during the summer and winter peaks. We class the import of electricity from abroad, energy storage used in industry and households, and the previously mentioned DSM / DSR as being among these mechanisms. Our Base scenario assumes that power coming from interconnections will rise in 2050 to 5.6 GW from 3 GW in 2016, and energy storage will be able to provide 1 GW of power[65] (0 in 2016). The consumption of hard coal and lignite in Poland will start to decline. The consumption of coal will drop from 30 to 18 Mt over a period of 35 years, and consumption of brown coal from 62 Mt in 2015 to 16 Mt in 2050. Due to the broader use of gaseous fuels, in 2050 consumption of gaseous fuels will rise from 2 to 7 billion cubic meters, reaching the highest value of 11 billion m³ in 2040.

The development of the energy sector in the envisaged Base scenario will cost the Polish economy in terms of capital expenditures at least PLN 160 billion. The change in the structure of electricity output and the rising prices of CO_2 emission allowances will affect the cost of electricity generation. It will go up by 57% over a period of 30 years and in 2050 it will reach 554 PLN / MWh, so it will be 6% lower under the Generation scenario (516 PLN / MWh and 11% lower for lower prices of CO_2 allowances). However, due to the higher electricity consumption in 2020–2050, Poles will spend around PLN 105 billion more than under the For Generations scenario (PLN 157 billion more for higher prices of allowances).

MAXIMUM SYSTEM CAPACITY UNDER FOR GENERATIONS SCENARIO HIGHER BY 43% COMPARED TO THE BASE SCENARIO

FIG. 14: BREAKDOWN OF MAXIMUM CAPACITY [GW]

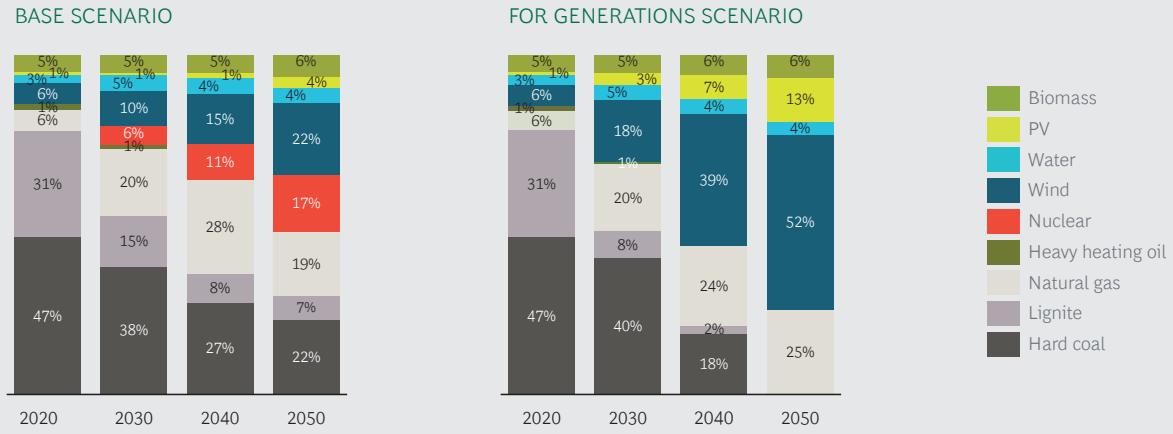


Source: BCG Merit Order Model, BCG analysis and project experience

65 Excluding pumped storage hydroelectricity.

GROWING ELECTRICITY OUTPUT FROM RENEWABLE ENERGY SOURCES AND GAS-FIRED POWER PLANTS UNDER THE TWO SCENARIOS

FIG. 15: BREAKDOWN OF ELECTRICITY GENERATION



Source: BCG Merit Order Model, BCG analyses and project experience
[1]Including pumped storage power plants

Poland 2050, For Generations scenario

This scenario assumes faster development of renewable energy sources in Poland thanks to the construction of new wind farms and photovoltaic power plants. We also assume that a nuclear power plant will not be constructed in Poland – it will be replaced by a combination of solutions using renewable energy sources and gas sources. This scenario is also based on the assumption that in the coming years the lithium-ion storages will become widespread. Batteries of this kind should be able to draw and supply power of greater capacity and last longer than those used today. We assume that by 2050, the power from energy storage will increase to 8 GW (4 GW will be allocated to industrial and business energy storages). Another factor affecting this scenario is the development of interconnectors in the EU (energy transfer between countries). This will mean that less gas can be used as a balancing source.

ZERO-EMISSION PATH: PROMISSING TECHNOLOGIES THAT MAY REVOULUTIONIZE ENERGY CONSUMPTION AND LEAD TO A ZERO-CARBON ECONOMY

If a target is adopted of reducing greenhouse gases to zero, energy storage technology will have to be developed further, to balance the power generated by renewable sources. Development enabling independence from fossil fuels is not unrealistic, especially in view of the rate of change (learning curve) in renewable sources since the 1970s, or development of the telecommunications sector over the last 20 years.

Compressed air – compressed air storage works in a similar way to pumped hydropower. Instead of moving the water up, the surplus of electricity is used to compress and store energy underground. When electricity is needed, compressed air is heated and released, driving the turbine. Immediately after pumped-storage hydroelectric power, compressed air is the second largest type of energy storage and is constantly being developed. Compressed air is usually best stored in existing geological formations, such as unused hard rocks, old salt mines or coal mines.

Hydrogen drives – Hydrogen is one of the most abundant elements available on Earth. This means that it is also an attractive fuel for energy-generating technology. In the automotive industry, hydrogen fuel cells are gaining in popularity particularly quickly. There are many indications that they are the future for instance of road transport, especially large trucks and inter-city buses, which consume too much energy to be able to replace conventional drives with electric ones. Fuel cells work in a similar way to batteries, with two electrodes separated by an electrolyte. However, hydrogen fuel cells do not wear out and do not need to be recharged. They can continue to generate electricity as long as the hydrogen and oxidant flow is pumped.

Synthetic gas (syngas) – This is a mixture of gaseous fuels consisting mainly of hydrogen, carbon monoxide and very often carbon dioxide. In the case of CO_2, it should be captured from the combustion process in order for the gas to be truly zero-emission. It is used as an intermediate in the synthesis of natural gas (SNG) for the production of ammonia or methanol. Syngas is usually a product of the gasification process, and the main application is the generation of electricity. Syngas is flammable and is often used as fuel for internal combustion engines. Synthetic gas can also be potentially created in situations where the electricity generated by Renewable Energy Sources exceeds the demand at any given time. Thanks to this, it may become the main fuel in the future, which will replace conventional natural gas.

Batteries – Batteries are now the main power source applied to most of home electronics due to high energy density and low self-discharge. Companies want to expand the use of this rapidly evolving technology, to take advantage of the ever increasing and better opportunities, including in particular battery electric vehicles (BEV) and safeguarding security of supply to the national and regional power grids. At the moment, the main raw material of batteries is lithium, but as there are limited resources of lithium, efforts are being made to use other raw materials as well, such as sodium.

Thanks to the propagation of the technologies described, and a further decrease in the costs of RES, Poland would be able to achieve a 75% share of RES in generation of electricity by 2050. To balance the system, 10 GW of installed capacity in gas-fired generating units will be required to offset fluctuations in generation of power from RES. Energy storages with 8 GW of achievable power (compared to 1 GW under the Base scenario) will also need additional balancing, which will be possible assuming a rapid development of energy storage technologies. This would make it possible to reduce carbon dioxide emissions in the power sector from the current level of 150 Mt to 19 Mt, of which a vast majority would originate from gas combustion. An effort to become independent from burning fossil fuels will become one of the main goals of Polish society. From 2020, no new coal-fired power plant will be built, and such power units of currently operating power plants whose life cycles are coming to an end, will be decommissioned. By 2050, coal sources will be completely excluded from Poland's energy mix. Due to the fact that the aim will be to reduce greenhouse gas emissions to zero, it will be necessary to further develop energy storage technologies that can balance the energy obtained from RES. Natural gas can potentially be replaced by synthetic gas.

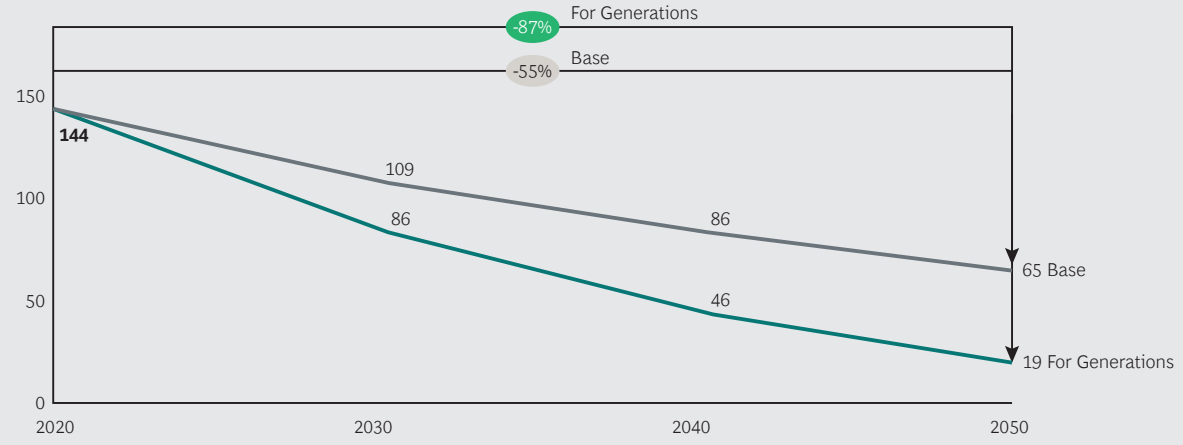
The government will not invest in nuclear energy, and the funds saved in this way will be invested in RES, and thus renewable energy will play a pivotal for the energy sector. If appropriate development conditions are created, 39 GW of wind power: 25 GW on onshore sites and 14 GW on off-shore sites, can be obtained. Similarly, in the case of PV, the total installed capacity will be 18 GW higher than under the Base scenario, and will be 25 GW. The development of such an energy system would involve higher capital expenditures ranging from PLN 194 to PLN 354 billion, i.e. PLN 32–76 billion more compared to the Base scenario. These investments mainly consist of costs related to onshore and offshore wind farms, which would cost a total of PLN 117-190 billion, photovoltaic plants - PLN 38-94 billion and energy storage houses, for which expenditures would range between PLN 10 and 22 billion[66].

The For Generations scenario would involve a higher weighted average cost of electricity of PLN 578 / MWh (11% difference compared to 516 PLN/MWh under the Base scenario) in 2050, assuming a fixed price of CO_2 emission allowances at EUR 29.67/t in 2030–2050. At higher EUA prices (EUR 29.67/t in 2030, EUR 45/t in 2040, and EUR 60/t in 2050), the generating cost would go up to PLN 590 /MWh (difference of only 6% compared to PLN 554 /MWh under the Base scenario). The lower prices under the Base scenario are due among other things to decapitalized coal-fired power plants being operated longer and no shutdown of new ones. The new structure of electricity output would mean greenhouse gas emissions could be reduced by an additional 46 Mt per year compared to the Base scenario.

66 Analysis based on lithium-ion technology; investment costs based on global benchmarks (3.4-5.2mln PLN/MW); cost decline at CAGR 4% in 2020-2050. Due to limitations of charging and discharging cycles, storage units may have to be often replaced, raising investment costs. Storage unit costs included in supply side.

CO_2 EMISSIONS WILL DECLINE BY 55-90% IN COMPARISON TO THE YEAR 2020, DEPENDING ON THE SCENARIO

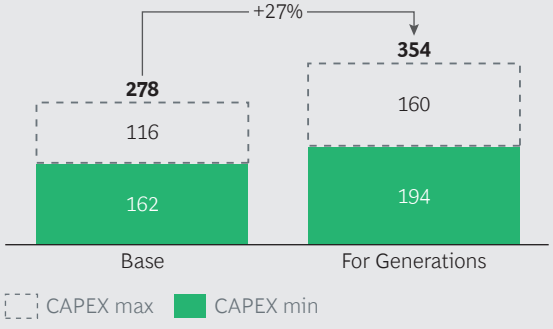
FIG. 17: CO_2 EMISSIONS [MT]



Source: BCG Merit Order Model, BCG analyses and project experience

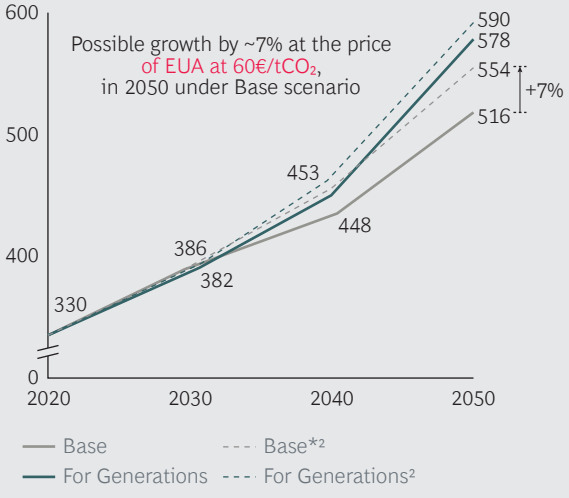
THE FOR GENERATIONS SCENARIO REQUIRES AN INCREASE IN CAPEX BY PLN 32-76 BN COMPARED TO THE BASE SCENARIO

FIG. 18: CUMULATIVE CAPEX [PLN BN]



Main factors:
Under the **Base** scenario high capex on nuclear energy.
Under the **For Generations** scenario, significant capex on energy storage and renewable energy resources, but these have low operating costs.

FIG. 19: AVERAGE WEIGHTED ENERGY GENERATION COST[1] [PLN/MWH]



Note: Average weighted cost of energy production assuming a fixed price of CO_2 emission allowances at the level of 29.67 EUR/t in 2030-2050
[1]Fixed and variable costs, including: cost of fuel, emissions, O & M [2]Weighted average energy production with the assumption of a higher CO_2 price: 45 euro/t in 2040 and 60 euro/t in 2050
Source: BCG Merit Order Model, BCG analysis and design experience

FIG. 20: COMPARISON OF ELECTRICITY SUPPLY AND DEMAND SCENARIOS

	Base Scenario	For Generations scenario	Difference between scenarios
Cumulative cost[1] of producing electrical energy for the economy in 2020-2050 [BN PLN]	2 280-2 370	2 175-2 213	Down by 105-157
CAPEX in 2020-2050 [BN PLN]	162-278	194-354	Up by 32-76%
Cost of generating energy in 2050 [PLN/MWh]	516-554	578-590	Up by 36-62%
Cost of generating energy at higher CO_2 emission prices in 2050 [PLN/MWh]	554	590	Up by 36%
Coal and lignite consumption in 2050 [Mt]	34	0	Down by 34%
Annual CO_2 emissions in 2050 [Mt]	56	19	Down by 37%
Share of RES in electric electricity output in 2050	36%	75%	Up by 39%

[1]In the For Generations scenario the cumulative cost includes the effects of reduced demand due to greater energy efficiency

The comparison above does not specify external costs, which, depending on the scenario, will affect our economy and quality of life. External costs are linked to the costs of dealing with the impact of climate change and air quality and resource use, and are therefore significantly higher for fossil fuels compared to renewable energy sources[67].

Transformation of passenger transport

Poland 2050 Base scenario

Under this scenario, we assume that the government will not make development of railways and public transport a priority. As a result, the share of rail transport in passenger transport will increase slightly in the period in question, from 6% to 6.8%. Due to a general increase in society mobility, passenger cars will remain the dominant means of transport for Poles. The share of transport by passenger car will rise from 70% to 72%.

Public transport will develop at a pace similar to that observed prior to 2018, which means that it will lose its market share slightly. The network of bus lines will be developed slowly and new intercity connections will be created at a similar rate. Due to the underdeveloped infrastructure and growing affluence of the society, the car will be chosen more often than the bus or tram. The use of Park & Ride facilities will be negligible, and the level of use of bicycles will remain unchanged. All this will translate into a decrease in the use of urban public transport and its share in transport from 13.5% in 2015 to 8%

67 Sample analysis of external costs depending on the energy source

in 2050.

The number of actively used cars per 1000 inhabitants will remain at the level of 418[68] and will remain one of the highest in the European Union.

Poland 2050, For Generations scenario

Under the For Generations scenario, it is assumed that in the 2020–2040 period multi-billion capital expenditures will be incurred for rail development. Railway lines will undergo modernization, 3,000 kilometers of new lines will be added, and the travel times between cities will be cut drastically. The European Rail Traffic Management System (ERTMS2) will be implemented. The railway infrastructure access fees will become competitive in relation to road transport, making passenger transport by rail more popular, while energy use in the transport sector will quickly become more efficient.

Investments will reduce journey times, improve the frequency of connections, and result in trains being more reliable. Some of the connections closed down in the 1980s and 1990s will be restored. In turn, the new lines created will cover towns and residential areas that to date had no access to the railway network. The number of railway connections will double, and service departures every half-hour will be the standard on the main lines.

As a result of these measures, passenger rail transport will increase its share in the modal split from 6% in 2016 to 8% in 2030 and 14% in 2050. At the end of this period, Poland will be able to boast a percentage of passenger rail transport comparable to that observed by European leaders such as Switzerland.

In addition, the system integrated with car-sharing, Park & Ride facilities, public transport, and use of bicycles will convince travellers to switch from a car to a train and public transport. Public transport will be more popular and more convenient. Local governments will support the development of low-emission bus networks, expand conventional and light railway systems, and, in Warsaw, the metro network will further develop the connections between more remote distant districts and the city centre.

The percentage of people who regularly use bicycles will increase from 7% to 22%. This will be a result comparable to that in Hungary[69]. Each year the statistical Pole will cover, on a bicycle and on foot, a distance 70% greater than today, and at the same time half of that of Dutch people. The common use of bicycles will translate into a drop in obesity and the number of chronic diseases among Poles[70].

In this situation, the number of actively used cars per thousand inhabitants will no longer be one of the highest in the European Union, and will fall by 5%, from 418[71] to 397 in 2050. As a result, subsequent generations will not waste so many hours in traffic jams, and less traffic on the streets will translate into fewer accidents. Thanks to the competitive network of railways and public transport, some households will be able to give up their car, or second car. This will mean additional savings for households, because the annual costs of keeping a car are higher than even regularly purchasing four season tickets for city public transport.

In order to reduce the volume of greenhouse gases emitted by the transport sector, the electrification of the remaining 7,300 kilometers of the Polish railway network needs to be completed. This would mean

68 PZPM, 2016 http://www.pzpm.org.pl/Publikacje/Raporty, download date 29 June 2018.
69 **As cited in:** Quality of transport, Special Eurobarometer 422a, European Commission, 2014 http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_422a_en.pdf, download date 29 June 2018.
70 **As cited in:** The Relationship between Sport Participation and Chronic Diseases among Men, MDPI http://www.mdpi.com/2075-4663/5/3/56/pdf, download date 29 June 2018.
71 **As cited in:** PZPM, 2016 http://www.pzpm.org.pl/Publikacje/Raporty, download date 29 June 2018.

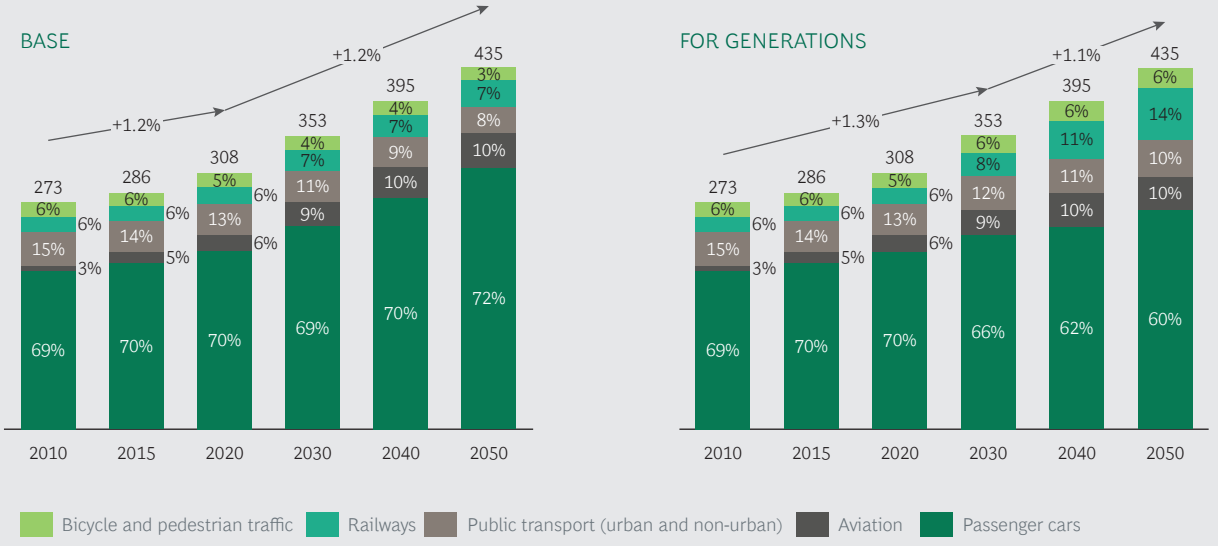
capital expenditure totalling PLN 23.4 billion in the period 2020–2030.

Thanks to the transfer of part of the transport system (freight and passenger) from road to rail, it will be possible to reduce annual greenhouse gas emissions by over 5 million tons by 2050 (under the Base scenario only 1.5 million tons), which means a reduction of total annual transport emissions by 23% (Base scenario: 7%).

Due to the growing use of air transport, in taking appropriate measures, the optimization of carbon dioxide emissions from aircraft will be extremely important. This would be possible, for example, by using synthetic fuels in the future instead of conventional oil, and by making proper use of railways.

UNDER THE FOR GENERATIONS SCENARIO, THE SHARE OF PASSENGER CARS IN PASSENGER TRANSPORT DECREASES BY 12 PERCENT THANKS TO RAILWAYS AND PUBLIC TRANSPORT

FIG. 21: BREAKDOWN OF PASSENGER TRAFFIC [BN PASSENGER KILOMETERS]



Source: Eurostat, CSO, transport demand forecasts for Poland until 2020 and 2030. Jan Burnewicz, February 2012, BCG analysis in cooperation with Jakub Majewski, Ph.D., the ProKolej Foundation

Future of electric vehicles

The development of electromobility was treated as a government priority as early as 2015. For the automotive industry to undergo an electrical revolution, however, the price and the cost of maintaining electric vehicles (Total Cost of Ownership) need to be reduced. Around 2022, this should be the same as in the case of conventional cars[72].

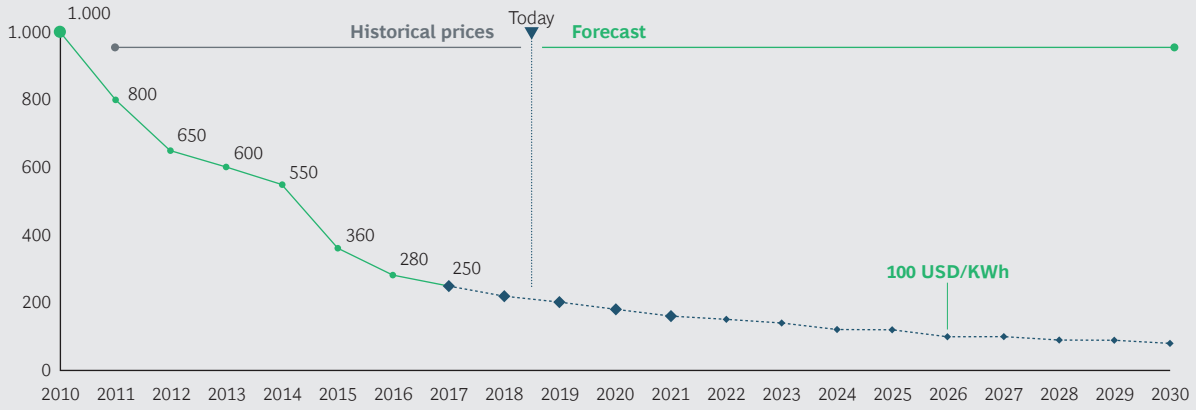
There will be incentives for drivers of electric cars, such as lower excise tax on the purchase of vehicles and a more favourable depreciation rate. Cars of this type will be temporarily allowed to use bus lanes, and parking in zones where parking fees apply for other cars will be free.

Charging electric vehicles will become a new type of business, so a license will not be required. This will mean that several thousand charging points can be opened in 2020–2030.

72 BCG analysis.

RAPID DECLINE OF PRICES PER KWH BATTERY STIMULATES EV MARKET

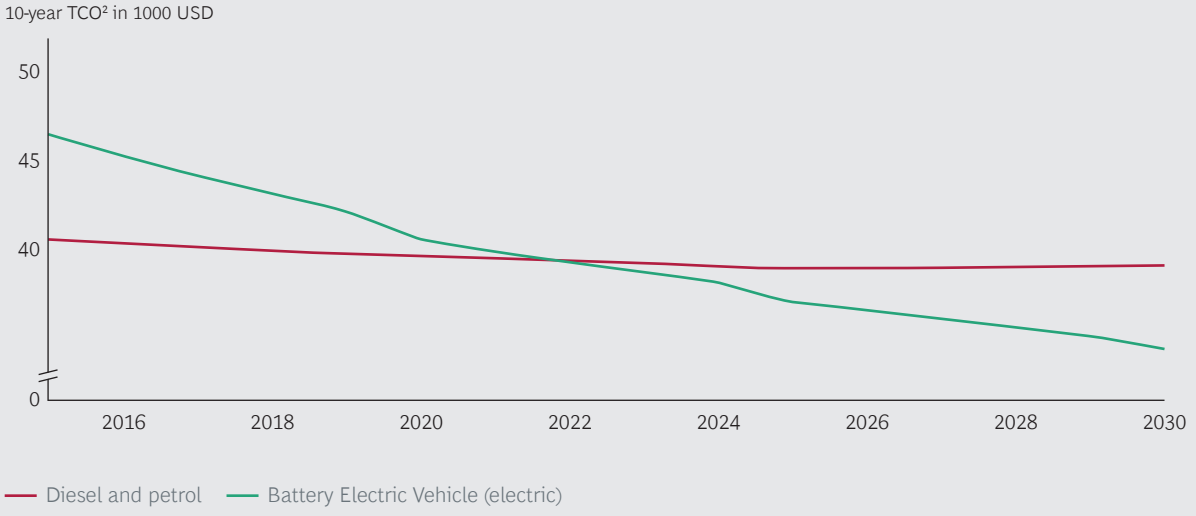
FIG. 22: BATTERY PRICES [USD/KWH]



Source: Bloomberg New Energy Finance, BCG analysis

IN EUROPE ELECTRIC VEHICLES WILL BE MORE COST-EFFECTIVE FROM APPROXIMATELY 2022[1]

FIG. 23: TOTAL OWNERSHIP COST (TOC) OF A CAR OVER A SPAN OF 10 YEARS DEPENDING ON THE YEAR OF PURCHASE



Source: BCG analysis

[1]Under the assumption of the average mileage in Europe at the level of 18,000 km. [2]TCO – Total Cost of Ownership

Poland 2050, Base scenario

Under the Base scenario, we assume that despite a promising start in Poland, there will be no revolutionary changes supporting the development of electric cars. The network of stations and charging points will not be developed enough to enable traveling by electric cars in a comfortable manner, while incentives to have an electric car will not be sufficient at the initial stage. The decrease in costs related to the purchase and use of electric vehicles will, however, be a stimulus for their role in the total number of vehicles to increase. This will also translate into the import of used electric cars. The share of electric cars will increase in to 22% in 2030, 40% in 2040, and 50% in 2050.

More and more electric city buses will operate in Polish cities. Even in the period 2018–2030, public funds will be made available to local governments under schemes established to partly finance the purchase of electric buses. However, in 2030 still only 39% of vehicles will powered by electricity.

Poland 2050, For Generations scenario

The recommended option would mean that the development of electromobility would become one of the government's priorities. The extensive infrastructure would enable convenient use of electric cars and will become the driving force for the sale of such vehicles. It might enable development towards well-conceived industrialization and the creation of new, highly skilled jobs. The share of electric car sales in the entire car market will grow faster in Poland than in many other European countries. Poland will join the European leaders with a share of electric cars among new cars at the levels of 38% in 2030, 50% in 2040, and 70% in 2050. Imports of second-hand electric cars will also go up.

Local governments and public transport under their management will not be excluded from the electric revolution. In 2020, a regulation will be issued that will force local authorities to replace all public transport buses with electric vehicles by 2030. Thanks to partial financing for example from the Low-Emission Transport Fund and the National Environmental Protection and Water Management Fund (mainly from European Union funds), this goal can be achieved without putting excessive strain on local budgets. Moreover, over time, probably at the beginning of the 2020s, the operation of electric bus fleets will be cheaper than their conventional counterparts, saving local governments money. Passengers choosing urban public transport will enjoy better travel conditions, because electric buses are quieter than their counterparts with internal combustion engines. One of the parties to benefit could be the automotive industry located in Poland (manufacture of buses). Their market position will be strengthened, and thanks to domestic demand manufacturers will have adequate resources and knowledge to expand into the Western markets. This will create new jobs for skilled employees.

Due to the faster development of electromobility under the For Generations scenario in 2050, fuel consumption in transport will be lower by about 5 million m^3, which means less annual oil imports worth PLN 9.8 billion[73]. In the overall 2020–2050 period, this implies savings of PLN 108 billion.

A high share of electric passenger cars and buses will help improve air quality and reduce road transport greenhouse gas emissions by 36% (compared to 25% under the Base scenario).

73 Assuming an average price per cubic meter of PLN 1,924 in accordance with the average net price of EU95 gasoline in 2017, according to the Polish Organisation of Oil Sector and Trade (Polish acronym POPiHN).

UNDER THE FOR GENERATIONS SCENARIO, OWING TO A LOWER OVERALL CAR PENETRATION RATE AND FASTER SATURATION WITH ELECTRIC CARS, THE PERCENTAGE OF ELECTRIC CARS WILL INCREASE BY 14 PERCENTAGE POINTS

FIG. 24: SHARE OF BATTERY ELECTRIC VEHICLES (BEV) IN NEW PASSENGER CAR SALES.

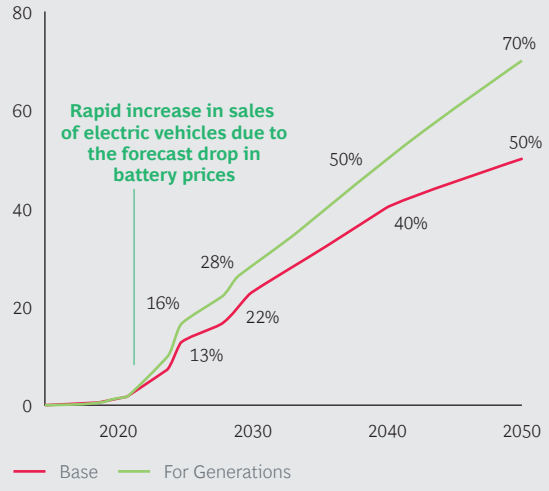
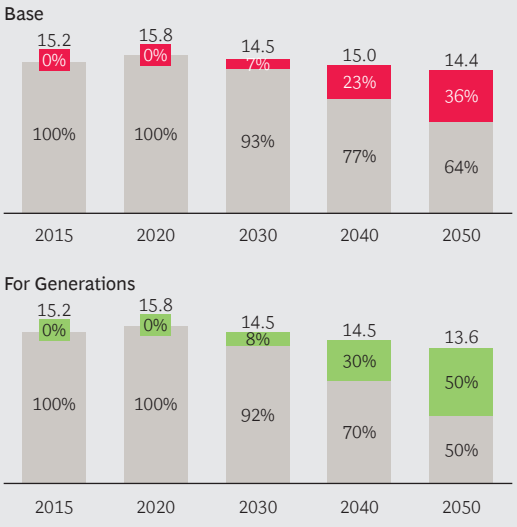


FIG. 25: SHARE OF BEVS IN THE TOTAL NUMBER OF ACTIVELY USED PASSENGER VEHICLES.



Source: PZPM, ACEA 2015, BCG analysis

FIG. 26: ZERO-CARBON PATH: HYDROGEN FUEL CELLS MAY BE THE FUTURE OF ZERO--CARBON ROAD TRANSPORT

Technology maturity		Energy carrier	Engine	Efficiency (original-final)	Range	Refueling time	Direct emissions
Internal combusion		Gasoline	Combustion engine	~30%	~1000 km	~2min	CO_2, NO_x
Biofuel vehicles	BIO	Biofuel	Combustion engine	15-20%	~1000 km	~2min	CO_2, NO_x
Electric vehicles		Electric energy[1]	Electric motor	~45% (50% of generated power, 90% EV)	~400 km	>30 min	Lack of direct emissions
Fuel cell vehicles	H_2	Hydrogen[2]	Fuel cell & electric motor	~20% (50% of generated power, 85% electrolysis, 50% fuel cell, 90% EV)	~600 km	~4min	Lack of direct emissions

The first series of mass-produced hydrogen fuel cell vehicles are beginning to appear on the market. They generate electricity through the reaction of oxidation of the hydrogen supplied to them. The only by-product is water vapor, which means that these drives do not generate direct CO_2 emissions. Currently, this technology is at a very early stage of commercialization. This is due, among other things, to huge infrastructure costs for hydrogen refueling. At the moment, the cost of building a hydrogen refueling station is even several dozen times higher than charging stations for electric cars. In the coming decades, when the production costs of such vehicles and infrastructure will drop significantly, perhaps hydrogen will be the fuel of the future for the automotive industry. It has a special potential in vehicles that consume a lot of energy and travel long distances, such as trucks or coaches. In their case, the development of electric drives is unlikely because of the amount of electricity they consume.

Source: BCG sources
[1]Primary energy converted into electricity in power plants (50% efficiency assumed). [2]Primary energy converted into hydrogen by gas units (fossil fuels) or electrolysis cells (following conversion into electricity)

ZERO-EMISSIONS PATH: PROMISING TECHNOLOGIES THAT MAY REVOLUTIONIZE ENERGY CONSUMPTION AND LEAD TO A ZERO-EMISSIONS ECONOMY

In the zero-emissions path in the transport sector, a program of investments in public transport in urban and rural areas would have to be implemented. It would be based on the construction of a nationwide network of multi-modal interchange nodes and thousands of Park & Ride, and Bike & Ride facilities and places for setting down and picking public transport passengers (Kiss & Ride). Facilities of this type will be developed in all cities, municipal villages and at all railway stations. Warsaw will have a third line of the underground railway. In all cities of over 100,000 residents, tram networks will have to be built, while in cities of a population of more than 200,000, suburban railway networks would be created. At the same time, the position of bus transport in the less urbanized parts of the country would be rebuilt thanks to the effective network of local buses (former PKS) serviced by a fleet of almost 16,000 buses with electric (or other alternative) drive. As a result, by 2050, the share of passengers using the railways could increase by an additional 2.6%, and the public transport system - not counting the railway - could even then handle ¼ of all travel. This would help to reduce emissions further in the transport sector, at the same time increasing the communication links of many areas of the country and improving social mobility.

Thermal efficiency improvement of buildings[74]

Poland 2050, Base scenario

This forecast assumes that the pilot programs carried out will help to reduce pollution in cities. The thermal efficiency improvement program covering 15,000–16,000 buildings, launched in 2018 in 33 municipalities, will not be rolled out into a nationwide project. Nevertheless, most households will gradually replace coal-fired boilers with newer generation equipment. The structure of fuels used in Poland for heating houses will also change partially. More households will use gas, oil, and electricity (heat pumps, etc.), and less will use coal, wood and biomass.

Between 2020 and 2050, thermal efficiency improvement measures will be undertaken in 1% of residential and commercial buildings. Minor modernization projects will be the dominant form (85% of the total), providing energy savings of an average of 15%. The share of moderate renovations will be lower (10%), which will mean average energy savings of 45%, as will extensive renovations (5%), which will reduce the use of energy by as much as 75%.

Poland 2050, For Generations scenario

The scenario regarding thermal efficiency improvement assumes that an ambitious plan carried out in 2020 and later, together with financial mechanisms supporting similar investment projects among less affluent people, will be continued on a nationwide basis and will produced the desired results.

By 2035, 2.5% of residential and commercial buildings will undergo the required renovation annually. In 2040, of all the renovation work performed, minor renovations, providing on average energy savings

74 Chapter prepared on the basis of analyses and expert opinion of Dan Staniaszek, Ph.D. of the Buildings Performance Institute Europe (BPIE).

of 15%, will account for only 5% of the total, moderate projects generating savings of 45% on average – 58%, and extensive renovations, generating average energy savings of 75%, will account for 35% of total projects. There will be positive energy buildings (3% of the total), or Near Zero-Carbon Emissions Buildings.

Poles will feel the difference in air quality, because the concentration of PM 2.5 and PM 10 particulate matter will be reduced in 2050 to the limits recommended by the World Health Organization. Before that, in 2030, they will achieve concentration levels in line with the European Commission's "Clean Air" package[75]. Thanks to the implemented measures, the number of premature deaths caused by poor air quality will fall by about half[76].

Appropriate thermal efficiency improvements can generate net savings of PLN 79 billion in energy costs and PLN 339 billion in external cost savings. By 2050, 24,000 jobs will be created, and CO_2 emissions from fossil fuel combustion will be reduced by as much as 23 Mt per year.

Impact of thermal improvement measures on health, the economy, and the environment

Thermal efficiency improvement of buildings also has economic, health, environmental, and quality of life benefits. Thanks to thermal efficiency improvement, houses will be better warmed up, with fewer under-heated, humid places (which will reduce mould and improve the indoor air quality).

Research has shown that investments to reduce energy consumption in buildings can stimulate the economy and help generate additional GDP and create new jobs[77]. According to European Environment Agency (EEA) estimates, lower energy consumption will mean a reduction of environmental external costs, such as air pollution (including a reduction in PM2.5 and PM10), climate warming due to CO_2 emissions, and the losses caused by these events, for example in agriculture or public health[78].

75 **As cited in:** European Council – „Clean Air Policy Package" http://www.consilium.europa.eu/pl/policies/clean-air/, download date 29 June 2018.
76 A. Gayer, D. Mucha, Ł. Adamkiewicz, *Report on the analysis of the health impact on the Polish population resulting from exposure to polluted air in 2030 and 2050, assuming a reduction of the concentration of air pollutants to the levels recommended by WHO*, the reviewer: M. Krzyżanowski, 2018.
77 Weisbrod et al., 1995, Grover, 2005
78 European Environment Agency, External costs of electricity production, https://www.eea.europa.eu/data-and-maps/indicators/en35-external-costs-of-electricity-production-1/en35, download date 29 June 2018.

FIG. 27: COMPARISON OF THE RESULTS OF MODELLING THE ELECTRICITY CONSUMPTION BY HOUSEHOLD AND BY SERVICES

	Base	For Generations	Difference between scenarios
Reduction of mean year total energy consumption [TWh]	23	107	84
Reduction of mean year total energy consumption as a percentage in 2016	7%	32%	26%
Reduction of annual CO_2 emissions from fossil fuels used for heating purposes [Mt]	5.0	23.3	18.3
Reduction of annual CO_2 emissions from fossil fuels used for heating purposes as a percentage in of 2016	11%	49%	38%
Aggregate economic calculus in 2020-2050			
Aggregate gross savings in 2020-50 generated on energy costs [billion PLN]	44	167	123
Capex [PLN BN]	(-27)	(-71)	(-44)
Aggregate net savings on energy costs in the 2020-50 period: gross savings less capex [PLN BN]	17	96	79
New jobs created [1000]	10.2	34.3	24.1

Source: Based on the analysis of Dan Staniaszek, Building Performance Institute Europe

FIG. 28: COMPARISON OF TOTAL ANNUAL ELECTRICITY CONSUMPTION AND CO_2 EMISSIONS BY HOUSEHOLDS AND SERVICES

Total energy consumption by households and services	1990	2016	Base	For Generations
Annual energy consumption [TWh]	265	329	306	245
Change in annual energy consumption compared with 1990		24%	15%	-8%
Direct CO_2 emissions by households and services	1988	2016	Base	For Generations
Annual CO_2 emissions [Mt]	94	44	39	21
Change of annual CO_2 emissions compared with 1988		-53%	-59%	-78%

Source: KOBiZE, Eurostat, BPIE analysis, BCG analysis

ZERO-EMISSIONS PATH: PROMISING TECHNOLOGIES THAT MAY REVOLUTIONIZE ENERGY CONSUMPTION AND LEAD TO A ZERO-EMISSIONS ECONOMY

Under the zero-emission path, only new zero-emission buildings could be built and deep thermal efficiency improvement and modernization would have to improve rapidly to a standard with a positive energy balance - up to 81% of the total in 2045. While this would mean tripling the number of currently implemented thermal efficiency improvements per year and incurring investment costs about PLN 169 billion, the aggregate savings for consumers for the years 2020-2050 would amount to PLN 338 billion. These changes would also result in the creation of an additional 82 thousand jobs. While such a range of modernization is technically possible, it would be necessary to create appropriate legal conditions and mechanisms supporting bearing investment costs.

Source: Based on BPIE report

Other sectors of the economy

We have identified key recommendation areas to support the decrease of greenhouse gas emissions and to improve air quality: energy, buildings, electrification of individual transport, and the development of railways and public transport, covering approximately 70% of emissions from the national economy. Reductions of emissions are also possible in other sectors of the economy.

Emissions are also caused by:

- fuel combustion in petroleum refining,
- fuel combustion in manufacture of solid fuels and other energy industries,
- fuel combustion in manufacturing industries and construction,
- fuel combustion in agriculture, forestry and fishing,
- fuels – fugitive emissions,
- emissions from industrial processes and product use as well as agriculture,
- land use, land use change and forestry (LULUCF).

WISEEUROPA MEEP SIMULATION MODEL

To estimate the total scale of decarbonization of other branches of the national economy, the WiseEuropa MEEP model was used. This is a microsimulation tool used estimate aggregate demand of the economy for energy and its emissions by applying various types of technology in sectors.

To calculate energy demand and GHG emissions for individual sectors, actual economic activity levels, learning curves and parameters of individual technologies are used which are forecast using econometric and statistical analysis methods. Examples of indicators determining the level of economic activity include the kilometers travelled, usable area per inhabitant, or the level and structure of output in individual sectors. Meanwhile, the technology learning curves take into account all gradual cost reduction methods, for example energy-efficient lighting.

The simulation model can be used to evaluate the impact of the policy supporting demand for reduced energy consumption while following a certain path of GDP growth and changing structure of the economy. Based on the adopted scenario, the required energy efficiency levels in individual sectors vary, which later has an impact on energy demand and size of emissions estimated by the simulation model.

Poland 2050, Base scenario

Under the Base scenario, it was assumed that current energy and market trends will be maintained. This means maintaining the same energy mix and production levels in particular industries. The important thing is, however, that in the case of past trends, emissions do not have to go in the same

direction. This depends to a large extent on the emissions drivers in the past. Due to significant forecast economic growth (i.e. among others, industrial output), if today's trends continue, the decrease in emission levels in sectors accounting for about 30% of total emissions will remain low. While it will be possible to reduce emissions by 26% compared to 1990, from 2015 the reduction will be only 7%.

Poland 2050, For Generations scenario

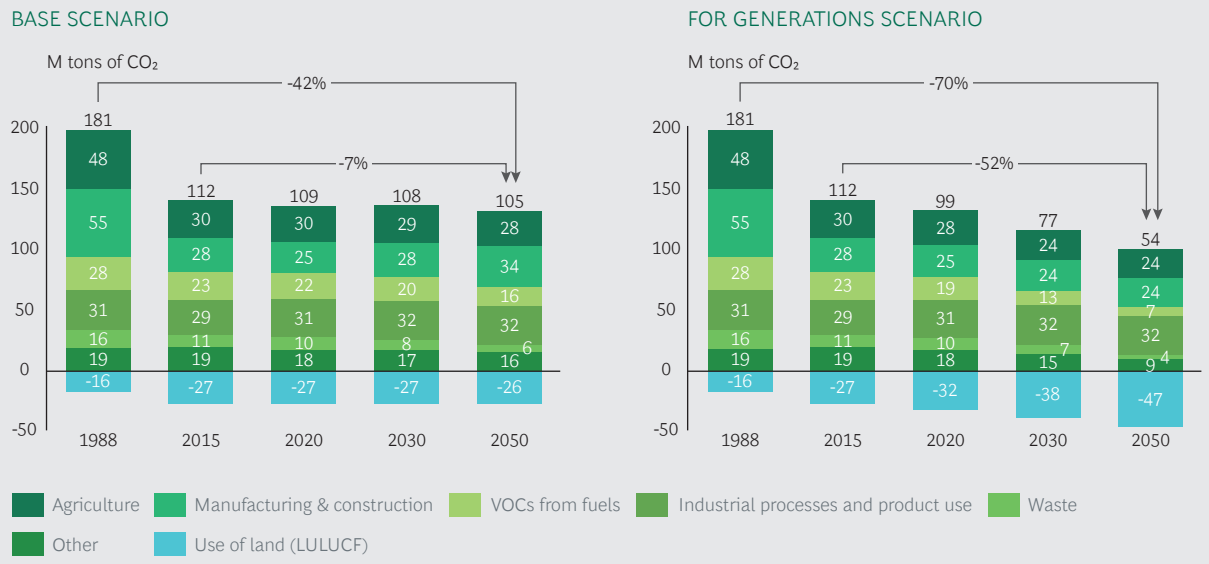
In the case of the recommended scenario, technological, organizational and energy changes deviating from today's trends are taken into account. This scenario focuses on the rapid implementation of energy-saving technologies in the industrial sector, reduction of emissions during manufacturing processes, less demand for emission products, and promotion of sustainable measures in agriculture, forestry and waste management.

These assumptions mainly translate into the volume of emissions in the fuel and energy industries (including forecasts for volatile emissions), which will depend on the consumption of fossil fuels in the scale of the entire economy and process improvements within the industries. In the category of land use, land use change and forestry (LULUCF), a reversal of the current unfavourable trend of decrease in CO_2 absorption by forests is assumed. A gradual return to the level of absorption of 40 million tons of CO_2 by 2050 was assumed. In addition, the impact of more sustainable agricultural practices leading to CO_2 absorption by soil has been accounted for. In the agricultural, forestry and fisheries sectors, the estimated decrease in emissions by 76% is achieved by reducing fuel consumption in favour of energy from local biomass, biogas, and solar energy, as well as by increasing energy efficiency and partial electrification of heating and machinery. In waste management, it is envisaged that the current recycling targets will be implemented by 2030, and fugitive emissions from landfills will be eliminated by 2050. In order to reduce energy consumption in industry, industry was to be restructured towards less energy-intensive industries, industrial processes that are more energy efficient, and sectoral energy mixes were to shift towards electricity, gas and biomass (as hard coal substitutes). The reduced volatile organic compounds (VOCs) will decrease mainly due to the reduction of solid fuel consumption, mining restructuring, and the improvement of conventional industrial processes. The presented vision does not involve the implementation of CCS and CCSU technologies[79].

79 WiseEuropa

EMISSIONS IN OTHER ECONOMIC SECTORS WILL DECREASE BY 52% COMPARED TO 2015 UNDER THE FOR GENERATIONS SCENARIO OF THE ECONOMY AND BY 7% UNDER THE BASE SCENARIO

FIG.29: EMISSIONS IN OTHER SECTORS OF ECONOMY



Source: Eurostat, WISEEuropa analysis

ZERO-EMISSION PATH: PROMISING TECHNOLOGIES THAT MAY REVOLUTIONIZE ENERGY CONSUMPTION AND LEAD TO A ZERO-EMISSION ECONOMY

For sectors such as agriculture, industry or waste management, forecasts indicate that achieving (almost) zero net emissions will not be possible only by using currently available technologies and maintaining current consumption patterns. Measures to achieve additional reduction targets in the long term would have to include:

- Change of lifestyle - including dematerialization of consumption and reduction of the amount of animal products consumed. A diet rich in animal products, especially beef, has a significant impact on greenhouse gas emissions. Annual livestock contributes to emission of 7.1 Gt / CO_2, which translates into 14.5% of global anthropogenic greenhouse gas emissions[1].
- Full implementation of the circular economy principles, the main principle of which is to reduce CO_2 emissions and minimize the consumption of raw materials and waste by creating a process in which the produced waste is used as raw materials for the production of other products.
- The application of CCS technology, i.e. sequestration of carbon dioxide in industry, in particular in the case of process emissions (e.g. cement plants) and the use of offsets where economic competitiveness requires it.
- Increased scale of CO_2 absorption through afforestation and maintenance of green areas.

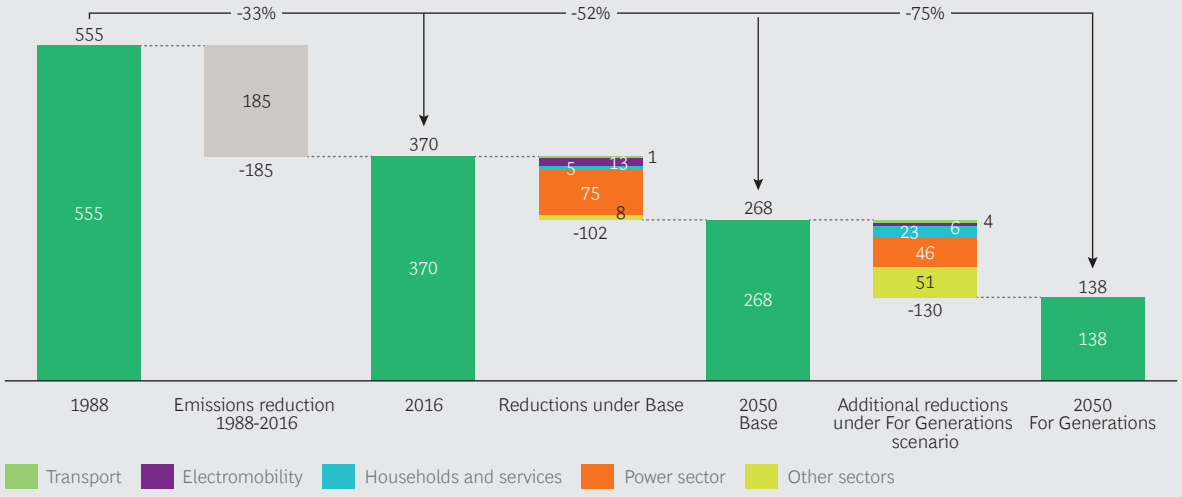
1 **As cited in:** Food and Agriculture Organization of the United Nations, Tackling Climate Change Through Livestock, 2013 http://www.fao.org/docrep/018/i3437e/i3437e.pdf, download date 29 June 2018

Total emissions in the economy

Reduction of greenhouse gas emissions as described above would be more extensive, if additionally the components presented in the "zero-carbon footprint" were implemented. Then it would comply with the Paris Agreement, i.e. the increase in mean global temperatures would remain at a level considerably below 2°C above the preindustrial level.

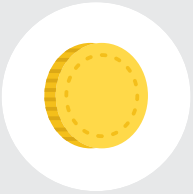
BY 2050, ANNUAL GREENHOUSE GAS EMISSIONS WILL DECREASE BY 57% UNDER THE BASE SCENARIO AND BY 78% UNDER THE FOR GENERATIONS SCENARIO COMPARED WITH 1988

FIG. 30: ANNUAL GREENHOUSE GAS EMISSIONS IN POLAND [MT]



Source: Eurostat, BCG analysis

BENEFITS UNDER THE FOR GENERATIONS SCENARIO



WELL-BEING

- PLN 105 – 157 billion savings on electricity generation costs
- PLN 108 billion savings on fuel imports thanks to electric cars
- PLN 79 billion savings on energy costs thanks to thermal efficiency improvements

HEALTH

- Fewer premature deaths and illnesses thanks to better air quality
- Reduction of external health costs by PLN 123 billion thanks to thermal efficiency improvements

FREEDOM

- More accessible and clean transport in the urban centers, as well as connecting transport between them
- Reduction of dependence on fossil fuel imports

Recommendations

- It is necessary to develop an innovative low-emission and economically optimal power generation system. This involves:
  - preparing a development plan for the economy in line with the Paris Agreement's objectives,
  - measures eliminating conventional energy sources by gradually phasing out coal-fired power units,
  - supporting renewable energy by providing an adequate market and legal climate for development,
  - accelerating development of offshore wind farms through the construction of appropriate transmission infrastructure,
  - regulatory changes enabling a return to rapid development of onshore wind farms in Poland,
  - introducing additional mechanisms (e.g. guaranteed feed in tariffs) supporting the development of dispersion of power generation and energy storage systems (prosumerism),
  - support systems for effective energy demand and supply management (DSR and DSM) in industry and individual consumer aggregators and enterprises to reduce the demand for electricity at peak times,
  - developing cross-border interconnecting capacity to enhance the flexibility of the national energy system and enhance its energy security,
  - developing government support programs that will enable companies to invest into R&D efforts concerning the development of RES and energy storages.
- Systemic support for the reduction of energy consumption in households and commercial buildings requires:
  - redistributing funds from the European Emissions Trading System (EU ETS) for the thermal efficiency improvement of buildings and replacement of inefficient heating systems. It will also be necessary to create in local government expert units for thermal efficiency improvement, which will provide advice and educational support,
  - synchronising quality improvement plans, including through thermal efficiency improvement measures, with the goal of reducing CO_2 emissions,
  - faster and more effective implementation of regulations regarding building permits for energy-efficient passive buildings,
  - as a transitional mechanism, implementing effective regulations eliminating the combustion of low-quality solid fuels.
- Development of electrical vehicles, hybrid (electric and hydrogen) vehicles and low emission vehicles implies for the government:

- supporting investments in electrical infrastructure (e.g. charging stations for electric cars), especially at the initial stage, when business ventures of this kind are not very cost-effective,
- investing in research and development in the field of production of batteries and other parts of electric and hybrid (hydrogen-electric) vehicles,
- replacement of the entire urban public transport fleet with electric vehicles,
- activating support of Distribution System Operators and simplification of laws on connecting free and fast charging stations to the network,
- better implementation of emission standards for passenger cars and trucks.

- The development of public transport, bicycle traffic and passenger rail transport will require[80]:
  - Investing in urban transport infrastructure (interchange nodes, bus lanes, tramlines or metro lines),
  - supporting local governments in creating zero emission zones and vehicle free zones,
  - developing areas with "Park & Ride" facilities, which will allow people regularly commuting to towns to switch conveniently to urban public transport,
  - expanding the network of bicycle paths and city bike stations,
  - developing infrastructure vital for high-speed railways.

80 Detailed recommendations on the railways can be found in the "Rivers" Chapter.

TIMELINE: CLIMATE AND AIR QUALITY

RES account for 13%
of electricity production

For Generations 2050

Base 2050

2025

Due to regulatory changes concerning wind farms approximately 10 GW of available wind farm capacity is in operation

The Ostrołęka C hard coal-fired power plant has been commissioned

2025

2030

More and more houses have solar collectors installed on their roofs and 1/10 of households has energy storage facilities at their disposal. RES account for 31% of electricity output. Consumption of hard coal and lignite totals 44Mt.

RES account for 21% of electricity output. Annual consumption of hard coal and lignite totals 67 Mt.

2030

2050

All households that have an opportunity to utilize solar collectors and energy storage facilities do so. RES account for 75% of electricity output, while hard coal/lignite have been completely eliminated from the energy mix.

Another 1500 MW power unit at the nuclear plant is under construction. RES account for 36% of electricity output. The consumption of hard coal for energy generating purposes totals 34 Mt.

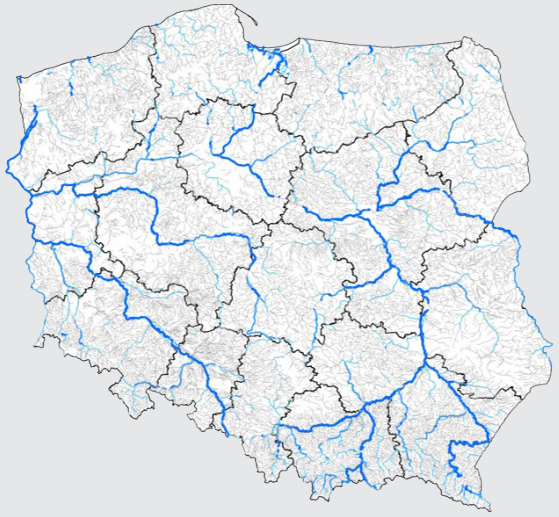
2050

RIVERS

Human life has always focused around rivers. It was in river valleys that settlements were formed, which later evolved into modern cities and agglomerations. Rivers provided people with water, served as a source of energy and food, and enabled people to work in fisheries. The fertile riverine soils allowed for agriculture development. The rivers represented natural transport routes, and were also used for defensive purposes. The surface of river basins (the area from which surface waters flow into a river) and river catchment areas (a catchment area is a collection of river basins) covers 312,700 km² in Poland. Practically, the whole country lies in areas covered by a network of rivers. The longest Polish rivers include the Vistula (1022 km), Warta (795 km) and Oder (726 km).

THE VISTULA AND ODER RIVERS ACCOUNT FOR 89.6% OF THE TOTAL AREA OF THE RIVER BASINS IN POLAND

FIG. 31: RIVERS IN POLAND BY WIDTH AT A CERTAIN SECTION



Source: BCG analysis

The water levels of Polish rivers vary with the intensity of rainwater supply, the melting of snow, and the ability to retain water on the surface and underground. High water levels are recorded when the snow melts in the spring and during intense summer rainfall. These factors mean that spatial development needs to be adjusted to the natural regime of rivers in order to limit the impact of flooding.

Fauna and flora of Polish rivers is at risk

The inland waters in Poland are populated by 58 native species of fish and lampreys[81] [82]. Over half of them are listed as endangered species. Particularly at risk are diadromous fish (spending some of their life in the sea and the remaining time in inland waters, because both environments are essential for life and reproduction), such as sturgeon, salmon or eel, and highly migratory freshwater fish. The reason for this is that the trails of their migration are today lined with hydro-technical damming structures. 32 non-indigenous species transferred to Polish waters from other geographical regions are also a threat to these species of fish.

Integrated water management – an opportunity for Polish rivers

Since January 2018, water management has been subject to the Ministry of Maritime Economy and Inland Navigation. The establishment of the National Water Management Authority creates favourable conditions for the implementation of the catchment management procedure recommended by the European Commission. This is vital in order to remedy negligence in the implementation of the Water Framework Directive and timely implementation of environmental objectives in this directive, as well as to comply with the general principles of other water management directives: relating to flooding, nitrate, as well as Habitat and Birds Directives.

For the first time since the political transformation in Poland, inland and sea waters have come under the management of a single ministry. If the overriding water management objectives adopted in the Water Framework Directive are implemented, we have a chance to make up for lapses in development of civilization: the restoration of some degraded water ecosystems and a departure from the previous approach to water management, which interfered with nature and was not very innovative.

INTEGRATED CATCHMENT MANAGEMENT NECESSARY TO REMEDY NEGLECT OF RIVERS AND RIVER VALLEYS

The Integrated Catchment Management is "a process linking different parties and stakeholders within the catchment area through regional land and water management plans to achieve holistic improvement of the catchment area". The ecosystem approach is an internationally recognized strategy for integrated management of land, water and life resources, that promotes protection and application in a fair and equitable sustainable manner.

Integrated Catchment Management consists of:

- Collecting the best available information to understand catchment areas
- Taking into account all applications of water, for drinking AND agricultural, industrial and recreational purposes, as well as dependent ecosystems
- Involving local communities in decision-making and managing the catchment area where they live
- Taking action to properly manage activities that pose a serious threat to water resources
- Use of scientific and local knowledge on the catchment area's operation to protect and improve water quality, providing healthy, resilient, productive and valuable resources

Source: Catchment.ie

81 The European species of parasitic lamprey is jawless fish of the order Petromyzontiformes, which is found on the majority of European shores.
82 *Fish: Animal Encyclopaedia*, translated by H. Garbarczyk, M. Garbarczyk, L. Myszkowski, The State Scientific Publishers PWN, Warsaw 2007.

Threats and their causes

For centuries, rivers have been excessively exploited by humans. Many of today's activities related to the exploitation of rivers only serve short-term benefits. The long-term effects of such activities are not analysed and, therefore, the irreversible damage that will be caused to river ecosystems as a result of making wrong strategic decisions is often not recognized.

Major risks driven by improper water management policy include:

- irreversible changes in river ecosystems by, for example, partitioning rivers for hydropower purposes,
- excessive exploitation of floodplains and improper flood risk management,
- limitation of floodplains leading to the disappearance of riparian forests.

The development of inland waterway transport may harm rivers

According to the Strategy for Responsible Development, shipping routes in Poland do not form a coherent network of inland waterways. They have been systematically decreasing in length since 2000, and the quality leaves much to be desired. In 2015, 5.9% of the total length of shipping routes met the international requirements enabling large-scale transport of goods. Poland has no favourable conditions for the development of inland waterway transport, with the greatest limitations of this development being: general climatic and hydrological conditions, morphological conditions of river beds, poor nautical infrastructure, and natural limitations in the development of rivers[83].

The reason for the restriction of waterway transport may be water flow that is too little or too high, and the formation of ice. The most frequent problems in Poland are the river water lows, i.e. periods when the lowest water levels are recorded. Long-term lack of rainfall in summer and autumn with intensive growth of vegetation at the same time, consuming large amounts of water, lowers the level of groundwater, hence limiting the water supplied to rivers and leading to less flow. In Poland, low water levels are observed every 2–3 years on average. Sometimes they cover the entire basin of the Middle and Lower Oder river.

In an average year of the multiannual period, the condition of class III is fulfilled only for approximately 90 days. As the analysis showed[84], during the intensive dredging works on four key sections of shallows, the sailing period may be extended to a maximum of approximately 150 days. The condition of class IV in the average year for many years is fulfilled only for a few days. Intensive dredging works on 7 key sections of shallows would allow for a longer sailing period of up to 10–15 days. This means that even in this situation, large cargo ships would be able to use the Oder for only between ten and twenty days a year on average. Meanwhile, the requirement for international waterways is 240 days.

The Ministry of Maritime Economy and Inland Navigation, however, assumes the development of inland waterways and the connection of the Polish rivers with the river systems of the European Union, as well as Belarus and Ukraine. In practice, this would mean transforming the Vistula, Oder, Warta and

83 **As cited in:** Design of the National Strategy for Water Management 2030 (including the 2015 stage), PROEKO http://assets.wwfpl.panda.org/downloads/projekt_nsgw2030.pdf, download date 2 July 2018.
84 **As cited in:** The analysis of determinants and economic efficiency of the Oder waterway development, Tomasz Żylicz, Prof., Ph.D., Agnieszka Markowska, Ph.D., Mikołaj Czajkowski, Master degree holder, Jakub Rak, a master degree holder, 2010 https://www.wwf.pl/sites/default/files/2017-07/Analiza%20uwarunkowa%C5%84%20i%20efektywno%C5%9Bci%20ekonomicznej%20rozwoju%20odrza%C5%84skiej%20drogi%20wodnej.pdf, download date 2 July 2018.

Noteć rivers into a channel or a series of reservoirs[85] [86] [87]. For the time being, the Inland Waterway Development Strategy has not yet been agreed and accepted. Relevant economic, social and environmental analyses are being drawn up, and the first findings cannot be expected until the turn of 2018 and 2019. This means that all government plans announced so far are not supported by the proper underpinning analyses required before such a large undertaking, which will affect the lives of thousands of people and threaten the degradation of river ecosystems.

Water transport is cheaper on existing waterways and is a factor that helps reduce CO_2 emissions, noise, and the number of accidents in comparison to road and rail transport[88] [89] [90]. However, in order to derive real economic benefits from it, Poland would first have to invest in multi-billion-dollar projects and compensate for potential losses associated with increased flood risk and environmental degradation. In contrast to the German rivers, Polish rivers are neither adapted to intense navigation, nor have adequate transport infrastructure, because in the last century the development of this transport branch was not profitable and did not represent a significant element of the national policy.

The very construction and modernization of selected sections of rivers in a way that promotes them to the category of international waterways, would cost approximately PLN 71–91 billion[91] according to preliminary estimates. Investment outlays at this level would be enough for example for more than 2,000 km of additional motorways in Poland[92] (at present Poland has 1,600 km of motorways).[93] Additionally, inland waterway transport requires constant maintenance, at a very high cost compared to road and motorway maintenance. Research shows that for inland waterway transport the total investment in infrastructure and its maintenance costs per tonne-kilometer are 60% higher than in road transport[94]. Our analyses have shown that maintaining such an extensive network of waterways and channels would involve annual costs of around PLN 2.5 billion[95] (including maintenance of rivers, canals, planned locks and ice-breakers). In addition, billions more should be considered for the appropriate infrastructure, enabling effective loading of goods transported by cars and railways to ships (intermodal terminals), and alterations to and lifting of the bridges on the Vistula and Oder rivers which after regulation (resulting in water accumulation) would be too low. Effective use of waterways would require investments in at least 10 large and 7 smaller inland ports and about 50 intermodal terminals. It would also be necessary to invest in roads and tracks to these ports and terminals. The estimated investment outlays for such infrastructure are around PLN 25–35 billion[96]. Raising bridges and all infrastructure related to such a project (making alterations to roads, tracks or foundations of some buildings) is another expenditure of at least PLN 20–30 billion[97].

Government plans related to water transport are not yet clarified. It is not known what the potential demand for such transport would be, and how much in all the regulation of rivers and raising bridges would cost, and what impact the whole process would have on the environment, and what developing the infrastructure would mean in terms of flood safety of riverside inhabitants.

85 **As cited in:** Assumptions for development plans for inland waterways in Poland, Ministry of Maritime Economy and Inland Navigation https://gospodarkamorska.bip.gov.pl/fobjects/download/150531/zalozenia-do-planow-sdw_15062016_projekt-roboczy-pdf.html, download date 2 July 2018.
86 **As cited in:** Expert opinion on the development of inland waterways in Poland in the 2016-2020 period with a view to 2030, Ministry of Maritime Economy and Inland Navigation https://mgm.gov.pl/wp-content/uploads/2017/11/ekspertyza_rozwoju_srodladowych_drog_wodnych.pdf, download date 2 July 2018.
87 **As cited in:** Plans for the development of inland waterways in Poland, Ministry of Maritime Economy and Inland Navigation https://mgm.gov.pl/wp-content/uploads/2017/11/prezentacja-mgmizs_2.pptx, download date 2 July 2018.
88 **As cited in:** Socio-economic impact of the development of the Lower Vistula River, Acta Energetica http://actaenergetica.org/pl/aktualnosci/ksiazka-spoleczno-ekonomiczne-skutki-zagospodarowania-dolnej-wisly-niedlugo-na-rynku.html, download date 2 July 2018.
89 Program for the development of inland waterway transport infrastructure in Poland, ECORYS https://mdwe70.pl/documents/1237983/1240047/img/87549003-747e-44f2-b210-8010a7c15cb2, download date 2 July 2018.
90 Inland shipping an outstanding choice, The future of freight transport and inland shipping in Europe 2010-2011
91 Expert opinion on the development of inland waterways in Poland in the 2016-2020 period with a view to 2030, Ministry of Maritime Economy and Inland Navigation https://mgm.gov.pl/wp-content/uploads/2017/11/ekspertyza_rozwoju_srodladowych_drog_wodnych.pdf, download date 1 July 2018.
92 **As cited in:** Trans.info, download date 30 June 2018.
93 **As cited in:** General Directorate for National Roads and Motorways, https://www.gddkia.gov.pl/pl/926/autostrady, download date 2 July 2018.
94 **As cited in:** Inland shipping an outstanding choice, The future of freight transport and inland shipping in Europe 2010-2011 http://www.ebu-uenf.org/fileupload/Power_inlandnavigation2010-2011.pdf, download date 2 July 2018.
95 BCG analysis
96 BCG analysis.
97 BCG analysis.

An analysis conducted by the International Commission for the Protection of the Rhine showed that river regulation for shipping and energy purposes could cause increasing flood losses[98]. The Basel – Karlsruhe section, where, due to hydro technical development, flood flow time decreased from about 64 h to 23 h, is an example. This heightened the risk of waves from side tributaries to the Rhine wave overlapping, and this occurred in January 1995. According to German specialists, the Upper Rhine hydro technical constructions increased the maximum flows in Cologne by approx. 700–800 m^3 / s and water levels by 40 cm respectively. The period of water repetition, considered at the start of the century to last 100 years, has been shortened to 30–40 years.

The implementation of such a wide-ranging river regulation plan in Poland would mean threats to the natural environment. For the Oder valley, the implementation of this strategy would mean the end of periodic floods that ensure the biodiversity of individual nature conservation areas. This threat may be faced by as many as 27 sites in the Natura 2000 network, five landscape parks on the Vistula and Oder in Poland, and the Lower Oder National Park in Germany[99].

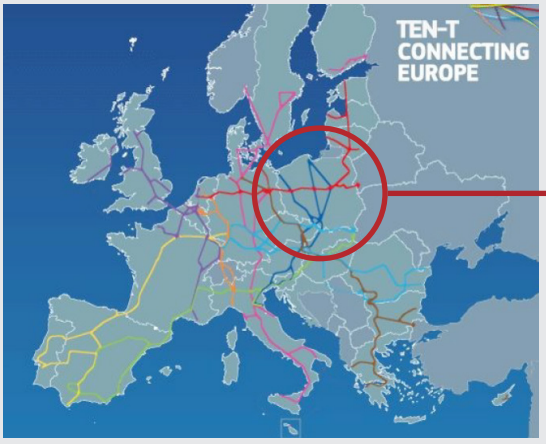
Poland's accession to the Agreement on Main Inland Waterways of International Importance (AGN) was analysed in 1997/1998, but, as the Supreme Audit Office's 2014 report showed, the request for signing the Agreement was not approved by the Minister of Finance (due to the high costs of the alteration work to the waterways – over PLN 90 billion). The Minister of Environmental Protection also did not accept the accession to the Agreement (due to significant interference in the river valley and river channels environment, involving partitioning them with dams and locks, in order to obtain navigational parameters appropriate for waterways of international importance)[100].

Perhaps on certain sections, the development of inland waterway transport could prove to be economically viable and even beneficial for the Polish population, and would not cause major environmental losses, but the decision initiating this process would require a multi-faceted analysis, which has not been carried out to date.

98 International Commission for the Rhine River Protection.
99 **As cited in:** Initial assessment of the risk of environmental impact of the Government's "Strategy for the Development of Inland Waterways in Poland in 2016-2020 with a view to 2030" on protected natural areas, Naturalists' Club http://www.kp.org.pl/index.php?option=com_content&task=view&id=633&Itemid=614&lang=polish, download date 2 July 2018.
100 **As cited in:** Operations of the Inland Navigation, Supreme Audit Office https://www.nik.gov.pl/plik/id,6232,vp,7990.pdf, download date 2 July 2018.

THE GOVERNMENT STRATEGY FOR THE DEVELOPMENT OF INLAND WATERWAYS IN POLAND PROVIDES FOR INCORPORATION OF POLISH RIVERS INTO THE INTERNATIONAL INLAND WATERWAY SYSTEM

FIG. 32: THE DEVELOPMENT PLAN FOR INLAND WATERWAYS IN POLAND PROVIDES FOR COMBINATION OF POLISH RIVERS WITH THE EU SYSTEM ...



... WHICH MEANS CONVERSION INTO A CHANNEL OR A SERIES OF DAMMED RESERVOIRS PRIMARILY OF THE ODER, VISTULA, WARTA AND NOTEĆ RIVERS

Source: Plans for the development of inland waterways in Poland of the Ministry of Maritime Economy and Inland Navigation

Poland still is not able to learn from past experiences of flooding

Poland has not used bad experiences of flooding to assess and fully review how the flood risk management system operates.

Therefore, it is still unclear which elements of the flood protection system do and do not operate correctly. From one flood to another, the same errors are repeated, and the changes introduced after them concern only technical details (for example regarding communication) or are compulsory under new EU regulations.

Despite the incorporation of decision-making even at parliament level, in the form of flood risk management plans which are treated as primary legislation[101], no system for monitoring the progress made with implementation of this plan has been established. Therefore, it is impossible to state reliably to what extent they are implemented at all. It is not known what facilities are most exposed to floods or what losses are caused by floods of a certain strength.

Only information on flood damage and losses in public assets and in the agricultural sector is systematically collected, and this is done for statistical purposes (Statistical Yearbooks of the Polish Central Statistical Office). Unfortunately, the Central Statistical Office does not archive information collected from individual municipalities. After a period of several years, such information is available only in aggregate form, which makes analysis and planning of crisis management difficult.

Poor spatial planning on floodplains poses a risk of flooding

The Regional Water Management Boards (Regional Boards), appointed by the central government authorities, define floodplains as areas at risk of flooding. As required under European Parliament

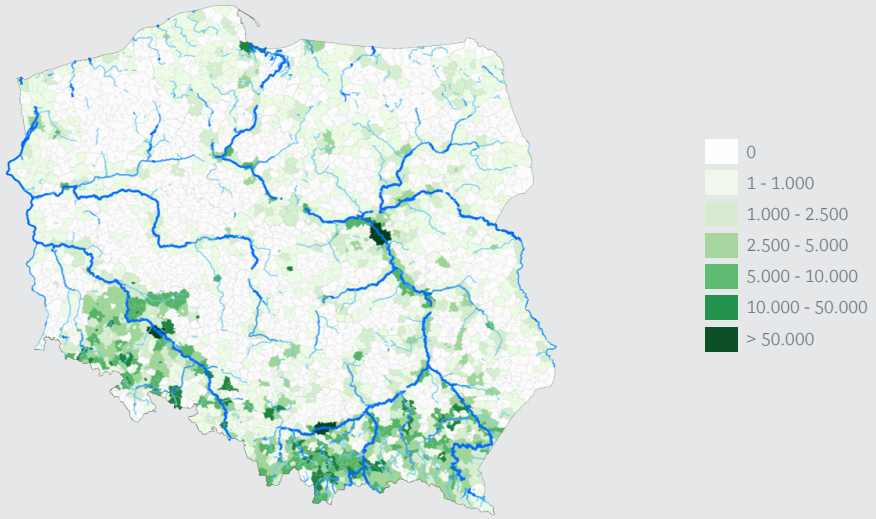
101 **As cited in:** Journal of Laws http://www.dziennikustaw.gov.pl/du/2016/1938/D2016000193801.pdf, download date 2 July 2018.

guidelines[102] the Regional Boards developed flood hazard maps for Polish municipalities use to limit the effects and losses caused by river floods. The most effective method of reducing the risk of flooding is simply to limit development of areas that are particularly exposed to risk of flooding.

This is a simple rule that requires only proper planning of spatial development. A review conducted by the Supreme Audit Office, however, showed that despite all the recommendations and tips received, local governments still do not act to protect the population against the effects of floods. The Supreme Audit Office found that decisions granting building permits to investors usually did not contain information about the flood risk in the area of the planned investment. Such information was also not given in many local spatial development plans. In 30% of the government offices reviewed, spatial development rules did not place restrictions on construction of buildings on floodplains[103]. As a result of such a carefree approach to spatial development policy, one project after another was executed in areas at risk of flooding, and today there are over 600,000 buildings inhabited by about 4 million people on this land[104]. It is not only officials in government offices that show their carelessness. Farmers also trivialize the issue of natural seasonal floods in floodplains, thus risking heavy crop losses.

APPROXIMATELY 4 MILLION POLES LIVE IN THE FLOOD-RISK AREAS

FIG. 33: SIZE OF POPULATION AT RISK OF FLOODING IN A GIVEN MUNICIPALITY WITH REGARD TO CERTAIN RIVERS



Source: BCG analysis based on addresses at flood risk, provided by AVIVA

Harmful changes in river ecosystems

River regulation also affects river ecosystems – the transformation of river banks and beds. The majority of Polish rivers (111,000 km) have already been regulated to various degrees. Only a quarter of them have been preserved in a near-natural state[105].

102 **As cited in:** Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 http://www.kzgw.gov.pl/files/dyrektywa-powodziowa/tekst_Dyrektywy_Powodziowej_PL.pdf, download date 2 July 2018.
103 **As cited in:** The Supreme Audit Office about investments in flood areas, The Supreme Audit Office, 2014 https://www.nik.gov.pl/aktualnosci/administracja/nik-o-planowaniu-i-realizacji-inwestycji-na-terenach-powodziowych.html, download date 2 July 2018.
104 BCG analysis based on the addresses at risk of 2, 3 and 5 degree flooding, provided by AVIVA insurance company.
105 Institute of Meteorology and Water Management

Regulation of rivers, causing serious degradation of river ecosystems, also involves huge investment outlays and means significant new costs of maintaining the infrastructure thus created.

The river water and river valley ecosystems are also adversely affected by structures for damming water. Both existing and planned dams prevent extinct populations of migratory fish such as salmon, sturgeon, migratory trout, vimba bream or eel from being restored to the Vistula and Oder.

Disappearance of floodplain forests

In the floodplain forests, the most common species of trees are the willow, poplar, alder, ash tree and oak. They grow in river valleys in floodplains. The floodplain forests are among the ecosystems richest in species in Europe – there are approximately 300 species of animals and plants[106]. In Poland, floodplain forests occupy about 338.6 km², which is less than 5% of their original area[107]. What ruined them was the development of riverside areas, tree felling and river regulation. The problem is also that floodplain forests often grow on very small areas not exceeding 0.5 ha. These areas are often protected in appearance only, because in practice riverside areas are accidentally destroyed, for example during the construction of infrastructure (e.g. roads) in forests.

Throughout the European Union, floodplain forests have the status of so-called priority habitat, and in many countries attempts are being made to restore their natural condition. Such projects are implemented under government and regional schemes to improve flood safety. It has been proven that the recovery of lost retention areas in valleys is beneficial in two ways: it improves flood safety and improves the condition of ecosystems dependent on river floods (floodplain forests, oxbow lakes, and wetlands and the related species).

In Poland, the WWF has been running projects for many years to protect floodplain areas, including floodplain forests. Examples include initiatives such as the Domaszków-Tarchalice Project, which was the first case in Poland of the removal of embankments from the river (2004) or Safe Municipality on the Oder River (2007) – reducing the risk of floods[108].

DOMASZKÓW AND TARCHALICE PROJECT

The Domaszków-Tarchalice Project was implemented in the Lower Silesia Voivodeship, in the Wołów Municipality. Under the Project, 7 km of embankments was moved further away from the Oder river bed, obtaining 600 hectares for the purposes of flood protection, on which the river can freely flow without generating losses. The old embankment - built close to the river - has been partly dug in to allow the free flow of water. At the same time, the process of renewal of the floodplain forest in this area was commenced. The Domaszków and Tarchalice localities were given better flood protection.

Similar activities are also undertaken in other countries. In Germany and Austria, the government schemes for reconstructing the floodplain forests have already been implemented and are being carried out on the Rhine[109], Danube[110] and Elbe rivers[111]. As part of the improvement of flood safety, river

106 **As cited in:** Tysol.pl http://www.tysol.pl/a4668-Polska-dzungla-Lasy-legowe-to-zielone-pluca-ziemi-Dbajmy-o-nie, download date 2 July 2018.
107 J. M. Matuszkiewicz, Forest Complexes in Poland, State Scientific Publishers PWN, Warsaw 2001.
108 **As cited in:** WWF, River Maintenance Good Practices, 2015 http://ratujmyrzeki.bagna.pl/images/Domaszkow_WWF.pdf, download date 2 July 2018.
109 **As cited in:** Integriertes Rheinprogramm https://rp.baden-wuerttemberg.de/Themen/WasserBoden/IRP/Seiten/default.aspx, download date 2 July 2018.
110 **As cited in:** Donau Auwald, Danube Parks, http://www.donauauen.de/, download date 2 July 2018.
111 **As cited in:** WWF, Mittlere Elbe: Landschaft im Fluss https://www.wwf.de/themen-projekte/wwf-erfolge/mittlere-elbe-landschaft-im-fluss/, download date 2 July 2018.

deregulation projects are also being carried out, in which the natural, often multi-channel river's course is reconstructed. Despite a relatively small total area, floodplain forests still play a very important role in shaping the environment and man-friendly environment.

Looking ahead – Poland in 2050

Regardless of the way in which Polish rivers are developed, in the coming decades rivers will represent an inextricable element of the economy and culture. What rivers will be like and how future generations will be able to use them remains to be seen.

Transformation of freight transport

Poland 2050, Base scenario

The Base scenario assumes that one of the main priorities in Poland in the period up until 2050 will be the partial transfer of the burden of freight transport from roads to rivers and railways. The railway infrastructure will be modernized slowly, and several years will pass until new lines begin to be built. The share of rail in the transport market in the period up until 2050 will remain at around 15%, because freight carried by trains will be taken over by ships carrying freight.

Although, after 2030, road transport by truck will stop growing at such a fast rate, its market share will remain the same. The share of road freight transport in the market in 2050 will be 83% – the same as in 2015.

The most important change related to transport will be the implementation of the investment plan related to regulation and adjustment to the required parameters of international navigation in the Middle and Lower Oder and Vistula rivers from the Baltic Sea to the City of Warsaw. The connection of the two major Polish river systems and connecting them with the east via the Vistula Lagoon will require over PLN 90 billion and will cover the regulation of over 1,000km of inland waterways.

When the scheme has been completed in 2040, the density of the waterway network will reach 70% of the EU average. This is due to a shortage of water resources in Poland and unfavourable hydrological conditions. The competitiveness of water transport is reduced by low speed, winter breaks in transport, periods of low and elevated water levels, and low-clearance bridges (insufficient distance from the water level to the bridge structure). That is why water transport, despite a rapid rate of development, will account only for 3.1% of the transport market and will carry 19.7 billion ton-kilometers of freight in 2050[112]. This will be an improvement, because the efficiency of water transport will increase from the current 4 million ton-kilometers to 9 million ton-kilometers per kilometer of the waterway. Only half of this volume will be goods taken over from roads. The rest will be taken over from railways.

During regulation and construction works, a contractor may encounter unforeseen difficulties, which will extend the time needed to complete and will increase the initial capital expenditures, as in the case in Malczyce[113].

One of the investment project-related issues will be alteration work to railway and road bridges. Traffic disruption in both of these systems will lead to conflicts with city authorities and monument conservation officers. The cost of maintaining the newly developed infrastructure will be borne by taxpayers. Another problem will be that the inland waterway development programs in the pipeline

112 BCG analysis.
113 According to preliminary cost estimates, the total cost was supposed to be PLN 250-300 million, and as a result PLN 1.1 billion has already been spent building it. Although it has been under construction since 1997, after all the delays that occurred, it did not start being used until 2019.

will not include the construction of appropriate infrastructure, for instance inland and transhipment ports, enabling intermodal transport.

The consequences of the development of inland waterway transport will also be borne by the environment, especially river valleys. 27 sites belonging to the Natura 2000 network, five landscape parks located on the Vistula and Oder rivers, and the Lower Oder National Park will be degraded[114].

Connecting the waters of different zoogeographical regions will enable migration of alien species, and this will pose a threat to native fish. Diseases not currently present in Polish fish species will spread in the water. This will lead to the extinction of brown trout[115].

Poland 2050, For Generations scenario

Under the optimistic scenario of the 2050 forecast, in the coming years one of the goals of transport policy will be to limit both freight and passenger road transport in Poland. Development of the railway will become a priority for the state. This choice will be determined by the fact that both passenger and freight transport can be carried out by rail and that the potential for limiting external costs is comparable to inland waterway transport with much less effort being required for the investment. At the same time, it is much higher than in road transport.

In the years 2020–2040, an investment program involving the construction of 3,000km of new railway lines and 3,000km of second and consecutive tracks adjacent to the existing ones will be implemented. The single-track railway lines and part of the double-track lines in the agglomerations will be adapted to the increased traffic load. The entire railway network will be electrified, modernized and equipped with an integrated communication and traffic control system. By 2030, each county will have a modern intermodal terminal enabling unloading and loading of railcars. The expansion and improvement of the quality of infrastructure will mean that new connections can be created, shorten the time taken to transport goods, improve punctuality. The railways will become more competitive: services will be launched in new market segments and the railways will begin to take over domestic and transit traffic from roads.

Around 2040, 24% of all freight transport will be transported by rail. This is the percentage achieved in Germany. By 2050, Poland will join the European leaders such as Switzerland. In Switzerland, the share of railways in freight transport was 30% even in 2016.

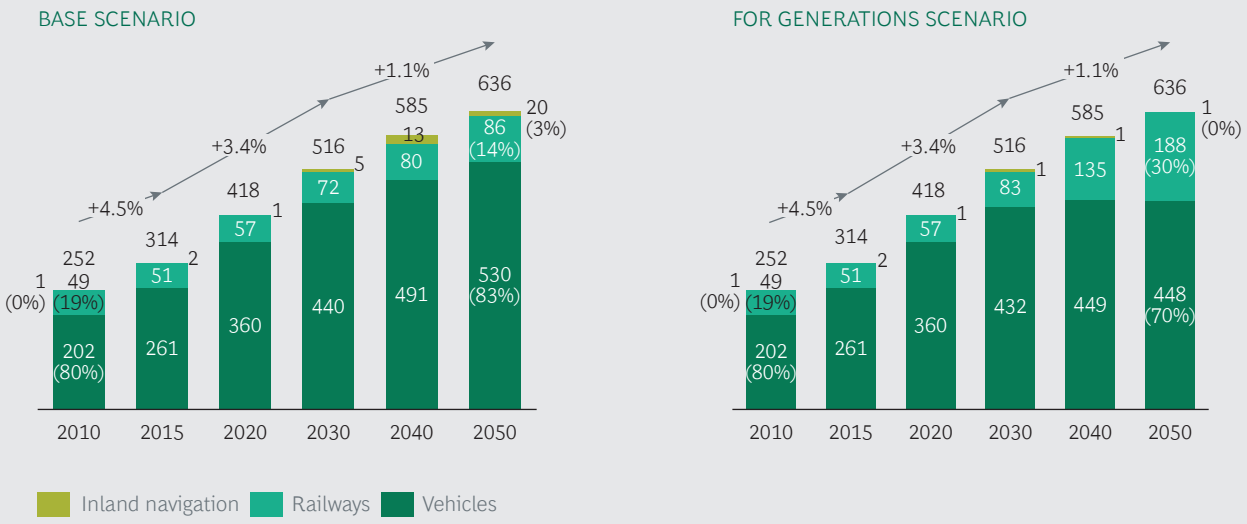
The change of the transport market structure will inevitably follow from systemic changes in Poland, such as the expansion of the toll collection system for trucks and buses (viaTOLL) to cover all national, voivodship, and county roads. At the same time, the railway infrastructure access fees will drop by 50%. Additional revenues from road tolls and savings resulting from reduced heavy vehicle traffic will offset the PLN 290 billion[116] investment program in railway infrastructure, which will involve among other things the electrification of 7,300 km of tracks, the construction of an additional 260 intermodal terminals, the development of an additional 3,000km of railway lines, modernization of a further 7,500 km of track, and fitting the ERMS2 navigation system in the missing part of the network.

The change in the transport structure and implemented recommendations will translate into an increase of the state budget revenues in the 2020–2050 period by PLN 260 billion. This will enable support to be provided for modernization of local government public buildings, such as schools and

114 **As cited in:** Initial assessment of the risk of environmental impact of the Government's "Strategy for the Development of Inland Waterways in Poland in 2016-2020 with a view to 2030" on protected natural areas, Naturalists' Club http://www.kp.org.pl/content/view/633/614, download date 2 July 2018.
115 **As cited in:** Strategic plan for the development of fish farming and breeding in Poland in 2014-2020, AKWAKULTURA 2020 https://www.minrol.gov.pl/content/download/49857/274182/version/1/file/Za%C5%82%C4%85cznik%20nr%206%20Strategia%20AQ%202020.pdf, download date 2 July 2018.
116 Investment plans as well as profit and loss account prepared by Jakub Majewski, Ph.D., the ProKolej Foundation.

DEVELOPMENT OF RAILWAYS INSTEAD OF INLAND WATERWAYS MAY REDUCE THE SHARE OF ROAD TRANSPORT BY 13 PERCENTAGE POINTS BY 2050

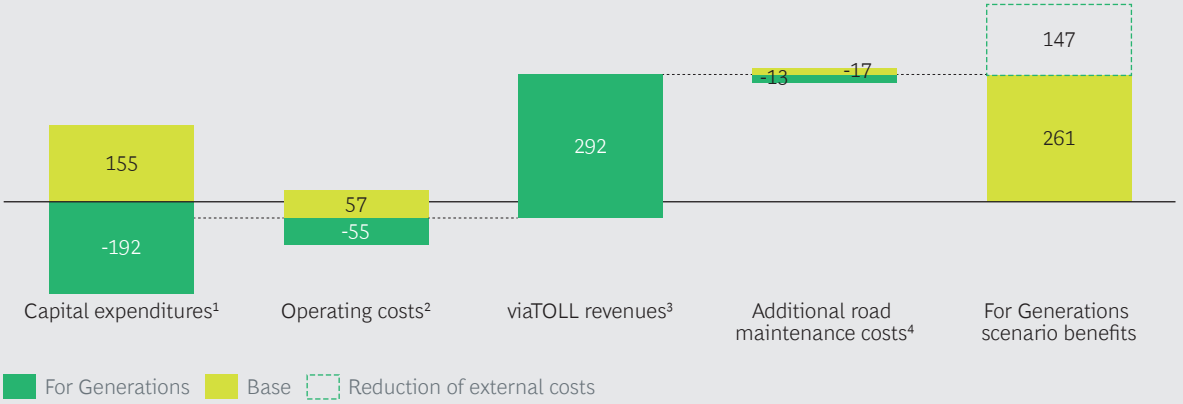
FIG. 34: BREAKDOWN OF FREIGHT TRANSPORT [BN TKM]



Source: Eurostat, CSO, BCG analysis in collaboration with Jakub Majewski, Ph.D., ProKolej Foundation

IMPLEMENTATION OF RECOMMENDATIONS MAY SAVE AN ADDITIONAL PLN 260 BN IN ACCUMULATED BUDGETARY REVENUES IN THE 2020-2050 PERIOD

FIG. 35: CUMULATIVE ECONOMIC CALCULUS FOR SCENARIOS IN 2020-2050 [PLN BN]



Source: Delft, The power of inland navigation, the budget of the Polish State Railways and the General Directorate of National Roads and Motorways, the construction of the CPK, Decree No. 144/2016 of the Council of Ministers of 23 November 2016, Analysis of investment and operational revenues and costs Jakub Majewski, Ph.D., The ProKolej Foundation

¹Smart: Electrification of the railway network (7300km), Construction of 310 intermodal terminals (in missing districts), Construction of new railway lines (4,000 km), Construction of new railway lines (3,000 km), Modernization of the missing part of the railway network (10,000 km), Equipment of the missing part of the network in ERTMS2 (6,000 km) BaU: Oder Waterway, along with the Gliwicki Canal and the Oder-Danube Canal, Middle and Lower Vistula Episodes from Warsaw to Gdańsk, The Śląski Canal, Warsaw-Brześć Waterway, Fee for carriers for the use of waterways ²Smart: Additional subsidy to rail passenger transport, reduction of access rates to railway infrastructure by 50%, BaU: Additional subsidy to railway, costs of road network maintenance based on estimated ton-kilometers and price of 12 gr / tkm ³400k PLN / km from the national road and 50kPLN / km regional road ⁴Costs maintenance of the road network dependent on the traffic volume of 80 kPLN / km in the base year increasing with use road freight transport ⁵Freight transport: Accidents, noise, pollution, climate; Passenger transport: Accidents, pollution (air, soil, water), climate change, noise, nature and landscape, loss of biodiversity, losses in urbanized centers

hospitals. Travel comfort and road safety will improve due to the lower number of cars. This will be beneficial to the environment and quality of air, water and soil. This will mean a reduction in costs of PLN 147 billion in the entire period under discussion[117] [118].

Flood risk and development of floodplains

The main factor that will influence the management of the flood protection system in Poland and improve it will be obligations under the Water Framework Directive and the Floods Directive as well as obligations resulting from our membership of the European Union.

Poland 2050, Base scenario

Under the less optimistic scenario, in the next decades, no specific measures will be taken in Poland with regard to flood risk management. Technical solutions, i.e. the construction of retention reservoirs and embankments, will still be preferred, despite the fact that they do not solve all of the problems related to floods.

Data from the Dam Technical Inspection Centre of the Meteorology and Water Management Institute shows that currently out of 8,500 km of embankments, approximately 25–30% are now pose a safety hazard[119]. Under our conservative scenario, we assume that this situation will improve slightly in the coming years, because the embankments will be modernized only at places where they have been broken by successive floods. As a result, thousands of Poles will feel the effects of subsequent floods.

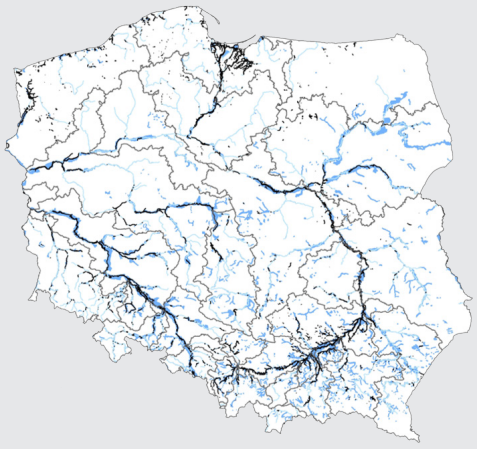
The type of flood protection systems on which government authorities will concentrate, will be retention reservoirs designed to reduce the flood wave. However, these have limited capacity and effectiveness. For this reason, while in some places they do in fact limit the occurrence of small and medium-sized floods, they do not stop major floods. This applies not only to multi-functional reservoirs, such as the reservoir in Brzeg Dolny, which during the great flood (as in 1997) would have been filled in within an hour[120],[121], but also retention reservoirs whose main function is flood protection. An example is the Czorsztyński Reservoir on the Dunajec river. The analyses[122] showed that during the great flood in July 1997, it actually protected the villages downstream of the Dunajec Gorge in the Pieniny Mountains thanks to the reduction of the first wave, but did not reduce the flood risk threatening the densely populated Dunajec valley in the vicinity of the towns of Stary and Nowy Sącz.

Local governments will still not pay enough attention to avoiding the construction of buildings in floodplains. They will continue to issue building permits for flood-risk areas. The use of such areas for arable crops will not be stopped either. The lack of proper regulations will lead to increased losses caused by damage to crops, which will result in higher food prices.

117 **Freight transport:** Accidents, noise, pollution, climate; Passenger transport: accidents, pollution (air, soil, water), climate change, noise, nature and landscape, loss of biodiversity, losses in city downtowns.
118 **As cited in:** Inland shipping an outstanding choice, The future of freight transport and inland shipping in Europe 2010–2011 http://www.ebu-uenf.org/fileupload/Power_inlandnavigation2010-2011.pdf, download date 2 July 2018.
119 National Water Management Board, Report on the state of safety of water-damming structures in Poland as of 31 December 2015, prepared by the Technical Inspection Centre of the Institute of Meteorology and Water Management, the National Research Institute, Warsaw 2016.
120 Analysis made by Roman Konieczny, Ph.D.
121 **As cited in:** the PWN Encyclopaedia, https://encyklopedia.pwn.pl/haslo/Brzeg-Dolny;3881342.html, download date 2 July 2018.
122 **As cited in:** The role of the Czorsztyn reservoir on the Dunajec river in flood protection in 1997, Janusz Żelaziński http://wolnerzeki.pl/wp-content/uploads/2018/02/Pien12_003-11_internet.pdf, download date 2 July 2018.

THREE LARGE FLOODS GENERATED LOSSES IN MANY AREAS WHERE FLOODBANKS WERE IN PLACE

FIG. 36: THE AREA COVERED BY FLOODS IN 1997, 2001 AND 2010 AND THE CONSTRUCTION OF FLOOD EMBANKMENTS.



— Embankments Rivers under Preliminary Assessment of Flood Risk – 1st stage of mapping

Flood coverage in the past Catchment area management boundaries

Source: Roman Konieczny, Ph.D.

Poland 2050, For Generations scenario

Our optimistic scenario assumes that the turning point will be the introduction of the obligation to make public decisions on flood risk taken by local governments and other public institutions as well as the introduction of compulsory insurance for residential buildings, industrial infrastructure and crops in flood risk areas. Decisions are announced publicly, which means that the opinions of various social groups can be compared and integrated, and consequently the measures devised will consider the standpoints of different communities. Adequate spatial policy and differentiation of insurance premiums will allow limitation of further development of flood risk areas.

Open dialogue will involve representatives of government authorities, local governments, representatives of vulnerable communities supported by naturalists, hydrologists, planners, sociologists, geographers and engineers. The program, developed as a result of open consultations, will become the basis for the flood risk management policy approved by the Polish parliament.

The basic principle of the program will be to pay special attention to areas at risk of floods occurring once every 10 years. It is these floods that cause the greatest losses in Poland.

FIG. 37: EXPECTED LOSSES IN A SELECTED AREA OF THE DUNAJEC RIVER CAUSED BY FLOODS ONCE EVERY 10 YEARS AND FLOODS ONCE EVERY 100 YEARS.

	Flood once every 100 years		Flood every 10 years	
Facility	Losses in absolute terms [PLN]	Expected losses - in value terms (incl. 1% chance) [PLN]	Loss in absolute terms [PLN]	Expected losses - in value terms (incl. 10% chance) [PLN]
Housing units	414 348 472	4 143 485	80 859 019	8 085 902
Industrial	195 025 417	1 950 254	51 621 441	5 162 144
Transport	25 416 822	254 168	6 608 287	660 829
All facilities	634 790 711	6 347 907	139 088 747	13 908 875

Source: Analysis of Roman Konieczny, Ph.D.

Once flood hazard zones have been identified, a ban on the construction of some facilities will be introduced in such zones. Part of this will be a government scheme to buy up buildings located in the affected areas. New construction standards will be also introduced where floods occur rarely, every 100 years. The strategy to guarantee that these facilities can withstand damage proved to be successful in the early 21st century in the USA[123].

Local governments are starting to use their spatial planning powers to provide protection against floods. In the case of municipalities, these are regulations that are already in place. They enable the development of crisis management plans, appropriate spatial planning (including protection and restoration of natural retention, i.e. water outflow), creation of plans for coordinating activities during flooding, and education of local communities with regard to flood hazards.

These activities will translate into fewer losses caused by floods in Poland.

River regulation and angling

Poland 2050, Base scenario

Under this scenario, we do not expect that government authorities and local governments will change their approach to managing rivers and river valleys in the coming years. Rivers will continue to be regulated and their banks strengthened. Special fishery will not be developed, so the revenues they generate will not grow quickly. As a result, in 2050, local communities and fishermen will lose an opportunity to obtain an additional PLN 550 million thanks to fisheries. In flood risk areas, there will be more inhabitants, and buildings will begin to be built in flood hazard zones, and thus floods will

123 Ch.P. Jones, W.L. Coulbourne, J. Marshall, S.M. Jr. Rogers, Evaluation of the National Flood Insurance Program's Building Standards, set up under 2001–2006 Evaluation of the National Flood Insurance Program, 2006.

CASE STUDY OF THE SAN ZWIERZYN-HOCZEWKA SPECIAL FISHERY

The San Zwierzyń-Hoczewka fishery was established in 2004 in the municipality of Solina in the Podkarpackie Voivodeship. It covers about 7 km of the San River, which due to its natural properties, including quite a low water temperature, creates favorable living conditions for the fish from the Salmonidae family and graylings. The Solina-Myczkowce dam complex has an impact on the conditions in the river. The surroundings, unchanged by anthropogenic activity, as well as the peace and quiet in the area are the main features that attract for anglers from Poland and around the world. The spawning grounds of all fish species are cultivated here, and the fish caught by anglers are completely wild, the river is not artificially stocked. This is helped by the fact that it is prohibited to kill caught fish. The fishery is a source of livelihood for the local community.

Fishing licenses generate about PLN 400,000 annually, and additional revenues are generated by hotels (approximately PLN 450,000 per year) and transport-related services, for example car rental (approximately PLN 100,000 per year). The fishing ground employs fishing guides and rangers, who make sure that illegal fishing does not occur. International events are held regularly here: the European Angling fishing championships (2005) and World Angling fishing championships (2010, 2018). Each of these generates at least PLN 500,000 in additional revenue for the local municipality. Thanks to the fishery, the municipality can count on more than PLN 1 million in revenues per year, which accounts for approximately 4.5% of the total income of the Solina municipality.

cause more and more economic and social losses (estimates based on expert opinions).

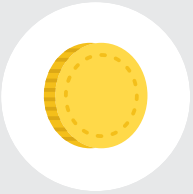
Poland 2050, For Generations scenario

Under our optimistic scenario, over the next few years local governments will change their approach to river and valley management. More sections of rivers will now no longer be regulated, when local authorities realise that strengthening the banks, creating rock filling, clearing riverbeds, and other types of river regulation do not make these areas more attractive for tourists at all. There will be a trend to restore the natural character of rivers and valleys. The gradual transfer and adaptation of existing infrastructure and a ban on new developments in the floodplains will reduce significantly economic and social losses caused by floods.

Improving conditions in river valleys will enable the development of 16 special fisheries, which today are sections of rivers such as the Dunajec, Raba and Vistula. The revenues generated by these fisheries will double, fuelling the local economy and creating new jobs.

There will also be ten new special fisheries similar to the San Zwierzyń-Hoczewka fishery. If our optimistic scenario is realised, the additional revenues that all Polish fisheries would generate in the 2030–2050 period would be higher than those envisaged under the Base scenario by as much as PLN 550 million.

BENEFITS UNDER THE FOR GENERATIONS SCENARIO



Well-Being

- Additional PLN 260 billion in savings due to development of railways
- The replenishment of numerous fish populations in Polish rivers and the creation of 10 new special fisheries for over 620,000 anglers in Poland, which will generate an additional PLN 530 million

Health

- Fewer accidents and less air pollution of soil and water by transferring part of the traffic to the railways
- PLN 147 billion in limited external costs, which is the amount of benefits under the family 500+ program for 6 years

Freedom

- Fewer people living in flood risk areas
- Lower risk and limited flood losses for other households and buildings

Recommendations

- A long-term investment plan for railway infrastructure needs to be drawn up and implemented.
  - Construction of new sections of railway connections and full electrification of the network, its range to be increased, and improving the capacity and competitiveness of railways in freight and passenger traffic, including high-speed railways,
  - making intermodal terminals universally accessible, enabling the railway to take over transport from road transit and making it possible to provide long- and medium-distance services,
  - doubling the number of passenger connections and the construction of integrated transport hubs enabling travel by rail, urban public transport, and bicycle, and parking facilities, to be combined.
- Changing the policy concerning rail and road infrastructure access fees.
  - reducing fees for access to railway infrastructure by 50%, which translates into lower fares and freight costs,
  - extending the system of collecting tolls for road infrastructure from trucks and buses to cover the

entire national and voivodship road network (while rates will continue to depend on the quality of roads),

  - optimization of the cost of maintaining the transport system infrastructure and making fees universal for users under investment, municipal and social policies, among other things by linking tolls to maintenance costs.

- Analysis of the development of inland waterway transport, considering its real impact on flood safety, the environment and inland waterway costs.

  - Investments in waterways implemented only on sections where economic analyses including external costs show an advantage of inland waterway solutions over the development of railway infrastructure.

- Transfer of potential funds from multi-billion-dollar investments in inland waterway transport to the development of railway infrastructure, improvement of road traffic safety and promotion of diversity of means of transport.

- Implementation of a central coordinated plan for river and flooded area management for:

  - better and more effective flood risk management through:

    - development of a state flood risk management policy, based on the conclusions reached in public dialogue between various stakeholder groups: public authorities, local governments, naturalists, hydrologists, planners, sociologists, geographers and engineers,

    - making public all flood-related decisions taken by local governments,

    - including flood hazard zones in local spatial development plans. Protection of floodplains from development and use as arable lands and changes laws limiting development and investments in flood risk areas (among other things banning construction in areas at risk of flooding once every 10 years and introduction of new construction standards in the areas that are rarely flooded, guaranteeing that buildings are able to withstand flood damage),

    - recovery and restoration of natural floodplains and purchase by the state of buildings and lands located in these areas,

    - introduction of diversified insurance premiums and other tools to discourage investments in high-risk flood areas,

    - development of a flood damage and flood loss record system, enabling them to be analysed and enabling the development of a flood risk management model in the future,

    - development and implementation of best practices with regard to afforestation of the country and planning the structure of new afforestation,

    - introduction of regulations prohibiting conversion of grassland into arable land, blocking the development of agriculture in river valleys at risk of flooding.

  - stopping the processes of regulation of rivers, removal of already existing regulation structures in river channels to restore rivers to their natural form.

TIMELINE: RIVERS

Non-road transport accounts for 15% of freight transport

For Generations 2050

2020

Start of 20-year investment plan for railway modernization

2040

3.000 km of new tracks were laid, 7.500 km of railway network was modernized. Non-road transport accounts for 23% of freight transport

2050

Road tolls generate approximately PLN 10 bn for the budget per year. Non-road transport accounts for 30% of freight transport

Base 2050

2020

20-year river regulation plan and building of appropriate infrastructure

2040

More than 1.000 km of rivers was regulated and more than 150 bridges were raised. Non-road transport accounts for 16% of freight transport

2050

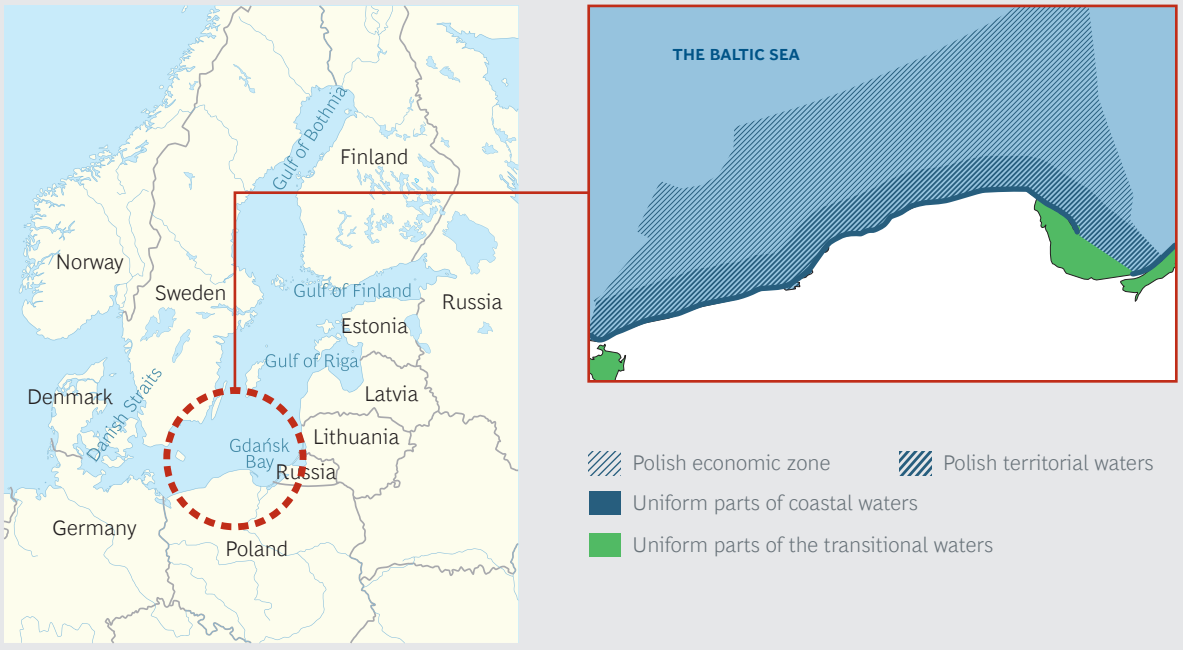
River maintenance costs approximately PLN 2.5 bn for the state budget per year. Non-road transport accounts for 17% of freight transport

THE BALTIC SEA

The Baltic Sea is among the youngest and least saline seas on Earth. It was created from the waters of a melting glacier over 10,000 years ago[124]. Until the 19th century, the Baltic Sea was one of the cleanest in the world, however two centuries of industry and agriculture development and population growth in the Baltic Sea catchment area made it one of the most polluted seas on Earth[125].

The waters of the Baltic Sea are surrounded by the European continent and are connected with the Atlantic Ocean only by the narrow and shallow Danish straits. Therefore, the rate of water replacement in the Baltic Sea is very slow and lasts about 30 years. Hampered water replacement, related among other things to the fact that the Baltic Sea consists of a series of deep basins separated by shallower ridges, and on more than one third of the total area the sea is less than 30 m deep, makes pollutant concentrations in the Baltic Sea relatively high[126].

FIG. 38: THE BALTIC SEA AND POLISH EXCLUSIVE ECONOMIC ZONE



Source: General Inspectorate for Environmental Protection 2014, Report for the European Commission, http://www.gios.gov.pl/bip/zalaczniki/konsultacje_spoleczne/folder_A/wstepna_ocena_stanu_srodowiska_wod_morskich.pdf, link active as of 24 September 2018

124 A. Majewski, Oceans and Seas, The State Scientific Publishers PWN, Warsaw 1992.
125 J. Fabisiak, Ecological Threats of the Baltic Sea Related to Chemical Pollution - Hydrocarbons, "Working Papers of the Navy Academy") 2008, Year XLIX No. 3 (174) 2008
126 M. Lepparänta, K. Myrberg, Physical Oceanography of the Baltic Sea, Springer Science & Business Media, 378 p. 2009.

The Baltic Sea is a unique ecosystem of marine and freshwater animals, and is home to over 2,700[127] species of fish, birds, mammals, invertebrates and marine plants. It is inhabited by several endemic species of plants and animals (i.e. those only present in this area).

Ecological problems related to anthropogenic pressure cause a continual decrease in the biodiversity of animals and plants. At least three of the species of animals once found in the Baltic Sea are now considered extinct: these are the Atlantic sturgeon, common skate and gull-billed tern. A further 69 species, including the harbour porpoise subpopulation, are threatened with extinction[128]. In the Baltic Proper, only approximately 500 harbour porpoises are left[129]. All species inhabiting the Baltic Sea, including those endangered, are essential for the proper functioning of this ecosystem.

The unique and specific nature of the Baltic Sea makes it particularly vulnerable to disturbances and pressures exerted by human activities.

The Baltic Sea catchment area[130] is four times bigger than the area of the sea itself and it is populated by more than 85 million people[131]. The Baltic Sea is surrounded by nine countries. It is a source of livelihood for many people from the region and is therefore heavily exploited today for example by the transport, tourism, and fisheries sectors, as well as by renewable energy systems. According to the Helsinki Commission[132] major threats to the stability of the Baltic Sea ecosystem include:

- eutrophication,
- dangerous substances,
- loss of biodiversity,
- offshore business activity[133].

The Marine Strategy Framework Directive (MSFD)[134] introduces a slightly different system of categorization and grouping of occurrences affecting or characterising the state of the marine environment. Nevertheless, the issues raised by the Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area) and the EU directive overlap.

In this report, we want to draw attention to selected problems related to human activity, such as eutrophication or fishing pressure (element of offshore business activity), to highlight problems that the public are only now beginning to realise are the threat – e.g. the presence of waste in the marine environment, including the presence of plastic microparticles.

127 HELCOM Report Checklist of Baltic Sea Macro-species, 2012 http://www.helcom.fi/Lists/Publications/BSEP130.pdf, download date 22 May 2018.
128 **As cited in:** A list of endangered species, HELCOM, http://www.helcom.fi/baltic-sea-trends/biodiversity/red-list-of-species, download date 22 May 2018.
129 **As cited in:** Anonymous (2016): LIFE+ SAMBAH project. Final report covering the project activities from 01/01/2010 to 30/09/2015. Reporting Date 29/02/2016 http://www.sambah.org/SAMBAH-Final-Report-FINAL-for-website-April-2017.pdf, download date 2 October 2018.
130 **As cited in:** Catchment area - a group of basins discharging water into one common sea, www.baltyk.pogodynka.pl/index.php?page=5&subpage=15&data=12, download date 14 September 2018.
131 **As cited in:** http://stateofthebalticsea.helcom.fi/humans-and-the-ecosystem/activities-pressures-and-welfare-impacts/, download date 30 June 2018.
132 The Helsinki Commission - HELCOM Baltic Sea Environment Protection Commission, is the executive body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area. The members of HELCOM are: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden and the European Union: www.helcom.fi
133 **As cited in:** HELCOM Baltic Sea Action Plan, 2007, www.helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP_Final.pdf, download date 13 September 2018.
134 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

Threats and their root causes

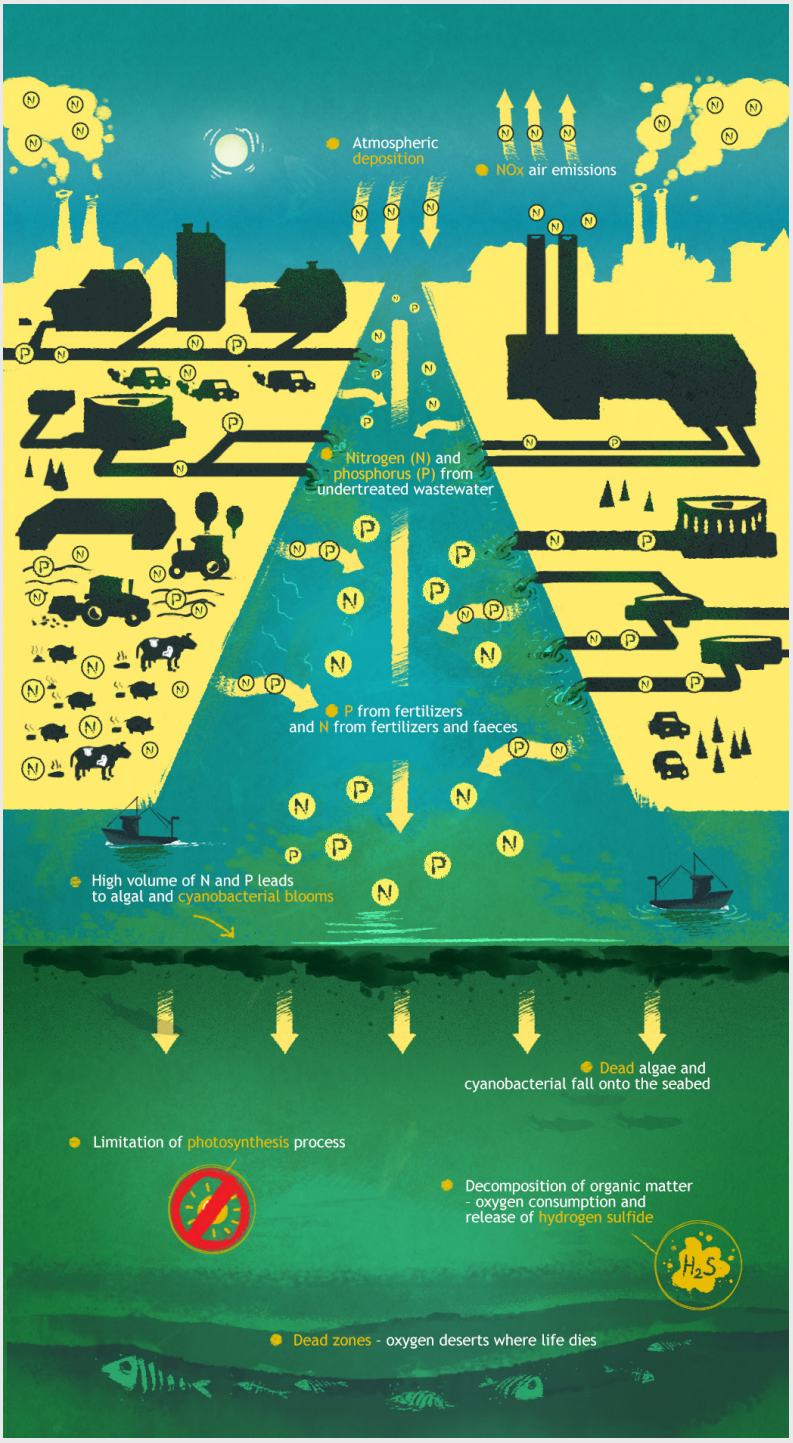
Eutrophication caused by excess nutrients entering the water poses a serious danger

Eutrophication is caused by excess nutrients entering the water (nitrogen and phosphorus compounds). One of the means by which they get into the Baltic Sea is as a result of farming activities, e.g. they originate from excessive volumes of fertilizers used in the fields and from inadequately stored animal waste, from municipal sewage and industrial effluents and from atmospheric deposition. When there are too many nutrients in the water and the water temperature rises, algae and cyanobacteria start to bloom, limiting the access of sunlight to the deeper layers of water. This restricts the development of plants living in deeper parts of the water that need sunlight in the process of photosynthesis. When the blooms are over, dying algae and cyanobacteria fall to the seabed, where they decompose. During the decomposition process, bacteria consume dissolved oxygen in the bottom layers of water. When the oxygen runs out, the process continues with anaerobic bacteria that produce hydrogen sulphide harmful to marine organisms. In this way, aerobic deserts (dead zones) and oxygen-depleted areas are created in the seas, and life dies out in these areas[135].

135 Conleyet al., Hypoxia is increasing in the Coastal Zone of the Baltic Sea, "Environmental Science & Technology", 2011, 45 (16), 6777-6784.

SOURCES OF NITROGEN AND PHOSPHORUS DEPOSITS IN THE MARINE ENVIRONMENT

FIG. 39: CAUSES AND EFFECTS OF THE EUTHTROPHICATION PROCESS

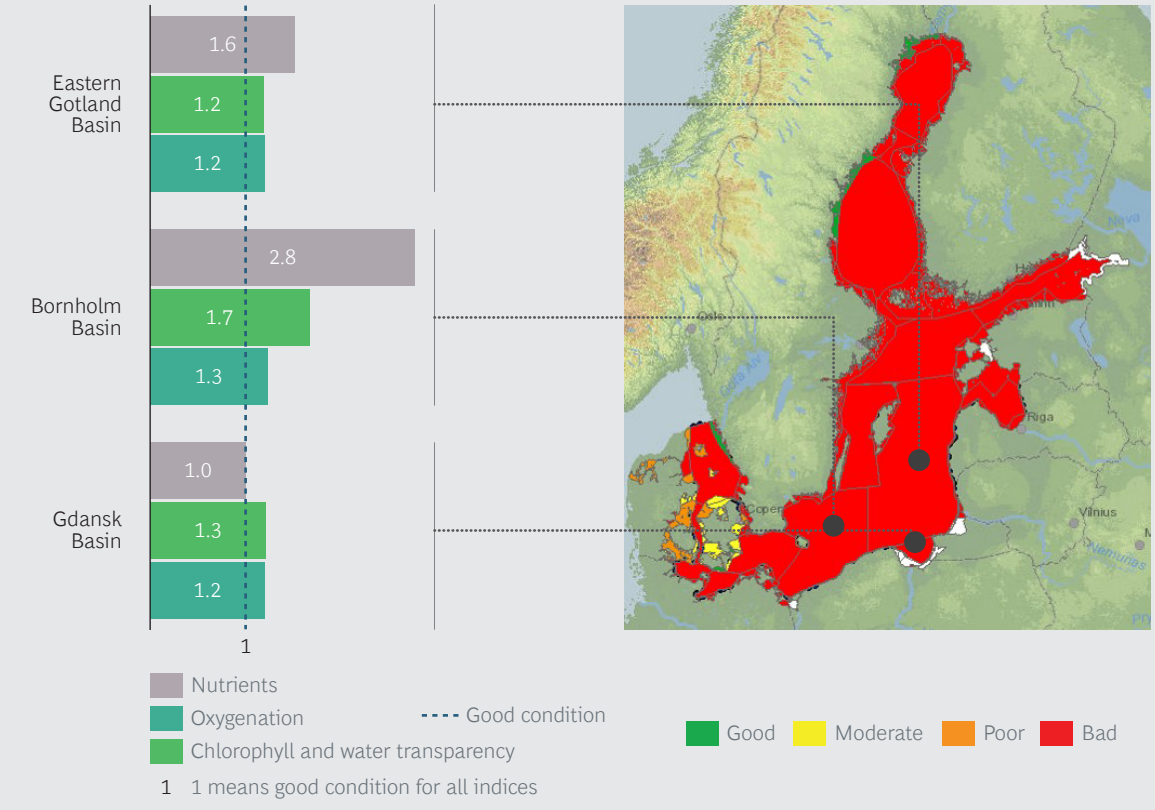


Source: WWF Poland

According to a report prepared by the Helsinki Commission, as much as 97% of the Baltic Sea showed eutrophication effects. The Commission evaluates the level of eutrophication by analysing three elements: concentration of nutrients (nitrogen and phosphorus) in surface waters in winter and summer, direct effects (chlorophyll content in surface waters and water transparency – also broken down by seasons) and indirect effects (as annual oxygen deficiency in deep water, this indicator applies only to deep areas)[136]. As part of the HELCOM TARGREV project, the levels of coefficients characterising those elements were adopted which were established as environmental goals, i.e. limits within which the condition of the environment is still considered good. These do not mean the level is pristine, but include the permissible and acceptable deviation above this level. If the limits are exceeded, this means an inadequate / poor condition of the environment[137]. In the HELCOM HOLAS II report, the target levels of these values, in the areas designated by HELCOM (Figure 39. The levels of eutrophication indices in individual basins in the Polish Influence Zone), which are covered by Polish marine sites of the Baltic Sea, have not been reached yet.

THE DEGREE OF EUTROPHICATION OF THE BALTIC SEA IN 2015 AND LEVELS OF EUTROPHICATION INDICES IN RELATION TO ENVIRONMENTAL OBJECTIVES IN BASINS IN THE POLISH INFLUENCE ZONE OF THE BALTIC SEA

FIG. 40: THE LEVEL OF EUTROPHICATION INDICES IN INDIVIDUAL BASINS OF THE POLISH INFLUENCE ZONE



Source: BCG analysis based on Integrated eutrophication status assessment http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/7ce6abce-583f-425e-9ae8-d1d6171e5198; http://maps.helcom.fi/website/mapservice/ - Status assessment – State of the Baltic Sea 2011-2015 (Hollas II 2017 version) – Eutrophication – Eutrophication assessment – Integrated eutrophication status assessment, link active as of 29 April 2018

136 **As cited in:** HELCOM, 2018, State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155 http://stateofthebalticsea.helcom.fi/wp-content/uploads/2018/07/HELCOM_State-of-the-Baltic-Sea_Second-HELCOM-holistic-assessment-2011-2016.pdf, download date 13 September 2018.

137 **As cited in:** HELCOM, 2018, HELCOM Thematic assessment of eutrophication 2011-2016 http://stateofthebalticsea.helcom.fi/wp-content/uploads/2018/07/HELCOM_Thematic-assessment-of-eutrophication-2011-2016_pre-publication.pdf, download date 13 September 2018.

Eutrophication root causes

Studies show that the content of nutrients in the upper sea layer grew rapidly from the mid-20th century to the 1980s and has been gradually decreasing since then.

THE VOLUME OF DEPOSITED NUTRIENTS INCREASED UNTIL THE 1980s, AND THEN IT DECREASED GRADUALLY

FIG. 41: NITROGEN LOAD RELEASED INTO THE BALTIC IN THE 20TH CENTURY AND ON THE ONSET OF THE 21ST CENTURY [TONS OF NITROGEN/YEAR]

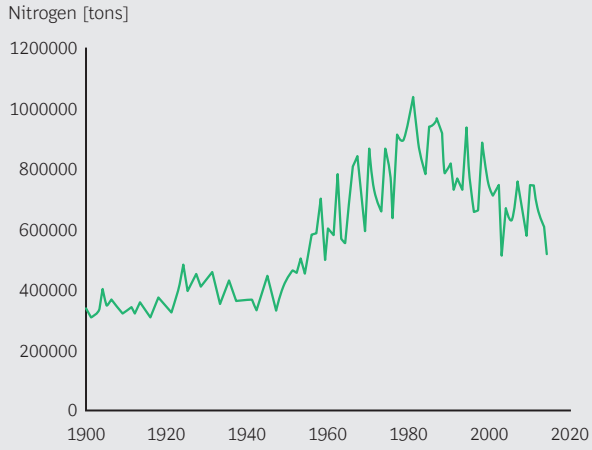
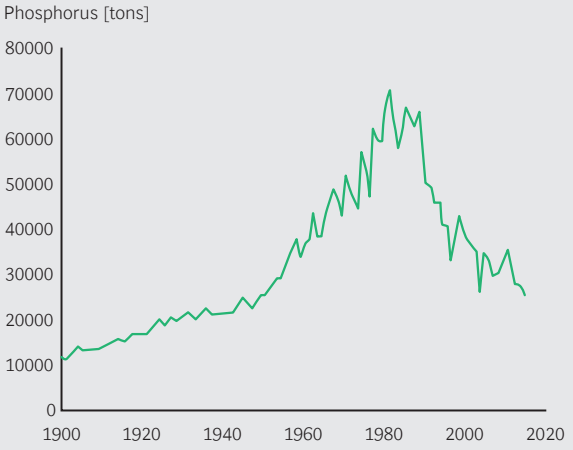


FIG. 42: PHOSPHORUS LOAD RELEASED INTO THE BALTIC SEA IN THE 20TH CENTURY AND ON THE ONSET OF THE 21ST CENTURY [TONS OF PHOSPHORUS/YEAR]



Source: HELCOM, 2017, The integrated assessment of eutrophication - supplementary report to the first version of the 'State of the Baltic Sea' report 2017., modified by BCG http://stateofthebalticsea.helcom.fi/wp-content/uploads/2017/09/HELCOM_The_integrated_assessment_of_eutrophication_Supplementary_report_first_version_2017.pdf link active as of 13 September 2018

Due to being primarily agricultural (about 50% of arable land in the entire Baltic Sea catchment area) and population (about 45% of the total population of the Baltic countries), Poland supplies the most nitrogen and phosphorus compounds to the Baltic Sea[138].

138 **As cited in:** HELCOM, 2012, The Fifth Baltic Sea Pollution Load Compilation (PLC-5) – An Executive Summary. Balt. Sea Environ. % No. 128A, 217 pp.; http://www.helcom.fi/Lists/Publications/BSEP128.pdf, download date 13 September 2018.

TOTAL (INFLOW FROM RIVERS, ATMOSPHERIC DEPOSIT, DIRECT) LOAD OF NITROGEN AND PHOSPHORUS RELEASED INTO THE BALTIC SEA IN THE LAST 20 YEARS IN THOUSANDS OF TONS

FIG. 43: TOTAL NITROGEN LOAD (1000 TONS)

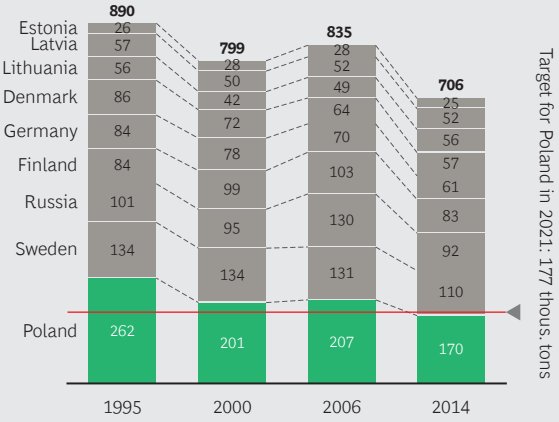
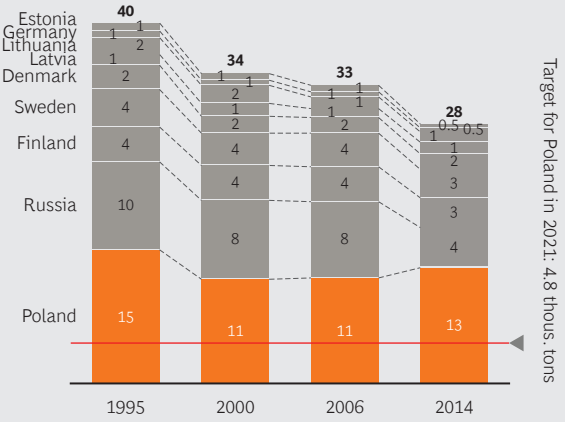


FIG. 44: TOTAL PHOSPHORUS LOAD (1000 TONS)



Source: HELCOM, 2018. Sources and pathways of nutrients to the Baltic Sea. Baltic Sea Environment Proceedings No. 153, modIfied by BCG
http://www.helcom.fi/Lists/Publications/BSEP153.pdf link active as of 21 September 2018

In the HELCOM Baltic Sea Action Plan, which is used to implement the Baltic Sea' conservation activities under the Helsinki Convention, the level of reduction of nitrogen and phosphorus emissions into the sea from individual countries was initially determined in 2007 and revised in the HELCOM 2013 report[139]. The maximum permissible nitrogen load (Maximum Allowable nutrient Inputs, MAI) stated in the report for the whole Baltic Sea was set at 792,200 tons (in 2014, the level of emissions in the entire Baltic Sea area was 89% of the permitted value), and for phosphorus – for 21,700 tons (in 2014, emissions exceeded the envisaged level by more than 30%). The targets for Poland are to reduce nitrogen emissions by 43,600 tons and phosphorus by 7,500 thousand tons (Country Allocated Reduction Target, CART) assuming that the starting point is the average emission levels recorded in 1997–2003 (defined as 220,600 and 12,300 tons respectively). In 2014, Poland was within the limit for nitrogen (the emission level reached 96% of the limit), but the permissible level of emissions of phosphorus was still exceeded by over two and a half times.

Unavailability of bathing areas

The negative effects of eutrophication of the marine environment include not only the increase in the range of the dead zones described above, but also the closing of bathing areas due to the toxicity of some of the cyanobacteria species occurring in phytoplankton blooms in the summertime.

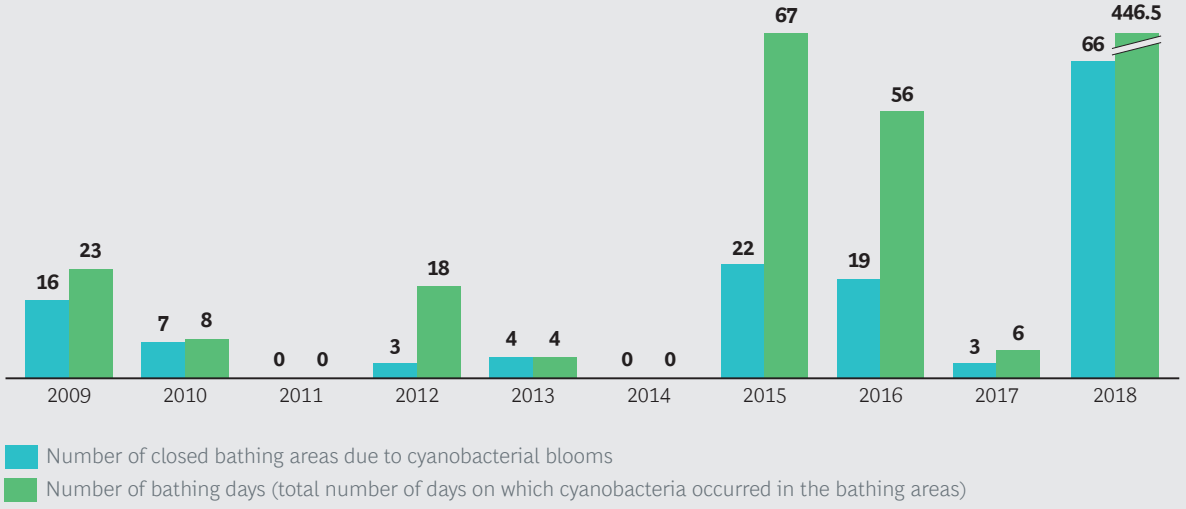
In 2016, the authorities of the State Sanitary Inspectorate stated that the water was not of quality suitable for recreational use in 27 bathing areas in Poland, i.e. in 13% of marine and inland bathing areas altogether. These decisions were due to microbiological indicators being exceeded, as well as cyanobacterial blooms. The cyanobacterial blooms attracted the special attention of the sanitary

139 **As cited in:** HELCOM, 2013, Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan http://www.helcom.fi/Documents/Ministerial2013/Associated%20documents/Supporting/Summary%20report%20on%20MAICART.pdf, sourced 13.09.2018.

authorities[140] because of toxins that are dangerous for bathers' health. Bathing in water in which there are toxic cyanobacteria can cause skin irritation, gastrointestinal complaints and even neurological disorders. Potential problems caused by cyanobacteria include skin rash, itching and watery eyes, vomiting, diarrhoea, fever, as well as aching muscles and joints[141]. Shutting down the bathing areas deters tourists and consequently may lead to the depletion of budgetary revenues of municipalities that live off the sea.

CYANOBACTERIAL BLOOMS LEAD TO CLOSURE OF BATHING AREAS

FIG. 45: NUMBER OF CLOSED BATHING AREAS AND NUMBER OF BATHING AREA DAYS (TOTAL NUMBER OF DAYS WITH CYANOBACTERIAL BLOOMS WHICH OCCURRED IN GIVEN BATHING AREAS) BASED ON THE MONITORING DATA PROVIDED BY THE STATE SANITARY INSPECTORATE



Source: BCG study based on reports on sanitary condition assessment and epidemiological situation made by the National Sanitary Inspection

While in the 2009–2014 period the cyanobacterial blooms had little effect on Polish tourism, in the 2015–2017 period the availability of bathing areas was already limited. In 2015, bathing areas were closed due to the blooms on average for 3 days in the season, in 2016 for 3 days, and in 2017 – for 2 days. According to the information from the Chief Sanitary Inspectorate, in the bathing season of 2018, for 146 bathing areas out of 483 bathing areas in Poland, 358 decisions temporarily banning bathing were issued, of which the highest number of failed inspection findings – 293, were issued by bodies of the State Sanitary Inspectorate due to temporary bloom of cyanobacteria (82% of decisions issued)[142]. Out of the 146 coastal bathing areas temporarily closed in 2018 due to the cyanobacterial blooms, 11 were in the Zachodniopomorskie Voivodeship, and 55 were in the Pomorskie Voivodeship. The longest bathing area that was closed longest to tourists due to cyanobacterial blooms – for 15 days, was located in the locality of Chałupy[143]. In 2018, seaside bathing areas were closed due to cyanobacteria for an average of 7 days during the season.

The occurrence, duration and intensity of blooms are affected by both water temperature and weather conditions (lack of wind and waves favouring the blooms) as well as the phosphorus concentration.

140 **As cited in:** Chief Sanitary Inspectorate, Bathing Area Portal, Water Safety Department https://sk.gis.gov.pl/cms/userfiles/files/Stan_sanitarny_kap_2016.pdf, s. 15, download date 14 May 2018.
141 **As cited in:** Chief Sanitary Inspectorate, Bathing Area Portal https://sk.gis.gov.pl/index.php/informacje, download date 14 September 2018.
142 Information from the Chief Sanitary Inspectorate as of 12 September 2018.
143 **As cited in:** Chief Sanitary Inspectorate, Bathing Area Portal, https://sk.gis.gov.pl/, download date 14 September 2018.

However, only the last factor could potentially be controlled by humans.

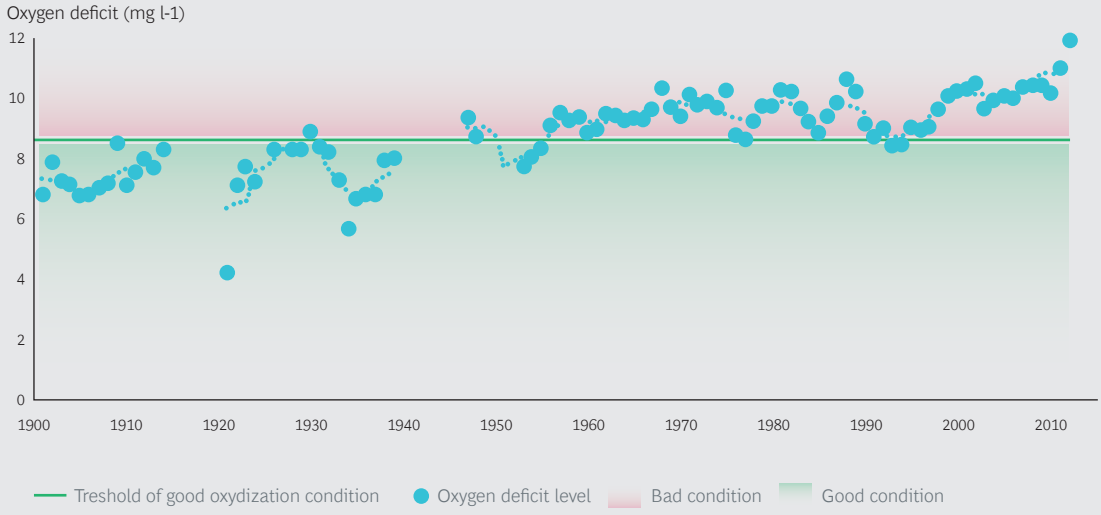
Lack of oxygen and dead zones

Dead zones have become a serious problem in the Baltic Sea in recent decades.

The largest area of oxygen deficit in Europe, caused by anthropogenic activity, is in the Baltic Sea. Since 1990, the area of dead zones in the Baltic Sea has increased tenfold – from 5,000 km² to 60,000 km², with the highest change rate after 1950.[144]

AS A RESULT OF AN ONGOING EUTROPHICATION, INCREASING OXIDISATION DEFICIT IN DEEP WATERS IN THE BALTIC SEA

FIG. 46: OXYGEN DEFICIT, BALTIC PROPER



Source: The Integrated Assessment Of Eutrophication, Helcom, First version 2017: http://stateofthebalticsea.helcom.fi/wp-content/uploads/2017/09/HELCOM_The_integrated_assessment_of_eutrophication_Supplementary_report_first_ version_2017.pdf link active as of 27 April 2018

144 **As cited in:** Ocean oxygen content https://www.eea.europa.eu/data-and-maps/indicators/ocean-oxygen-content/assessment, download date 15 June 2018.

THE DEAD ZONE AREA IN THE BALTIC SEA INCREASED 10-FOLD IN THE LAST 100 YEARS

FIG. 47: LOCATION AND SIZE OF DEAD ZONES IN THE BALTIC SEA

Source: https://www.eea.europa.eu/data-and-maps/indicators/ocean-oxygen-content/assessment; http://stateofthebalticsea.helcom.fi/in-brief/our-baltic-sea/, link active as of 20 January 2018

Hypoxia of demersal waters has a devastating effect on the biological diversity of the sea. In areas with the least oxygenation, only organisms with high resistance to hypoxia live (e.g. polychaete Harmothoe sarsi). Limiting the amount of oxygen available in water reduces the number of species occurring in a given area, until the creation of zones devoid of higher organisms other than bacteria, i.e. dead zones.

At a time when the area of the Baltic Sea seabed deprived of adequate oxygen resources increased tenfold, the mass of macrofauna (larger animals inhabiting a given environment) dwelling at on the seabed dropped by approximately 1.7 million tons[145]. The appropriate oxygen level[146] is required for example by the spawn of cod, very popular in Poland. This is vital for it to preserve its reproductive abilities. The increasingly low level of oxygenation of the deep-sea waters of the Baltic Sea contributes to the decline of fish populations in the Baltic Sea[147]. The zones at the bottom of the Baltic Sea completely deprived of oxygen, the so-called dead zones, created as a result of a combination of adverse natural conditions and eutrophication observed since the 1960s, may adversely affect population levels of Baltic Sea fish, limiting for instance the potential space convenient for fish (including cod) for spawning, and reduce availability of ecological niches for demersal fish.

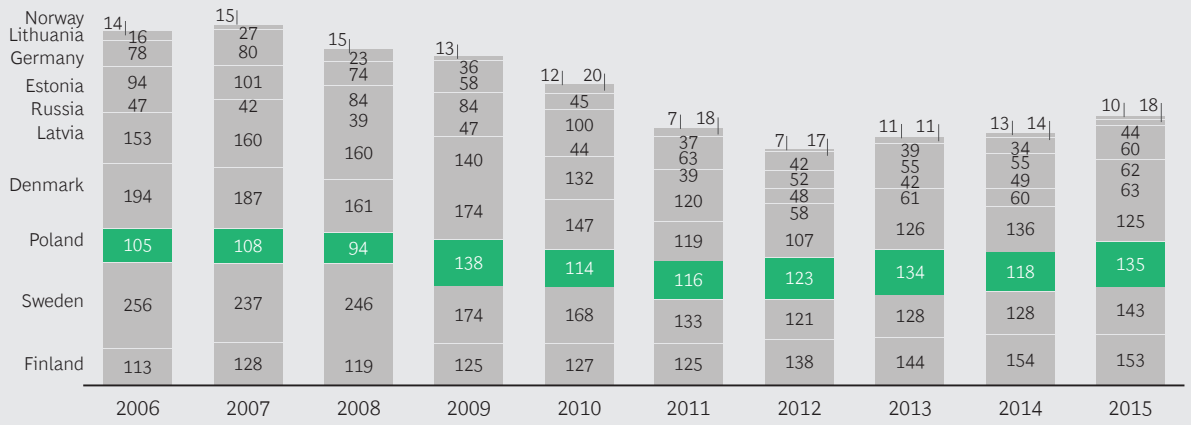
Declining fish population

The quantity of fish caught in the Baltic Sea depends among other things on fishing limits, the scale of illegal fishing, and the general state of the environment. Poland, together with Finland, Sweden, and Denmark, have been intensively exploiting fish stocks in the Baltic Sea for decades now.[148] The Polish fleet mainly catches sprat, herring and cod, which account for 95% of all fish obtained in this manner.

145 **As cited in:** J. Carstensen, J. H. Andersen, B. G. Gustafsson, D. J. Conley, Deoxygenation of the Baltic Sea during the last century, 2014 http://www.pnas.org/content/111/15/5628, download date 30 May 2018.
146 Ibid.
147 Ibid.
148 **As cited in:** http://www.ices.dk/marine-data/Documents/CatchStats/OfficialNominalCatches.zip, download date 30 April 2018.

POLISH FLEET AMONG THE COUNTRIES WITH THE HIGHEST FISH CATCH IN THE BALTIC SEA

FIG. 48: SIZE OF CATCHES OF ALL FISH SPECIES SUBJECT TO FISHING LIMITS IN THE BALTIC SEA BY COUNTRY [1000 TONS]



Source: ICES: http://www.ices.dk/marine-data/Documents/CatchStats/OfficialNominalCatches.zip; link active as of 20 May 2018, BCG analysis

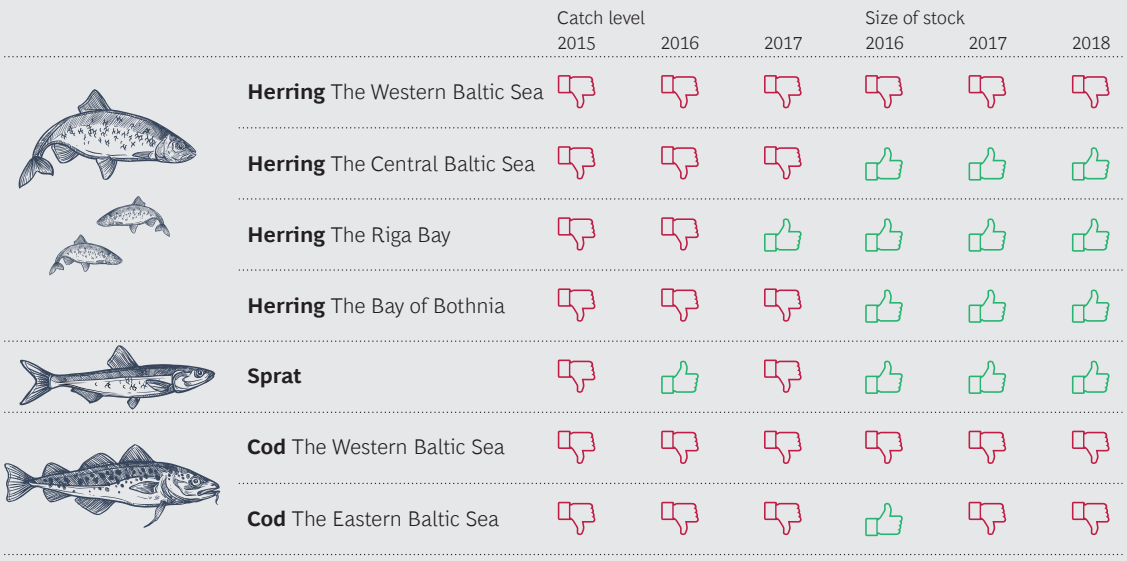
The management of fisheries in the Baltic Sea is regulated by the Common Fisheries Policy of the European Union and by Russian laws. They are advised by institutions such as the International Council for the Exploration of the Sea (ICES) or the Scientific, Technical and Economic Committee for Fisheries of the European Commission (STECF). ICES and STECF carry out research projects to assess the state of the Baltic Sea. When advising, these institutions recommend the size of catches that is safe for preserving stability of stocks and could serve to restore the stocks to the level of biomass able to achieve the Maximum Sustainable Yield[149]. Fishing limits in the Baltic Sea are set annually by the EU Agriculture and Fisheries Council (AGRIFISH) on the basis of recommendations made by the European Commission and scientific institutions. Unfortunately, they are often set at a higher level than that advised by scientists. Poland is party to this decision-making process[150]. In 2010–2014, the setting of fishing limits above scientific recommendations affected salmon stocks the most, and since 2015, the problem has mainly affected cod. In 2018, Poland gained the opportunity to catch 1,700 tons of fish due to scientific advice being exceeded when establishing catch limits for Eastern Baltic cod, plaice and salmon[151]. However, the short-term profit will translate into a long-term loss for the entire sector.

Overfishing, disturbing the reproductive capabilities of the fish stock, leads to a decline in its biomass. If the level of spawning stock biomass - the amount of fish able to spawn – is too low, this will result in reduced reproductive capacity of the population. Two fish stocks in the area targeted by the Polish fleet and others, western Baltic cod and western Baltic herring, are endangered because their biomass is already below the critical conservation reference point[152].

149 Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC 'Maximum sustainable catch means the largest theoretical sustainable catch that can be continuously obtained on average from a stock under existing environmental conditions without significant impact on the breeding process.'
150 **As cited in:** New Economics Foundation; http://action.neweconomics.org/landing_the_blame_database, download date 19 April 2018.
151 **As cited in:** New Economics Foundation; https://neweconomics.org/uploads/files/Landing-the-blame-Baltic-2018.pdf, download date 19 April 2018.
152 **As cited in:** Baltic Sea Ecoregion – Fisheries overview, ICES, 2017 http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/Baltic_Sea_Ecoregion_Fisheries_Overview.pdf, download date 16 May 2018.

CONDITION OF SELECTED FISH STOCKS IN THE BALTIC SEA AND CATCH LEVELS AGAINST REFERENCE POINTS BASED ON MAXIMUM SUSTAINABLE YIELD

FIG. 49: CONDITION OF SELECTED FISH STOCKS IN THE BALTIC SEA



Source: BCG analyses based on consulting services provided by ICES; Selected reports http://www.ices.dk/sites/pub/Publication%20Reports/Forms/defaultone.aspx?RootFolder=%2Fsites%2Fpub%2FPublication%20Reports%2FAdvice&FolderCTID=0x0120005DAF18EB10DAA049BBB066544D790785&View=%7B24A83160%2D91CE%2D481D%2D9F57%2D7E1A03F87B79%7D, link active as of 18 June 2018

The problem is further aggravated by illegal fishing. For example, for salmon it is estimated that in 2019 as much as 29% of catches may be misreported, and even up to 6% unreported[153]. Despite the Baltic Sea Action Plan, the Baltic countries have failed to create an effective system of monitoring and counteracting illegal fishing, so the data on poaching available to the public are only estimates.

Another factor affecting the decrease of fish stock populations is the failure to implement effectively the landing obligation in the Baltic Sea, which has existed since 2015 and requires landing of all fish of stocks regulated by EU fishing limits, the so-called "discard ban". Member States are required to implement the landing obligation under the Common Fisheries Policy. It aims to eliminate the wasteful and socially unacceptable practice of discarding - throwing away dead fish that have been caught, and were not the target, back into the sea from the vessel. Accidentally caught fish must be kept on board, registered and unloaded at the port. The idea behind the landing obligation is primarily to motivate the fishing industry to use more selective fishing gear, thereby minimising or even eliminating bycatch. Another advantage of the landing obligation is collection of more complete data on the fish actually being caught on a particular fishing trip. Despite the fact that discarding is now illegal, according to ICES, discards accounted for 11% of eastern Baltic cod stock caught in 2017[154] and approx. 39% of caught plaice.

The fish population decline is also influenced by climate change[155]. Changes in temperature and

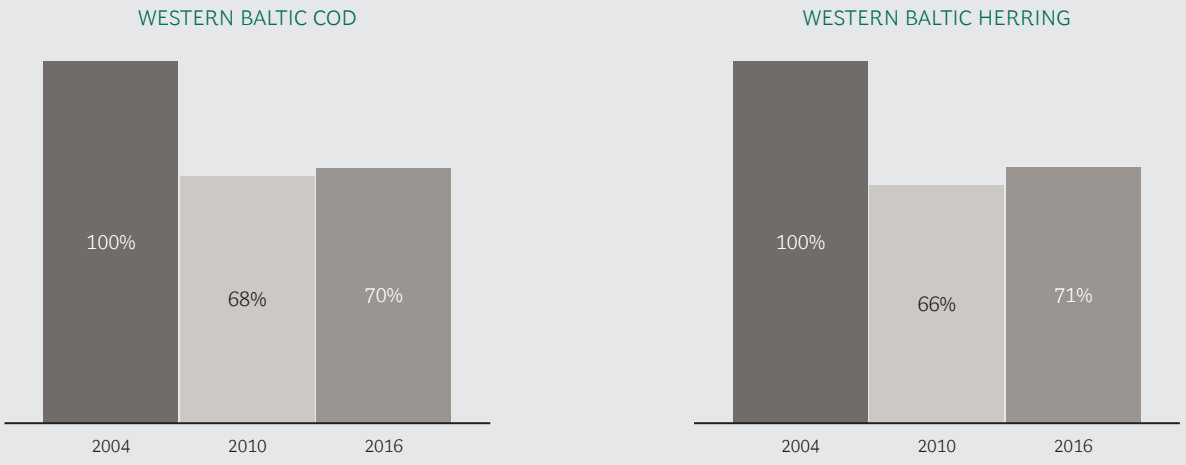
153 **As cited in:** Atlantic salmon (Salmo salar) in subdivisions 22–31 (Baltic Sea, excluding the Gulf of Finland), ICES, 2018 http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/sal.27.22-31.pdf, download date 30 June 2018
154 **As cited in:** http://ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/cod.27.24-32.pdf, download date 15 June 2018.
155 **As cited in:** 95th anniversary of the Maritime Fisheries Institute: current topics of scientific research. VOL. II - The condition of the southern Baltic environment, Sea Fisheries Institute, 2016 https://www.oceandocs.org/bitstream/handle/1834/9433/t.2..pdf?sequence=1&isAllowed=y, download date 5 June 2018.

salinity of water translate into the amount of food available for fish in the sea (phytoplankton and zooplankton). The simplified food cycle in the Baltic Sea is as follows: predatory fish (cod, salmon), feed on smaller fish (herring, sprat), which in turn feed on zooplankton (protozoa and small crustaceans) feeding on phytoplankton. Increased catches of large fish, including cod in the 1970s and 1980s, led to an increase in the number of small pelagic fish such as sprat and herring. What is more, warmer waters create optimum conditions for development for pelagic fish. Climate change therefore favors their reproduction. More and more small fish eat more zooplankton, which causes less consumption of phytoplankton. Meanwhile, the accumulation of phytoplankton on the seabed and its subsequent decomposition absorbs oxygen, thus increasing the oxygen deficit.

Overexploitation of fish stocks combined with the ecological problems of the Baltic Sea and other environmental factors mean that the population of some of the most popular fish stocks, such as herring or cod, is much lower than between ten and twenty years ago.

THE WESTERN BALTIC COD AND THE WESTERN BALTIC HERRING POPULATIONS HAVE SHRUNK BY APPROXIMATELY 30% SINCE 2004

FIG. 50: POPULATION OF POPULAR FISH SPECIES OF THE BALTIC SEA COMPARED TO 2004



Source: BCG analysis; http://standardgraphs.ices.dk/stockList.aspx; cod.27.22-24; her.27.20-24; spr.27.22-32 – SBB in tons

WESTERN BALTIC HERRING AND COD ARE NOT THE ONLY ENDANGERED POPULATIONS IN THE BALTIC SEA

ONLY ABOUT 500 PORPOISES REMAIN IN THE BALTIC SEA!

The HARBOR PORPOISE (Phocoena phocoena) is the only species of whale permanently found in the Baltic Sea.

Porpoises were common in the Baltic Sea basin in the first half of the twentieth century, but nowadays they can only be found occasionally.

Over the last 100 years, the porpoise population in the Baltic Proper has drastically dropped (among other things as a result of intensive hunting, pollution, by-catch), and in 2008 the porpoise was recognized to be critically endangered of extinction by the International Union for Conservation of Nature (IUCN).

The latest data on the size and location of the harbor porpoise population was provided under the SAMBAH project, which shows that the Baltic population of porpoise was estimated at about 500 individuals (95% CI 80 - 1091).[1]

The main threats identified today to porpoises in the Baltic Sea include:

- by-catch - accidentally getting tangled in fishing nets,
- underwater noise,
- pollution in the marine environment.

Porpoises get their orientation in the water and they hunt using echolocation. Contemporary synthetic and very thin fishing net fabrics do not reflect the sounds emitted by the porpoise, and so the reflected sounds do not reach the porpoise with adequate strength and in time. Unable to identify and bypass the nets, porpoises fall into them, get tangled up, and die as a result of suffocation. Fixed gillnets, used mainly in salmon and cod fishing are especially dangerous to porpoises. The lost nets, which are also called “ghost fishing nets”, also represent a threat to porpoises.

The priority with respect to porpoise protection is to reduce by-catch almost to zero. If the Baltic porpoise population is to survive, the anthropogenic factors must not cause mortality higher than 1-2 individuals per year in the entire Baltic Proper.[2]

The mortality rate of porpoises (recorded in the Polish exclusive economic zone) is usually higher than 4 individuals per year, which confirms that the condition of the species may be subject to systematic deterioration.

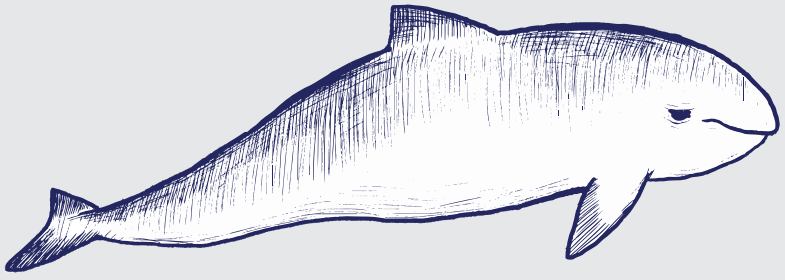
Only approximately 500 porpoises are left in the Baltic Proper

Is this population going to survive until 2050?

To increase the chances of survival of the porpoise population in the Baltic Sea, the Polish government (and the governments of other Baltic countries), supported by science, business, NGOs and fishermen, should immediately implement the following recommendations:

- To reduce by-catch through:
  - changing fishing tools and techniques to those safe for porpoises, increasing the efficiency of by-catch monitoring,

- limiting the negative impact of underwater noise on porpoises,
- development, approval and implementation of conservation plans for Natura 2000 marine sites, as well as the supplementation of the nets in these areas for the porpoise,
- conducting further research and supplementing knowledge about the population of porpoises in the Baltic Sea (their location, migrations, breeding sites, threats),
- implementation of the recommendations of the Harbour Porpoise Conservation Plan.[4]



[1]Anonymous (2016): LIFE+ SAMBAH project. Final report covering the project activities from 01/01/2010 to 30/09/2015. Reporting Date 29/02/2016. http://www.sambah.org/SAMBAH-Final-Report-FINAL-for-website-April-2017.pdf; [2]ASCOBANS (2016): (Agreement on the conservation of small cetaceans in the Baltic, North East Atlantic, Irish and North Seas) Recovery plan for Baltic Harbour Porpoises Jastarnia Plan (2016 Revision) http://www.ascobans.org/sites/default/files/document/MOP8_2016-3_JastarniaPlan_inclAnnex.pdf; [3]WWF/SMIOUG database of observations of mammals and seabirds: http://link.wwf.pl/baza_ssaki/public/; [4]General Directorate for Environmental Protection, 2015: Port porpoise protection program https://www.gdos.gov.pl/files/aktualnosci/46170/Program_ochrony_morswina.pdf

THE GROWING NUMBER OF TANKERS AND FREIGHTERS IS A POTENTIAL ENVIRONMENTAL THREAT

According to IMO[1] estimates and HELCOM, between 2006 and 2016, every day an average of 1340 vessels were moving on the Baltic Sea.[2] The Baltic Sea is one of the world's most heavily used seas, and is one of the top seven most congested waters, just behind the Chinese coast or the east coast of India[3]. A large number of vessels, combined with specific shipping conditions (such as narrow straits, ice or limited visibility in winter) make the Baltic Sea a difficult navigation area. The largest group of vessels in the Baltic Sea are large tankers (22% of all vessels in 2016) and freighters (48%) transporting dangerous substances.[4] In the last decade, between 2006 and 2016, the number of tankers in the Baltic Sea rose by almost 30 percent, and freighters a little over 5 percent.[5] The increased number of ships carrying dangerous substances and an increasing number of industrial plants means[6] that an accident is likely.

The two most recent large-scale accidents (over 1000 tons of spilled oil) took place in 2001 and 2003:

- in 2001, in the Danish Straits, as a result of a collision between the "Tern" freighter and the "Baltic Carrier" tanker, 2,.700 thousand. […] of heavy oil was spilled into the sea, polluting the environment and the surrounding beaches. Compensation for fishermen and others affected by this incident accounted forcame to EUR 3.5 million euros.

- In 2003, another accident occurred as a result of the collision of the "Fu Shan Hai" tanker and "Gdynia" container ship on the coast of Bornholm[7] This time, over 1,200 tons of oil poured out from the tanker. It is estimated that the cost of this accident was EUR 8.8 million.[8]

Minor accidents also take place in the Baltic Sea. Each year, there are about 140-150 incidents. Although they are not dangerous individually, their cumulative effect is, or could be, directly harmful to the environment. Spills of petroleum substances pose a serious threat to the marine environment, in which they can persist a long time, acting on many levels.

When crude oil (or its derivatives) finds its way into the water, then the entire ecosystem is at risk. Oil and oil derivatives have a toxic impact on marine organisms. Oil stains reduce the production of phytoplankton and thus disrupt the proper functioning of the food chain, up to the predators at the top of it, including birds of prey and seals. In sea birds, pollution from oil leads to changes in the structure of feathers, destroying their water resistance, causing them to get soaked and die as a result of hypothermia. Cleaning their feathers and eating contaminated food leads to poisoning, anemia, hypoxia and other dysfunctions. The risk associated with spills of petroleum substances and their harmful effects on the marine ecosystem can be reduced by appropriate measures, such as:

- implementation and enforcement of restrictive procedures regarding the use of ships and work on off-shore investment projects, and effective monitoring and control systems.

- Increasing the readiness of the relevant services and volunteers to take action to deal with the effects of a spillage (existing and practiced operational procedures, training, securing funds, and human and hardware resources).

[1]International Maritime Organization; [2]www.helcom.fi/helcom-at-work/groups/maritime; [3]https://www.marinetraffic.com/en/data/?asset_type=vessels; [4]BCG analysis based on HELCOM data; [5]http://www.helcom.fi/Lists/Publications/BSEP152.pdf, page 25; [6]http://www.helcom.fi/Lists/Publications/BSEP152.pdf, page 153; [7]http://www.vragguiden.dk/FuShanHai.pdf; [8]http://wwz.cedre.fr/en/Resources/Spills/Spills/Fu-Shan-Hai-Gdynia

The WWF organizes practical training for volunteers and veterinarians on how to help animals affected by oil spills. We were also involved in the development of the National Oil-Covered Animals Rescue Plan, which was adopted in 2018. The development of appropriate procedures will help to optimize the action taken in the event of an accident and action to rescue injured animals.

It is estimated that between 100,000-500,000 ducks, murres and other bird species are lost per year due to small oil spills in the Baltic Sea.[9]

[9]A.G. Kostianoy and O.Yu. Lavrova (eds.), Oil Pollution in the Baltic Sea, Hdb Env Chem (2014)

Water pollution due to plastic is on the increase

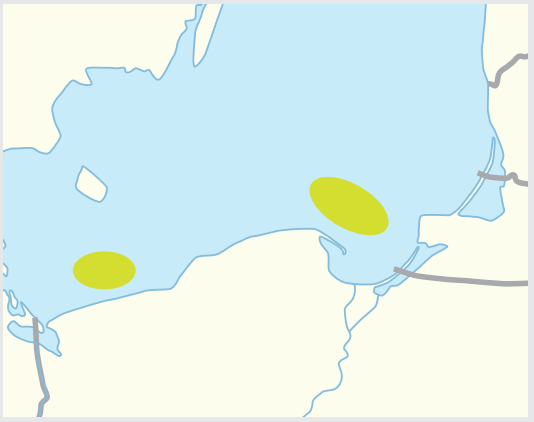
Annual global plastic production now exceeds 280 million tons and will grow by 4% per year[156]. With growing plastic production, the amount of pollutants released into the environment will grow. In sea waters around the world there are already over 5 trillion plastic particles[157]. In the entire natural environment, plastic accounts for 60–80% of pollution. This is mostly in the form of microparticles of plastic of a diameter not exceeding 5mm[158].

Plastic waste that enters the seas and oceans comes from four sources: from insufficiently treated wastewater containing plastic microparticles from cosmetics, detergents or clothes fibres that flow into the sea via rivers, from macro-waste (for example from lost fishing nets containing plastic), and from garbage from ships and industrial installations at sea. Microparticles of plastic are absorbed by zooplankton and consumed by smaller fish. Smaller fish are food for larger predators, and these are in turn consumed by humans. In this way plastic microparticles reach the human body.

We also consume plastic through bottled water. Research on a sample of about 260 bottles of water from eleven different brands in nine countries showed that in every liter of water sold there were on average 325 plastic microparticles[159].

UNDER THE PROJECT "REMOVAL OF DERELICT FISHING GEAR, LOST OR DISCARDED BY FISHERMEN IN THE BALTIC SEA" APPROXIMATELY 268 TONS OF WASTE WERE COLLECTED

FIG. 51: AREAS WHERE THE LARGEST AMOUNT OF WASTE WAS COLLECTED



Highest waste amount was collected

Source: „Removal of the fishing gear lost by fishermen and lying on the seabed of the Baltic Sea", WWF Polska 2015

156 **As cited in:** http://www.helcom.fi/Pages/Microplastics.aspx, download date 30 May 2018.
157 **As cited in:** Marine Plastic Pollution and Seafood Safety, 2015 https://ehp.niehs.nih.gov/doi/10.1289/ehp.123-a34, download date 1 October 2018.
158 Ibid.
159 **As cited in:** An article from The Guardian https://www.theguardian.com/environment/2018/mar/15/microplastics-found-in-more-than-90-of-bottled-water-study-says, download date 30 June 2018.

A significant problem here are lost fishing nets. After years at the sea bottom, the ghost nets disintegrate into microplastics. Floating in the water column they continue to catch fish, but mammals and seafowl can also get caught up in them. Between 2005 and 2008, every year ships from EU countries reported a loss of between 5,500 and 10,000 fishing nets. As with poaching, not all such cases are reported. A survey conducted among Polish fishermen in 2016 under the Marelitt Baltic project, in which WWF Poland participates, showed that as many as 90% of vessels lost their fishing equipment at least once, while 20% of respondents said it happened at least once a month, 45% said it happened at least once a year, and only 35% of respondents said it happened less than once a year. In 2015, as part of the project entitled "Removal of derelict fishing gear lost or discarded by fishermen in the Baltic Sea" implemented by the Kołobrzeg Fish Producers Group in cooperation with WWF Poland, an expert group composed of representatives of the Polish Baltic fisheries sector and leaders of organizations grouping fishermen, representatives of the world of science, sea fisheries inspectors and coordinators on behalf of WWF Poland planned and carried out a campaign to search for and retrieve lost fishing nets. As a result, over 216 tons of fishing gear[160], ropes and other equipment, in total about 268 tons of marine litter, was retrieved from the seabed. Also, old fishing nets have to be utilized properly, and this type of marine litter has to be received properly in ports.

Looking ahead – Poland 2050

Poles and all other inhabitants of the Baltic Sea Region will have to face the problem of climate change, demographic changes, and the ever-increasing demand for food and energy, and consequently increasing agricultural use of land. The state of the environment is important not only because of economic aspects. Nature is also intangible values that benefit humans. The way the environment is preserved translates into health, freedom of choice, and general welfare of people. The conclusions contained in the second holistic assessment of the condition of the Baltic Sea published in 2018 by the Helsinki Commission indicate that the environmental goals set in 2007 in the HELCOM Baltic Sea Action Plan have not been achieved and will not be achieved by 2021.

However, the presented assessment states that despite the gaps in the implementation of preventative measures and the wide margin of activities not yet applied, the condition of the Baltic Sea environment has improved. Nevertheless, further orchestrated efforts are required to reduce pressure on the natural environment and restore the ecological balance of the marine ecosystem.

We propose two scenarios: Base scenario, under which it is assumed that the Baltic Sea will continue to be used in the same way and that the approach to nature conservation will not change, and the For Generations scenario, which assumes compliance with the Blue Economy principles and the implementation of some changes to the current policy and manner of exploitation of the natural resources available to us, aimed at their sustainable use.

Tourism: an opportunity for growth or road to stagnation

Poland 2050, Base scenario

Under this scenario, Poland will keep reducing the flow of nutrients at the current level, but will not introduce any additional measures to reduce the load of these compounds supplied from the country to the Baltic Sea, for example there will be no wider promotion of the so-called Good Agricultural Practice and there will be no major investments to properly organize sewage management in areas in which buildings are widely dispersed, or in the modernization of sewage treatment plants with installations for removing phosphorus and nitrogen, etc. On the other hand, this scenario provides for intensive

160 WWF Poland, Removal from the Baltic Sea bed of fishing gear lost by fishermen and lagging, 2015.

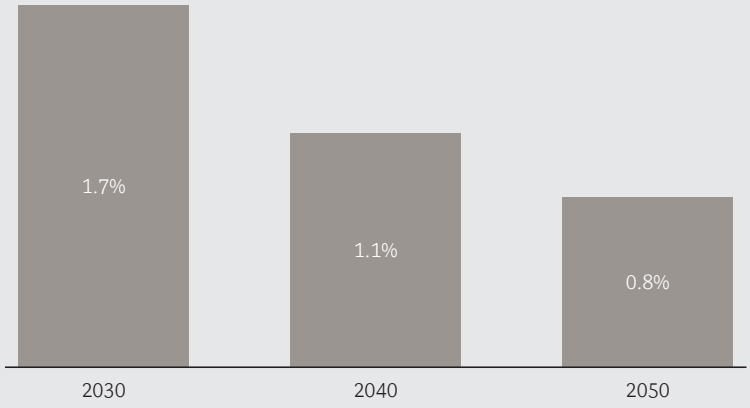
agricultural development. A significant increase in nutrient emissions from agriculture should be expected, considering the transformation occurring in Polish agriculture, which is rapidly changing from the form of small family farms to large-scale homogeneous field form and large-scale animal husbandry. The authors of the chapter "Socio-economic analysis of the use of marine waters and the costs of marine environment degradation" in the Polish report for the European Commission Update of the preliminary assessment of the marine environment, predict that by 2020 there will be an increase in the number of medium-sized farms and an increase in the number of units in the groups of larger area, but exact values are difficult to estimate. However, it is expected that the amount of fertilizers used, compared to 2012 (76.6 kg N [nitrogen]/ha and 24.6 kg P [phosphorous]/ha), will grow annually by approximately 5%[161].

The increase in loads of nutrients reaching the sea from Poland will limit the process of improvement of the condition of the sea, and the adverse effects will be felt in the nearest coastal zone – especially in the bays. Blooms of cyanobacteria could appear more frequently in the summer, leading to sanitary services closing bathing areas. Bearing in mind climate change and the increasing high temperatures in Poland, in the coming years, the intensity of blooms seen during the summer of 2018 could repeat or even increase. An increase in the frequency and scale of cyanobacterial blooms may translate into limited availability of bathing areas due to closure by sanitary and epidemiological stations due to the growing health hazard to people using these waters.

Closing the bathing areas may adversely affect the income from coastal tourism. In 2010–2017, the growth of coastal tourism remained at 5.6%[162], however, the coming years could see stagnation in the industry. The increase in revenue from tourism will hover around the inflation rate.

CONTINUAL DECREASE IN THE RATE OF GROWTH OF THE COASTAL TOURSIM SECTOR

FIG. 52: EXPECTED AVERAGE CHANGE IN THE VALUE OF TOURISM IN RELATION TO POLISH GDP IN SELECTED YEARS.



Source: Oxford Economics; BCG analysis

Slow growth (0.8%) will be felt in the hotel and accommodation sector, the catering sector, and amongst companies providing services associated with the sea resorts (transport and recreational sports, sea

161 Chief Inspectorate for Environmental Protection, Update of the Initial Assessment of the Condition of Sea Waters, 2018.
162 BCG analysis based on Polish Central Statistical Office and WTTC data.

cruises, amateur fishing, etc.). Based on these assumptions, the value added of the tourist sector for the gross domestic product in the coastal region will be PLN 11.9 billion by 2050[163]. This is about 20% lower than the value that could be generated in the case of a sustainable approach to managing maritime and agricultural management under the For Generations scenario[164].

As a result of the slow growth in the tourism sector and low wages, the number of people employed in catering, hospitality and related branches of the coastal economy will grow very slowly, and with time will start to fall. It is estimated that the number of jobs will increase by 6,000 by 2050 (an increase of around 15% compared to 2017).

The cost of environmental degradation will mean less of the related benefits for society. Degradation will have many adverse effects that directly or indirectly affect humans, such as the mentioned turbidity of water, the appearance of algae, reduction of fish stocks, contamination of fish and seafood, and loss of biodiversity.

Due to the intensive development of agriculture and the expected increase in the use of fertilizers, there will be an increase in the loads of nutrients reaching the sea. This will place limits on the process of improving the condition of the sea, and this will affect both freedom – limiting the availability of bathing areas, and health – the possibility of exposure to cyanobacteria, which will have implications for the general well-being of Poles.

Poland 2050, For Generations scenario

The Application of the Blue Economy rules[165] will mean that the integrity of the marine ecosystem can be preserved while ensuring the economic development of the maritime economy sectors, and thus – long-term prosperity. The introduction of the recommended measures and regulations will help to bring about more sustainable exploitation of the Baltic Sea and coastal areas, and thus improve the condition of the marine environment, which will begin to resemble the condition considered desirable.

Under the For Generations scenario, Poland will significantly reduce the amount of nitrogen and phosphorus compounds released into the sea. We will achieve and maintain the reduction targets set by HELCOM in the Baltic Sea Action Plan and then updated at the HELCOM ministerial meeting in 2013 (177,000 tons of nitrogen and 4,800 tons of phosphorus). Due to the properties of the Baltic Sea and the process of purifying its water, in the first 30 years, the concentration of nitrogen in the water will unfortunately increase steadily. The level of nitrogen in the waters of the Baltic Sea will begin to approach the environmental target only a few decades later. It may take up to 80 years for the correct condition of the water to be achieved. In the case of phosphorus, the situation will improve much faster: after 30 years a reduction of up to 50% in the concentration of this element in sea water can be expected. The environmental targets can be expected to be achieved five decades later[166].

A decrease in the amount of nutrients, and thus a reduction of the excess nutrients in the water, may help to reduce the number of days in which cyanobacterial bloom occurs. Bathing areas will not be closed as often and tourist traffic will increase. Under the For Generations scenario, the coastal tourism sector will grow at a rate of 1–5% per year in the period up until 2050, thanks to which it will generate added value of PLN 14.5 billion, up by PLN 2.6 billion compared to the Base scenario, in which the seaside tourism sector will grow at a rate of 1.7–0.8% per year in the period up until 2050. Under the

163 See Figure 20.
164 BCG analysis.
165 **As cited in:** WWF https://www.wwf.pl/sites/default/files/2017-07/Zadady%20zr%C3%B3wnowa%C5%BConej%20niebieskiej%20gospodarki.pdf, download date 3 October 2018.
166 **As cited in:** HELCOM, 2013, Summary report on the development of revised Maximum Allowable Inputs (MAI) and updated Country Allocated Reduction Targets (CART) of the Baltic Sea Action Plan http://www.helcom.fi/Documents/Ministerial2013/Associated%20documents/Supporting/Summary%20report%20on%20MAI-CART.pdf, download date 13 September 2018.

For Generations scenario, 11,000 additional jobs will be created by 2050 in the seaside tourism sector compared to the Base scenario (a 30% increase compared to 2017).

The condition of the Baltic Sea is improving slowly, but thanks to close regional cooperation it is visible. However, there is still a need to significantly increase the effort to reduce pressure, restore endangered species and habitats to good condition, and ensure the long-term sustainability of the environment and its resources.

UNDER THE FOR GENERATIONS SCENARIO, 11,000 MORE JOBS WILL BE CREATED BY 2050 THAN UNDER THE BASE SCENARIO

FIG. 53: EMPLOYMENT IN TOURISM - BASE SCENARIO [THOUS. JOBS PER YEAR]

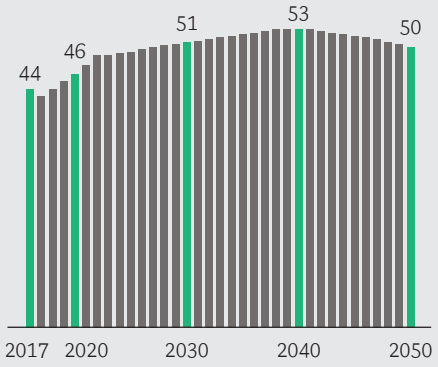
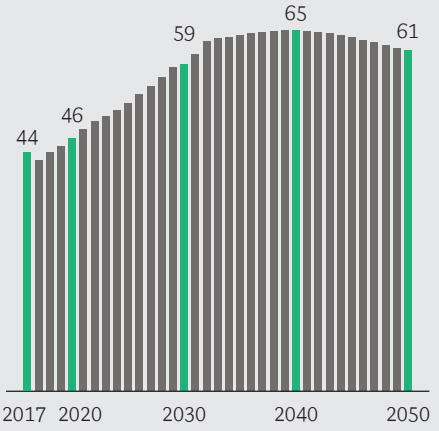


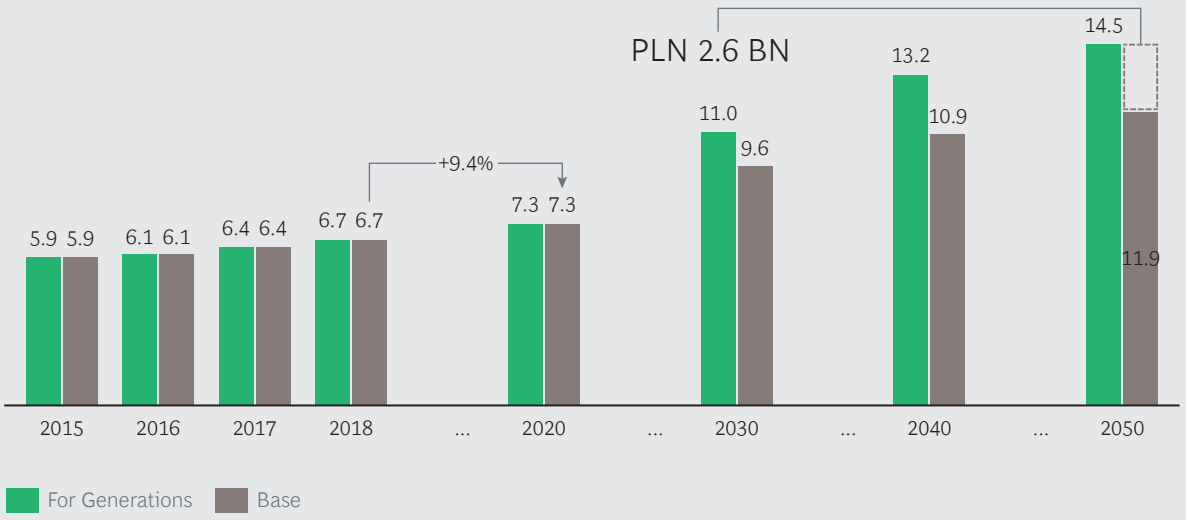
FIG. 54: EMPLOYMENT IN TOURISM - FOR GENERATIONS SCENARIO [THOUS. JOBS PER YEAR]



Source: BCG analysis; Oxford E.xonomics; CSO; WTTC; value estimated using 2010 prices

THE EXPECTED ADDED VALUE IN THE TOURISM SECTOR ON THE POLISH BALTIC COAST UNDER THE TWO SCENARIOS - DIFFERENCE OF PLN 2.6 BN

FIG. 55: ADDED VALUE OF THE TOURISM SECTOR ON THE POLISH BALTIC SEA COAST BY 2050 [PLN BN]



Source: BCG analysis; Oxford E.xonomics and CSO; WTTC; The added value is measured using 2010 prices; Added value calculated as the sum of indirect and direct economic branches

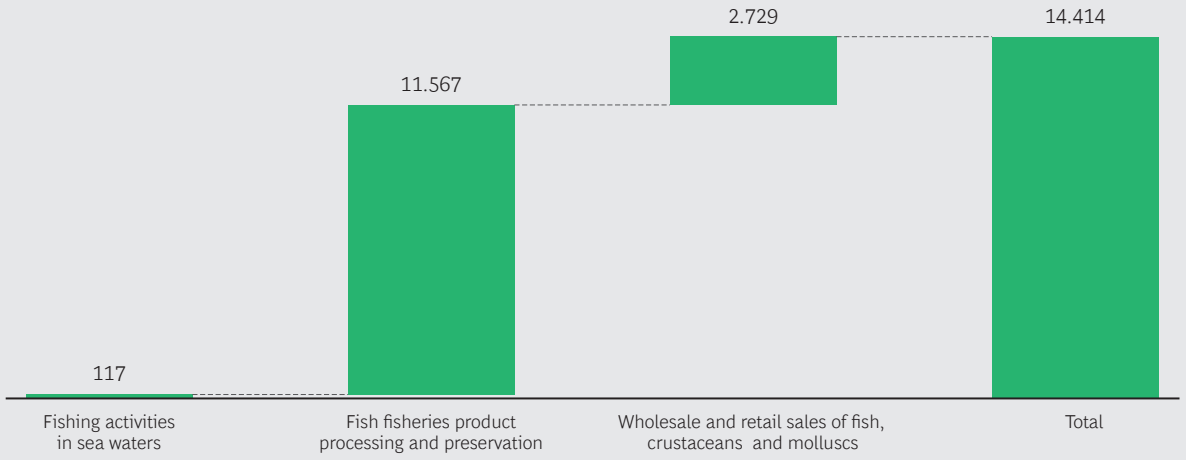
Fisheries: slow death or sustainable development

Marine fisheries in Poland consist of three main areas: fishing activity, processing, and the wholesale and retail sale of fish and seafood. In 2016, the total value of the entire industry was estimated at almost PLN 14.5 billion[167].

167 **As cited in:** Maritime Economy in Poland in 2016, Polish Central Statistical Office, https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/transport/gospodarka-morska-w-polsce-w-2016-roku,7,14.html, download date 1 June 2018.

THE FISHERIES SECTOR IN POLAND COMPRISES 3 MAJOR ACTIVITY AREAS

FIG. 56: FISHERIES REVENUES IN 2016 [PLN M]



Source: BCG analysis; CSO

The stability of the sector depends to a large extent on the condition of marine ecosystems and the condition of fish stocks. The fishing activity alone generates only a small part of its revenues. A significant part of the value of this market is generated by processing companies and the sale of fish products. The raw material they use comes not only from the catches of the Polish fishing fleet in the Baltic Sea, but is also imported from various parts of the world. That is why it is crucial to end the overfishing, and a transformation is needed towards sustainable fisheries throughout the European Union and at the global level. Lack of fish would mean stagnation not only for native fishermen. It would limit access to an important semi-product for other companies reliant on the industry.

Poland 2050, Base scenario

The Base scenario for development of the fisheries sector assumes that inefficient fisheries management – setting fishing limits too high and ignoring scientific advice – will lead to its degeneration. As a result of overfishing there will be a decrease of fish stock biomass, which will reduce drastically the economic efficiency of the Baltic Sea.

As shown in the analyses presented below, the decline in fish stocks in the Baltic Sea will affect employment in fisheries. The rate of creation of new jobs will slow to an average of 0.4%[168] annually, generating revenue of PLN 17 billion. The number of people working in fisheries will shrink by 22% in 2030, and then by another 40% in 2050, stopping at 14,000 jobs.

It is estimated that the annual losses arising from lost fishing nets (ghost nets) fluctuate around PLN 2 million[169]. By 2050, the aggregated cost of these nets will reach PLN 71 million. The fishing nets lost by fishing vessels float in the water column and are a threat to fish and other marine animals. By 2050, by-catch from such ghost nets may exceed 400,000 tons, which is three times the value of the annual catch

168 Oxford Economics data.
169 BCG analysis based on surveys among fishermen and fishing net producers.

of the Polish fleet in 2016[170].

As a result of the increasing concentration of plastic microparticles, the number of synthetic organic compounds in the meat of fish caught in the Baltic Sea will increase. Eating this meat can lead to an increased incidence of cancer or hormonal disorders.

Poland 2050, For Generations scenario

We assume that fishing limits will be set in accordance with the scientific advice of ICES and STECF, and the problem of illegal fishing will disappear due to effective monitoring. For other Baltic States, Poland will become an example of compliance with the law and efforts to establish catch limits in line with scientists' recommendations.

Fish populations will increase to a level where the spawning biomass of the stock will allow the assumed sustainable level of catch to be obtained. In particular, the population of cod and herring from the Western Baltic will increase (by 5–10% by 2050).

Thanks to the use of electronic labelling of fishing equipment and the introduction of appropriate collection processes for the utilization of used fishing nets, the number of ghost nets in the Baltic Sea will drop. If the number of these nets in the sea is halved, fishermen will save about PLN 35 million, and the by-catch will fall to 200,000 tons[171].

Thanks to the increased availability of fish, the pace of fisheries development will be slightly higher than in the case of the Base scenario, and will reach 0.7% per year, generating revenue estimated at slightly over PLN 18.5 billion[172]. Recovery of fish stocks will also improve employment, and its downward trend will be somewhat milder, resulting in a difference of 4,000 jobs between the two scenarios[173].

This scenario will generate not only economic benefits. Owing to an increase in the population of stocks, the entire ecosystem of the Baltic Sea is achieving a balance. Stable populations of fish stocks contribute to the proper functioning of the food chain of the marine ecosystem, starting from the large predators, and ending with phytoplankton. A Baltic Sea full of fish will also contribute to Poland's food security, making Poland less dependent on fish imports.

170 BCG analysis based on Statistical Yearbook of Maritime Economy 2017, table 8.6, lines 51-52, as part of the project of Marelitt Baltic and Tschernij V., Larsson P.-O. 2003: Ghost fishing by lost cod gill nets in the Baltic Sea. Fisheries Research, 64(2–3), 151–162.
171 BCG analysis based on Statistical Yearbook of Maritime Economy 2017, table 8.6, lines 51-52, as part of the project of Marelitt Baltic and Tschernij V., Larsson P.-O. 2003: Ghost fishing by lost cod gill nets in the Baltic Sea. Fisheries Research, 64(2–3): 151–162.
172 BCG analysis based on Statistical Yearbook of Maritime Economy 2017, table 8.6, lines 51-52, as part of the project of Marelitt Baltic and Tschernij V., Larsson P.-O. 2003: Ghost fishing by lost cod gill nets in the Baltic Sea. Fisheries Research, 64(2–3): 151–162.
173 Scientific, Technical and Economic Committee for Fisheries (STECF), Multispecies management plans for the Baltic (STECF-12-06), April 2012.

UNDER THE FOR GENERATIONS SCENARIO THERE WILL BE 4,000 MORE JOBS BY 2050

FIG. 57: EMPLOYMENT IN FISHERIES, BASE SCENARIO [THOUS. JOBS]

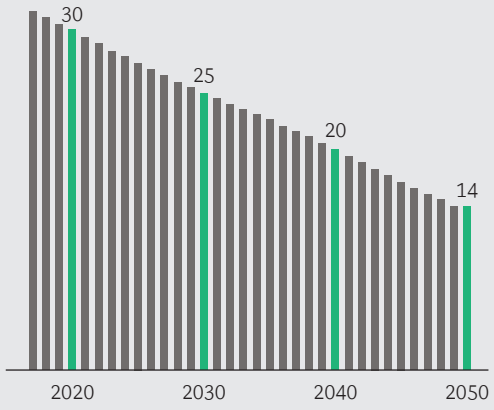
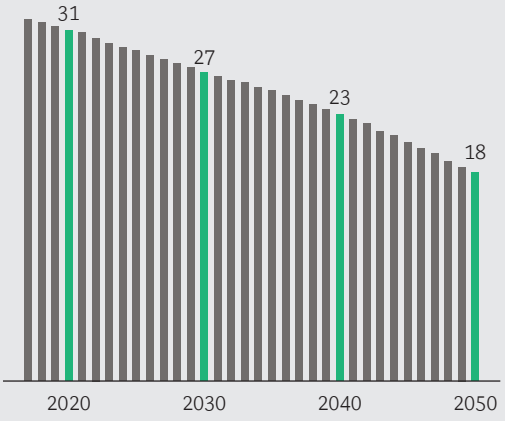


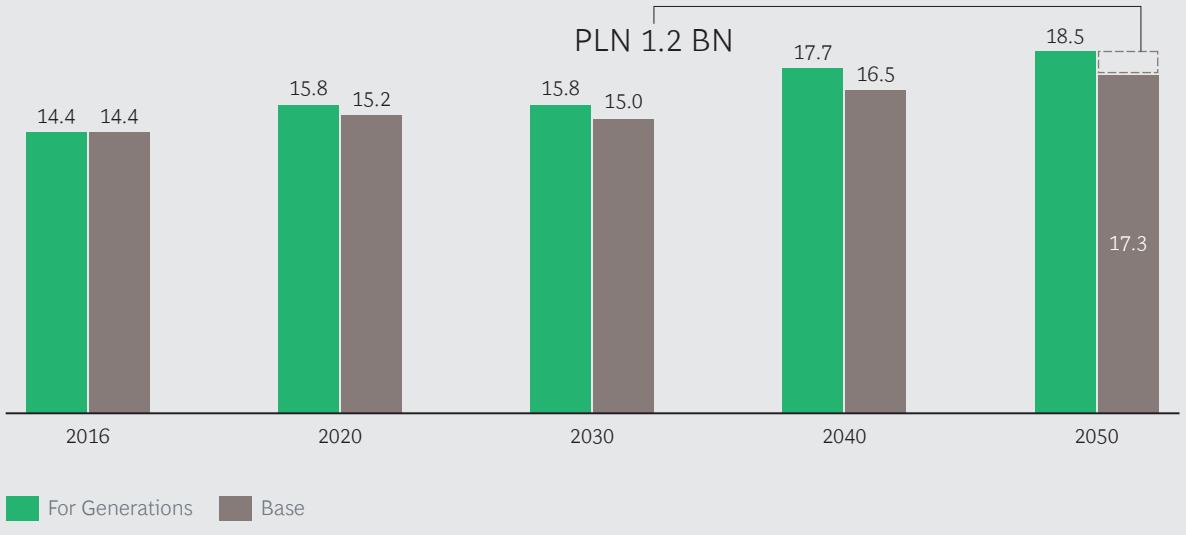
FIG. 58: EMPLOYMENT IN FISHERIES, FOR GENERATIONS SCENARIO [THOUS. JOBS]



Source: BCG analysis; Oxford E.xonomics; CSO; WTTC; The value is estimated at 2010 prices from 2010; Added value calculated as the sum of indirect and direct economic branches

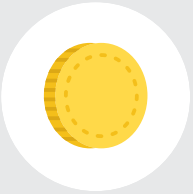
IMPLEMENTATION OF THE FOR GENERATIONS SCENARIO COULD GENERATE ADDITIONAL REVENUES OF PLN 1.2 BN IN 2050

FIG. 59. FISHERIES REVENUES IN THE PERIOD UP UNTIL 2050 [PLN BN]



Source: BCG analysis; Oxford Economics; CSO; WTTC; Value estimated using 2010 prices

THE BENEFITS UNDER THE FOR GENERATIONS SCENARIO



WELL-BEING

- Over PLN 3.8 billion[1] more revenues from tourism and fisheries
- Over 15,000 more jobs[1] under the For Generations scenario

HEALTH

- Less risk of contact with cyanobacterial toxins
- Reduction and elimination of plastic microparticles harmful to human life

FREEDOM

- Sustainable fishing will lead to the preservation of all major fish stocks and allow the development of amateur and commercial fisheries
- Fish stocks recovery will help to ensure food safety
- Increased availability of bathing areas for users of beaches

[1] Total added value being the difference between the For Generation and Base scenarios for tourism and fisheries

RECOMMENDATIONS

Appropriate changes are needed in the approach to management of agriculture, fisheries, waste, and environmental protection in Poland in order to avoid the situation described under the Base scenario. Recommendations should include investments in innovative technologies, ensuring proper education and a training system, and creating a system of incentives conducive to the implementation of environmentally friendly solutions. The key issue is also the introduction of appropriate legislation.

The Polish legal system regulating the activities of entities that may influence the quality of waters includes provisions implementing EU law and international conventions to which Poland is party. The most important document concerning the measures necessary to keep the marine environment in good condition or to bring this about, including environmental objectives, is the National Marine Waters Protection Programme (NMWPP)[174]. This document lists a number of measures currently being taken, and new measures as well, which will help to improve the condition of the marine environment. Below we describe how selected issues will evolve, and suggest new measures to support sustainable fishing,

174 Regulation of the Council of Ministers of December 11, 2017 concerning the adoption of the National Program for the Protection of Sea Waters (Journal of Laws of 29 December 2017, item 2469).

to reduce nutrient discharges into the Baltic Sea from Poland, and to reduce the generation of marine waste.

Improving the current laws, support systems and technology development, which comprises the following activities:

- With regard to reduction of eutrophication:
  - achieving and maintaining reduction targets set by HELCOM in the Baltic Sea Action Plan, and subsequently updated during the HELCOM ministerial meeting in 2013,
  - ensuring that the State Environmental Protection Inspectorate has adequate resources to monitor compliance with the implemented Nitrates Directive[175],
  - giving bodies that inspect and monitor agricultural activities and areas where it is conducted additional tools to facilitate more efficient, faster and more precise fact finding (e.g. access to and processing of satellite data), and providing appropriate training for bodies responsible for monitoring (Voivodeship Environmental Protection Inspectorates and the Agency for Restructuring and Modernization of Agriculture) and implementing the Nitrate Action Program[176],
  - making the so-called Nitrate Action Program more specific and amending the Program where it conflicts with the requirements of certain national laws,
  - drafting recommendations for best agricultural practice referred to in Art. 103 of the Water Law of 20 July 2017[177],
  - introducing legislation regulating the limits of phosphorus application in agriculture, which will recognize the need to limit environmental discharge,
  - enhancing phosphorus removal requirements in wastewater discharged from municipal wastewater treatment plants,
  - limiting the proportion of phosphoric acid and its derivatives in detergents and gradually switching to another types of detergent,
  - running comprehensive awareness and training activities for farmers responsible for the implementation of the Nitrates Action Program, as well as for the advisory and local government bodies directly cooperating with them, and ensuring financing of these activities,
  - providing subsidies for farmers to adapt to the requirements of the so-called Nitrate Action Program, e.g. precision fertilization, ensuring appropriate storage of natural fertilizers, etc. (for example. under the Rural Development Program (RDP)[178]),
  - running on a broader scale training for farmers on agricultural practices friendly to the marine environment, ensuring financing of these activities, and providing subsidies for farmers who decide to apply appropriate practices, for example soil liming (for example under RDP),

175 Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC).
176 Regulation of the Council of Ministers of 5 June 2018 on the adoption of a Program of measures to reduce the pollution of waters with nitrates from agricultural sources and prevention of further pollution (Journal of Laws of 2018 item 1339).
177 Act of 18 July 2001 called Water Law (Journal of Laws of 2017, item 1121).
178 Rural Development Program (RDP).

- co-financing so-called small retention, including revitalization and maintenance of peat bogs, acting as a natural filter for water,
- providing subsidies for investments in household wastewater treatment installations in areas of dispersed infrastructure,
- co-financing waste water treatment plants for infrastructural projects concerning storage and disposal of sewage sludge.

- With regard to marine waste control:
  - introduction of a register of fishing nets enabling the number of nets held to be monitored and records to be kept of nets that are lost,
  - introduction of regulations enabling the number of fishing nets in use on fishing vessels to be monitored,
  - effective enforcement of the "polluter pays" principle which means charging fees for the cost of cleaning up the Baltic Sea proportional to the scale of pollution,
  - co-financing prototypes of electronically marked fishing nets,
  - co-financing the utilization of spent fishing nets,
  - installing containers for the free depositing of spent fishing nets in ports,
  - implementation of an electronic fishing net marking system to identify the owner,
  - developing recycling technologies for old fishing nets.
- With regards to overfishing and the need for a transformation towards sustainable fisheries:
  - Poland taking the lead on demanding annual fishing limits for fish stocks in the Baltic Sea to be set by European Union Fisheries Ministers, in accordance with the scientific recommendations of the International Council for the Exploration of the Sea (ICES),
  - setting fishing limits for the Baltic Sea fish stocks in accordance with the objectives and requirements of the current Common Fisheries Policy (CFP), including ending overfishing by 2020 at the latest for all fish stocks in accordance with Article 2.2 of the basic regulation and in line with UN Sustainable Development Goal 14[179],
  - implementing ecosystem-based fisheries management to minimize the harmful impacts of fishing activities on the marine ecosystem in accordance with Article 2.3 of the CFP,
  - ensuring full implementation of the obligation on the Baltic Sea to land all fish subject to fishing limits (the so-called "discard ban"), based on effective monitoring, inspection of fishing vessels and enforcement, as well as full documentation of catches,
  - ensuring effective compliance monitoring, for instance in order to combat illegal fishing and

179 As cited in: UN Resolution adopted by the General Assembly on 25 September 2015. 70/1. We are transforming our world: Agenda for Sustainable Development 2030 http://www.unic.un.org.pl/files/164/Agenda%202030_pl_2016_ostateczna.pdf, download date 10 July 2018.

effectively implement the landing obligation, by requiring fishing vessels to have video surveillance (CCTV) on board. This video surveillance obligation should be applied first and foremost to those with high risk of breaching the law or of having an adverse impact on the natural environment,

- introduction of transparent criteria for the allocation of fishing rights, including in particular environmental, social and economic criteria pursuant to Article 17 of the CFP. In the first place, access to fish stocks should be granted to fishermen that have a less harmful impact on the environment and able to show a long track record of legal compliance,

- collection of catch data, including the obligation to report species of fish, seabirds, marine mammals and other marine animals that have been by-caught

- providing incentives in the form of preferential access to fishing rights for owners of fishing vessels equipped with selective fishing gear or using fishing techniques with a limited environmental impact, in accordance with Article 17 of the CFP,

- raising awareness and providing information for fishermen on the long-term benefits of sustainable fish exploitation, including economic, social and environmental benefits,

- organising trainings on how funds can be obtained for introducing fishing methods that are less destructive to the environment, including those that reduce by-catch,

- investing in the development of more selective fishing gear that is friendlier to the marine environment, including equipment that minimizes by-catch of marine organisms that are not the target of fishing (e.g. marine mammals). Support for pilot projects.

TIMELINE: THE BALTIC SEA

97% of the Baltic Sea is affected by eutrophication, intensive cyanobacterial blooms, closed bathing areas, decreasing fish stocks and marine waste as the biggest threats to the Baltic Sea

For Generations 2050

2020

Poland is strengthening efforts to limit the flow of nutrients from agriculture and sewage, and is introducing sustainable fisheries methods respecting scientifically recommended catch limits

2040

Revenues from coastal tourism reach PLN 13.2 billion. Employment in coastal tourism increases by approximately than 50% compared to 2017

2050

The population of the most important commercial fish is preserved. Fishery revenues reach PLN 4.2 billion and employment goes up by 18%.
The reduced volume of nutrients flowing from Poland translates into the reduction of eutrophication of the Baltic Sea and the occurrence of cyanobacterial blooms, and increases revenue in coastal tourism

Base 2050

2020

Irrational fertilizer management contributes to increased eutrophication and closing of bathing areas in the Baltic Sea. Traffic on the Baltic Sea grows

2040

The amount of pollution released grows. Over a period of 20 years, the cost of lost fishing nets reaches PLN 50 million. Revenues from coastal tourism are lower by PLN 2.3 billion compared to the For Generations scenario

2050

The Western Baltic cod and herring stocks disappear. Fishing vessels must travel far greater distances in search of fisheries. The volume of by-catches from ghost fishing nets is three times higher than in 2016. The high level of eutrophication and cyanobacterial blooms continues, and the revenues from coastal tourism decrease

BIODIVERSITY

BIODIVERSITY DESCRIBES THE NATURAL richness of nature around us. It can be defined at many levels, from genetic diversity, through species diversity, to complex natural systems such as entire ecosystems.

Man-made changes and transformations in nature have led in many places on Earth to considerable simplification and degeneration of natural systems, whereas a good state of biodiversity is key to proper functioning of our planet. Life on Earth depends on ecosystem services provided by natural systems. Ecosystem services can be interpreted as benefits gained from the work of natural capital. Thanks to this work, such as the production of oxygen and air purification (the proverbial green lungs of the Earth), water filtration or soil fertilization, nature, in a sense, provides services. One example is food production, which largely depends on ecosystem services provided by pollinators. More than 75% of the leading crops on Earth make use of pollination[180]. From an economic point of view, pollination increases the global value of crop production by USD 235-577 bn per year, thereby keeping food prices down, which is hugely important for us as consumers.

For generation of these services, in the event of abnormal functioning of nature, we would have to pay as a society. If natural processes are disrupted, and these services are not carried out, the real costs of maintaining the desired condition will have to be borne, for example by building water treatment stations or air purifiers, or using additional agrotechnical measures. In addition, losses related to the occurrence of extreme weather anomalies such as droughts, floods and losses in agriculture will have to be covered. The introduction of the concept of ecosystem services is aimed at presenting the values that nature provides in economic terms, to show the importance of the ecological system.

Ecological economics is a branch of science that deals with the development of models that allow the valuation of services provided by nature. In 1997, a group of economists headed by a Professor at the University of Maryland, Robert Costanza, estimated the global value of ecosystem services[181] to be USD 33 trillion per year (in 1994), which is more than the global Gross National Product. The publication first appeared in Nature magazine and was later reprinted by the journal Ecological Economics. This estimate was later revised in 2014, and based on the updated data the global value of ecosystem services was estimated to be in the range of USD 125 trillion per year (in 2007 prices)[182]. It was limited to calculating values only for those selected services for which data sources can be considered reliable. The results given by the Constanza team show the minimum value of ecosystem services, which in reality might be significantly higher.

180 Klein, A.-M. et al. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society Biological Sciences 274: 303-313 (2007).
181 R. Costanza, R. d'Arge, R. Groot, S. Farberk, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Suttonkk, M. Belt, The value of the world's ecosystem services and natural capital, "Nature" 1997, No. 387, pp. 253–260.
182 Costanza, R. et al. Changes in the global value of ecosystem services. Global Environmental Change 26: 152-158 (2014).

ECOSYSTEM SERVICES PLAY A KEY ROLE IN THE CORRECT FUNCTIONING OF THE EARTH

Regulation of climatic processes	Ensuring the regulation of temperature, humidity and other biologically conditioned climatic processes
Regulation of atmospheric gases	Ensuring the right balance of the chemical composition of the atmosphere (e.g. ensuring the appropriate CO_2 / O_2 ratio)
Regulation of extreme weather events	Reduction of the impact of extreme weather events, such as storms or floods (e.g. due to adequate floodplain absorption ability)
Water regulation	Providing suitable water systems for irrigation or as a method of transport
Water supply	Retention and storage of water in aquifers
Regulation of erosion processes	Prevention of soil blowing away due to appropriate richness of plant life
Soil formation processes	Decomposition and accumulation of biological material fertilizing the soil
Nutrient circulation regulation	Fixation of nitrogen and phosphorus compounds and purification of water
Waste water treatment	Purification of water thanks to filtration by soil
Plant pollination process	Transfer of pollen to allow plant to grow
Regulation of biological balance	Ensuring in the food chain (e.g. through the adequate supply of predators)
Providing shelter (habitat) for flora and fauna	Providing protection and enabling all organisms on the Earth to grow
Food provision	Providing nutrients for both animals and humans
Provision of raw materials	Provisioning intermediate products (for example wood, fossil fuels, valuable ores) supporting human economic activity
Ensuring the diversity of the gene pool	Providing biological materials supporting processes of evolution, production of medicines, research,etc.
Provision of recreational value	Laying down foundations for eco-tourism, sports and other recreational activities
Provision of cultural value	Provision of aesthetic, educational and spiritual values,etc.

Source: Costanza R., d'Arge R., Groot R., Farberk S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R. V., Paruelo J., Raskin R. G., Suttonkk P., Belt M. 1997. The value of the world's ecosystem services and natural capital. Nature, 387, p. 253–260

For the purposes of this report, the values calculated by the Constanza team were used, which in turn were converted per hectare of biomes occurring in Poland[183]: sea and coastal areas, temperate forests, meadows and pastures, wetlands and floodplains, lakes and rivers, and arable land. On this basis, it was estimated that the value of ecosystem services for the whole of Poland was about PLN 120 billion per year (in 2018 prices)[184].

Threats and their root causes

Inefficient protection of biodiversity and related natural habitats and provided ecosystem services

A habitat is a set of climatic and soil factors that enable the development of plant communities and associated animal groupings. Natural habitats are land or water areas identified as being separate on the basis of geographical, abiotic and biotic features[185], both fully natural and semi-natural[186]. They are therefore systems of groups of organisms that are unique and represent a certain biological diversity.

Proper protection of natural habitats enables the natural features of areas most important for the natural heritage of Poland to be preserved. In order to ensure that protected natural habitats and species are kept in proper condition, national forms of nature protection (national parks, nature reserves, landscape parks) have been created, as well as the network of Natura 2000 sites. The question of the types of habitats and species protected in the European Union is regulated by the Habitats Directive and Birds Directive. There are 80 habitat types in Poland which are protected under the Habitats Directive, together with 92 species of plants and 143 species of animals, excluding birds (protected under the Birds Directive[187]). In order to maintain the proper condition, natural range, or to restore habitats and species, almost 20% of the land area of Poland, protecting 849 habitat sites and 145 bird sites, are protected within the Natura 2000 network[188].

Under Polish law, protected habitats and species located in Poland are monitored. This monitoring determines not only the state of the most valuable natural sites, but also the prospects for their protection. The condition of habitats and species is assessed on a three-point scale: favourable, unfavourable, bad.

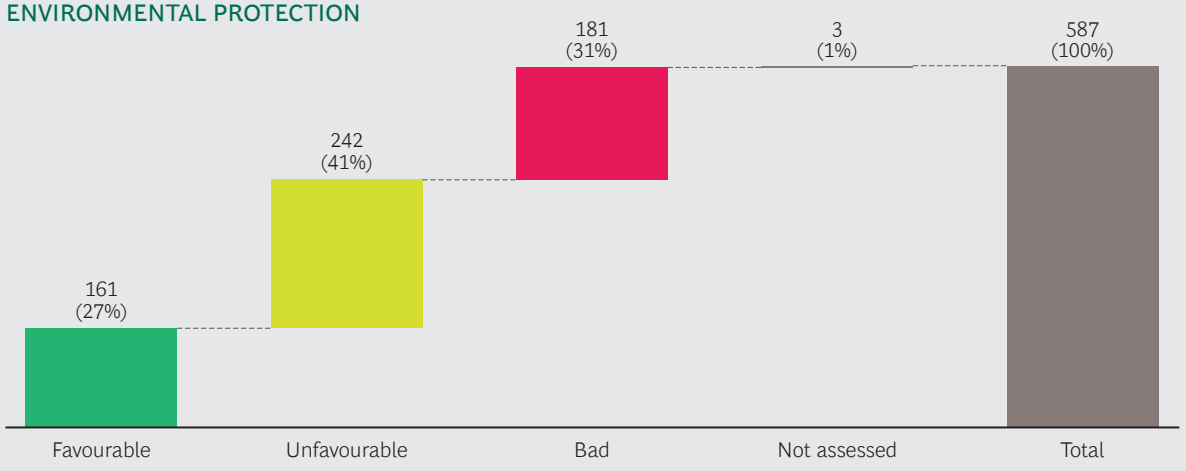
Inadequate condition of protected habitats in Poland

Despite the fact that such a large part of the area of Poland is covered by the network of Natura 2000 sites, the condition of habitats and species covered by this program is unfavourable. The 2016 Report on the condition of species and natural habitats prepared on the basis of monitoring data shows that in the continental region (around 96% of Poland) most habitats and species are in unfavourable condition. Only 27% of habitats were in the favourable condition and over 70% were in inadequate or bad condition. Species and habitats in the Alpine region (Carpathians) were found to be in better condition, while this is approximately 4% of the area of Poland. In both regions, the condition of species was graded higher than the condition of natural habitats.

183 Biom is an area with a specific climate, a characteristic vegetation and a group of animals, separated for comparison sake.
184 Prepared by: Zbigniew Szkop and Sviataslau Valasiuk.
185 Biotic - related to living organisms of a given environment, Abiotic - associated with inanimate components of the environment (As cited in: Dictionary of the Polish language https://sjp.pl).
186 As cited in the Habitats Directive.
187 **As cited in:** Chief Inspectorate for Environmental Protection http://www.gios.gov.pl/stansrodowiska/gios/pokaz_artykul/pl/front/stanwpolsce/ochrona_dziedzictwa_przyrodniczego/roznorodnosc_biologiczna_ochrona_gatunkowa_i_obszarowa, download date 25 April 2018.
188 **As cited in:** Chief Inspectorate for Environmental Protection, http://natura2000.gdos.gov.pl/natura-2000-w-polsce, download date 28 April 2018.

ONLY 27% OF HABITATS IN POLAND ARE IN THE PROPER CONDITION

FIG. 60: ASSESSMENT OF THE CONDITION OF THE NATURAL HABITAT BY THE CHIEF INSPECTORATE FOR ENVIRONMENTAL PROTECTION



Source: http://siedliska.gios.gov.pl/images/pliki_pdf/wyniki/2015-2018/podsumowanie2016/Zestawienie-ocen-na-stanowiskach-siedlisk-przyrodniczych-monitorowanych-w-2016-roku-PDF-382-KB.pdf

Condition of protected habitats in the national parks

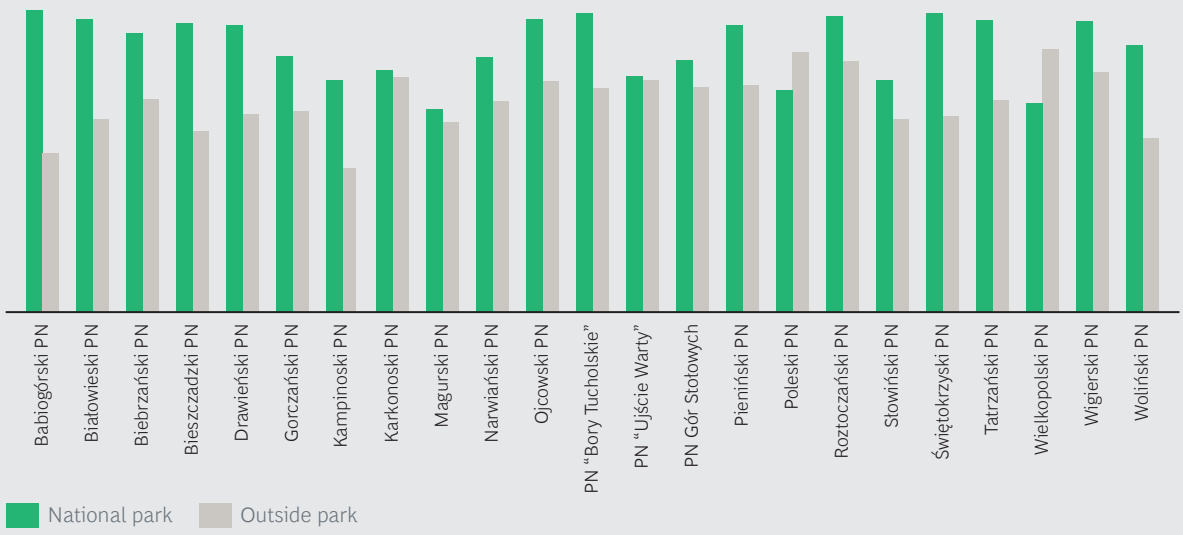
Although the unfavourable condition of natural habitats is worrying, there are areas where their condition is better than the national average.

In Poland, nature is afforded the most protection in national parks. Therefore, the natural environment should presumably be better preserved in the areas in which exceptional natural values are protected. Based on the data of the Chief Inspectorate of Environmental Protection, a comparative assessment of the condition of Natura 2000 sites in national parks and "natural areas" near parks was carried out.

The analysis showed that in almost all cases, the condition of natural habitats in national parks (both forest and non-forest) was better than the neighbouring Natura 2000 areas. This applied to 21 out of the 23 national parks. Only two national parks (Wielkopolski and Poleski) are adjacent to Natura 2000 sites with natural habitats in a similar or better condition.

THE CONDITION OF NATURAL HABITATS IN NATIONAL PARKS IS BETTER THAN IN AREAS SUBJECT TO LESS STRICT PROTECTION

FIG. 61: COMPARISON OF HABITAT CONDITION IN NATIONAL PARKS



Source: Prepared by Wojciech Mróz based on data published on the website at crfop.gdos.gov.pl

Not all human activity in natural habitats is undesirable. In the case of some non-forest habitats, especially meadows, active measures are required to prevent bush encroachment. Conservation measures are successfully carried out in many national parks. At the same time, monitoring studies show that forest natural habitats in national parks are in much better condition than those outside national parks.

When reviewing specific examples of habitats that are in better condition, it is worth looking at forest habitats in the Białowieża Forest. A study was conducted there[189], including the Białowieski National Park (about 17% of the entire forest), reserves (about 18% of the area) and three forest districts (about 65% of the area, including the so-called reference zone excluded from forest management in 2016).

Summarising the assessment of all types of forest habitats[190], the ones in favourable condition were mostly found in the national park, in the Orłówka area (80%) and Hwoźna area (40%), and in reserves (almost 40%). The smallest number of habitats in favourable condition was recorded in managed forests (forest districts) – around 15%. The highest number of bad scores was reported in forest districts, in the reference part (about 50%) and in managed forests (almost 40%), and much less in the national park, in the Hwoźna area (under 20%) and reserves. The lowest number was in the national park in the Orłówka area (about 2%).

These results clearly show that in order to preserve the most valuable natural areas, they need to be made national parks or, in the case of smaller areas, nature reserves.

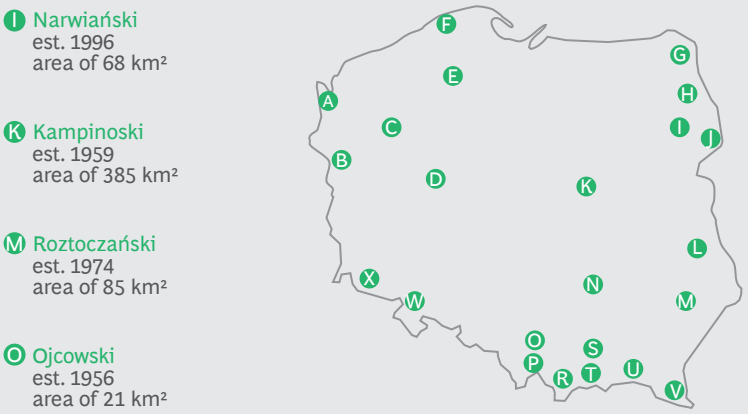
189 J. Tabor, *Condition of Forest Natural habitats in the Bialowieza Forest, presentation from the conference Presentation of the results of natural and cultural inventory of the Białowieża Forest*, Sękocin Stary 22 November 2017 https://www.lasy.gov.pl/pl/wideo/telewizja-lasow-panstwowych/wideo/prezentacja-wynikow-inwentaryzacji-puszczy-bialowieskiej-w-latach-2016-2017, download date 20 June 2018.
190 **As cited in:** https://naukadlaprzyrody.pl/2017/12/11/co-wynika-z-inwentaryzacji-w-puszczy-bialowieskiej/, download date 20 June 2018.

There are too few National Parks in Poland to ensure effective protection of the most valuable natural areas

The most effective form of protection of the most valuable natural areas is National Parks and, for smaller areas, reserves.

The most recent national park, "Ujście Warty" (Mouth of the Warta River), was established in 2001. National parks, of which there are 23 in Poland, only cover 3% of the area of all protected areas in Poland.

FIG. 62: IN POLAND THERE ARE 23 NATIONAL PARKS



A Woliński
est. 1960
area of 109 km²

B Ujście Warty
est. 2001
area of 81 km²

C Drawieński
est. 1990
area of 115 km²

D Wielkopolski
est. 1957
area of 76 km²

E Bory Tucholskie
est. 1996
area of 46 km²

F Słowiński
est. 1967
area of 327 km²

G Wigierski
est. 1989
area of 151 km²

H Biebrzański
est. 1993
area of 592 km²

I Narwiański
est. 1996
area of 68 km²

J Białowieski
est. 1947
area of 105 km²

K Kampinoski
est. 1959
area of 385 km²

L Poleski
est. 1990
area of 98 km²

M Roztoczański
est. 1974
area of 85 km²

N Świętokrzyski
est. 1950
area of 76 km²

O Ojcowski
est. 1956
area of 21 km²

P Babiogórski
est. 1954
area of 34 km²

R Tatrzański
est. 1954
area of 212 km²

S Gorczański
est. 1981
area of 70 km²

T Pieniński
est. 1954
area of 23 km²

U Magurski
est. 1995
area of 194 km²

V Bieszczadzki
est. 1973
area of 292 km²

W Gór Stołowych
est. 1993
area of 63 km²

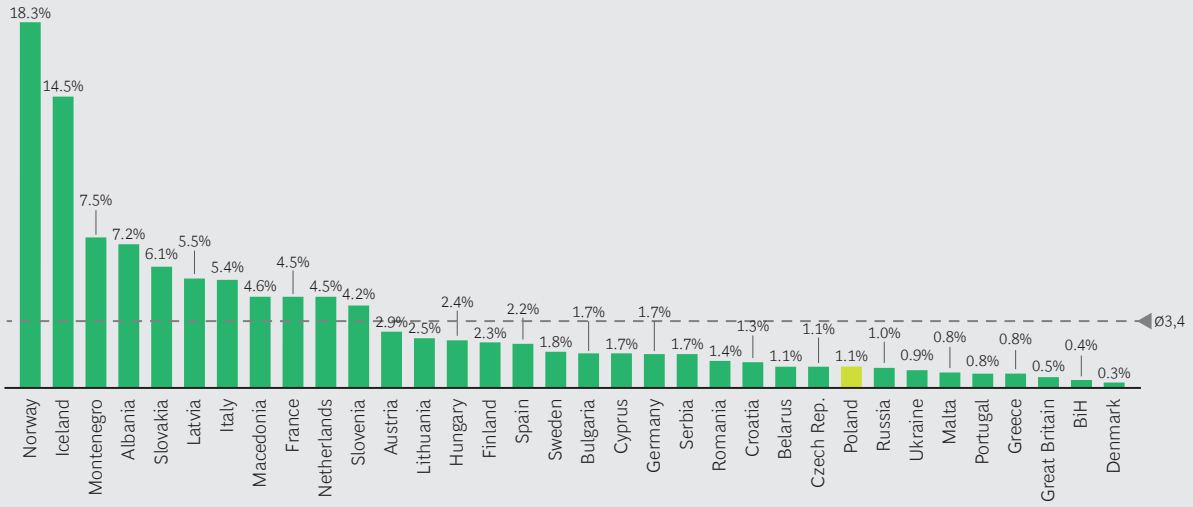
X Karkonoski
est. 1959
area of 56 km²

National parks cover a total area of 315,000 ha, which only accounts for 1.1% of the area of Poland. For comparison, the average for Europe is 3.4%, and Poland is ranked 26th in this regard[191].

191 National Parks defined according to the standards of the International Union for Conservation of Nature (IUCN) as a category II of protected areas https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-ii-national-park, download date 21 June 2018.

THE AREA OF NATIONAL PARKS IN POLAND IS SMALLER THAN IN OTHER EUROPEAN COUNTRIES

FIG. 63: THE AREA OF NATIONAL PARKS COMPARED TO THE TOTAL AREAS OF COUNTRIES IN EUROPE



Source: Own analysis based on data extracted from The World Database on Protected Areas http://wcmc.io/wdpa_current_release

Among the countries neighbouring Poland, only Russia and Ukraine have a lower ratio of the area of national parks to the area of the country. In light of the results mentioned above, of monitoring of habitat condition (in the continental region more than 70% of habitats are in poor or unsatisfactory condition), we may be concerned about preservation of the most valuable natural areas for future generations. This state of affairs is very worrying, and hence the establishing of national parks in the near future is a challenge that is not only important, but also urgent.

However, in order to make a reasonable decision about changing the land use status of a given area and the establishment of a national park, an appropriate cost-benefit analysis should be performed, showing whether this solution is optimal from natural and social perspectives. If the total benefits of expanding a national park exceed the costs, and this is confirmed by research[192], such a project is economically viable and should be carried out.

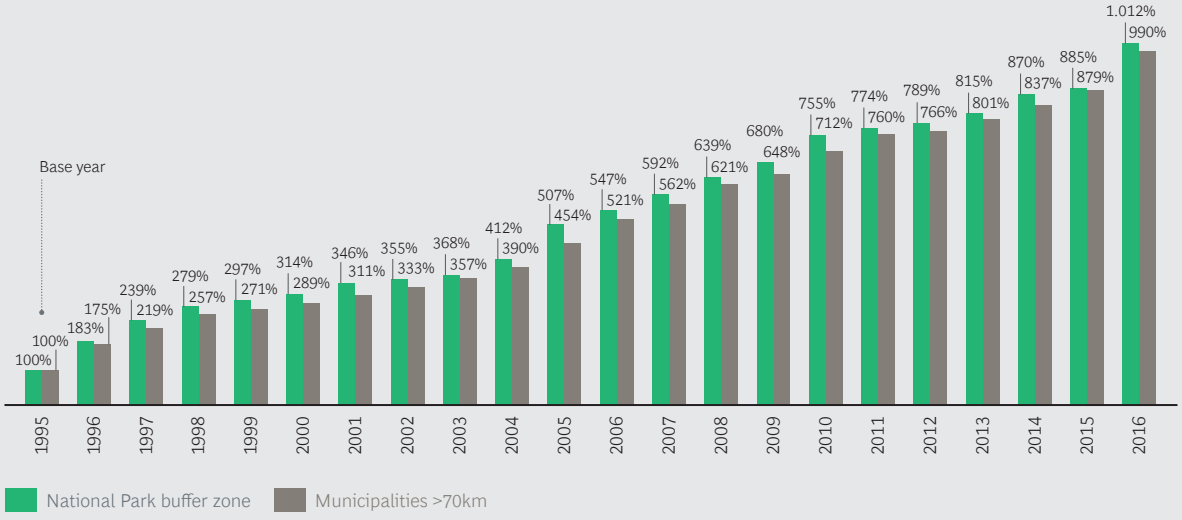
Protected areas generate a greater stream of ecosystem services value than areas that are not protected. On the basis of the value of recreational benefits provided to the public by the Białowieski National Park, calculated on the basis of the frequency of visits and expenses related to travel costs, the Białowieża Forest generates a net benefit each year of PLN 11.5 million (2002)[193].

In addition, it is worth looking at the impact that national parks have on local government budgets. An analysis of budget revenues of 60 municipalities located within (and in buffer zones) of national parks established in 1990–2001 clearly shows that their financial standing is at least the same or better compared to municipalities of a similar amount of forest area and population in the same voivodeship, but located at a distance of more than 70 km from a given national park.

192 S. Valasiuk, M. Czajkowski, M. Giergiczny, T. Zylicz, K. Veisten, M. Elbakidze, P. Angelstam, *Are bilateral conservation policies for the Białowieza Forest unattainable? Analysis of stated preferences of Polish and Belarusian public*, "Journal of Forest Economics" 2017, No. 27, pp. 70–79.
193 M. Giergiczny, Recreational Value of the Białowieża National Park, "Economy and Environment" 2009, No. 2(36), pp. 116–128.

THE EXISTENCE OF NATIONAL PARKS DOES NOT HAVE AN ADVERSE IMPACT ON MUNICIPALITIES' REVENUES

FIG. 64: GROWTH OF REVENUE OF MUNICIPALITIES LOCATED WITHIN NATIONAL PARKS AND OUTSIDE NATIONAL PARKS IN AREAS OF SIMILAR FOREST DENSITY (YEAR 1995 = 100%)



Source: Own analysis based on CSO data: Forestry 2017

In areas of high natural value, forest management is often not economically justified, as exemplified by the need to co-finance three forest districts of the Białowieża Forest. In the 2007–2016 period, the losses of these forest districts totalled PLN 126.2 million[194], and in 2016 alone, the Forest Districts of the Białowieża Forest received PLN 22.9 million in subsidies. The situation of the Eastern Carpathians mountain range, where there are plans to create the Turnicki National Park, is similar. The subsidies made to the Regional State Forest Management Authority in Krosno in 2010–2017 reached almost PLN 600 million[195]. Low profitability of forest management in high nature value areas may be another motivating factor for the establishment of national parks.

Future of biodiversity in Poland

In view of the unquestionably better condition of natural habitats and the lack of economic grounds for not creating national parks, it is worth considering the future state of biodiversity in Poland as well as that of communities in and around the national parks.

Poland 2050, Base scenario

Under this scenario, in the next 30 years no national park will be established or expanded, and no new reserves will be created. The idea of expanding the Białowieski and Bieszczadzki national parks will be abandoned. The Turnicki National Park will not be created either. In the Białowieża Forest and the areas of great natural value in the Carpathian Forest, forest management will continue, including logging and artificial planting. The forested areas of greatest natural value in Poland will be transformed into an ordinary commercially managed forest.

Natural habitats will not be adequately protected, and their condition will deteriorate. Poland will be

194 **As cited in:** A reply to the MP question No. 12917 http://orka2.sejm.gov.pl/INT8.nsf/klucz/658C47EF/%24FILE/i12917-01.pdf, download date 20 June 2018.
195 https://serwisy.gazetaprawna.pl/ekologia/artykuly/1325521,zwiekszona-wycinka-drzew-w-bieszczadach-czy-warto-scicac-drzewa.html, download date 2 July 2018.

lagging behind the European Union countries in terms of the surface area of national parks. Under such circumstances the tourism sector will suffer, and some ecosystem services will not be provided. The potential of national parks to drive socio-economic growth in rural areas will not be fully realised.

Poland 2050, For Generations scenario

The area of national parks in Poland will grow among other things due to implementation of the general outline for the National Spatial Development Concept 2030[196] and the Program for the Protection and Sustainable Utilisation of Biodiversity, and the 2015–2020 Action Plan[197].

A program designed to establish new national parks and expand existing ones, enabling the establishment of protected areas also privately or socially, including a system for compensation of lost profits, will be established and consistently implemented. Legal solutions will be created allowing efficient creation of national parks, the national park management system will function effectively, and organizational and financial solutions will be improved. National parks will function in a coherently coordinated fashion, which will allow effective transfer of knowledge and know-how, and communication and awareness-raising with regard to nature conservation. The financing of national parks will mean that qualified personnel can be hired.

The interests of local communities will be secured, among other things, by carrying out social consultations, in which optimal solutions will be developed to maximize the benefits. Mechanisms of social control and solutions enabling effective cooperation with local communities will be implemented. This will make national parks more acceptable to local communities and enable national parks to play the effective role they can and should play in regional socio-economic development.

Local communities will receive expert support and tools to boost the development of municipalities and counties based on natural values and the national park brand. Regions that take care of natural values will be given preferential treatment with regard to grants and subsidies.

By 2020, the Turnicki National Park will be set up, covering the Bircza, Ustrzyki Dolne and Fredropol municipalities. The Bieszczadzki (in the Lutowiska municipality) and the Białowieski National Park will be enlarged. This park will cover the entire Białowieża Forest area (to be enlarged to include the Hajnówka and Dubicze Cerkiewne municipalities and enlargement in the Białowieża and Narewka municipalities). Poles will enjoy the natural values that will be provided by some of the last sections of natural forests in Europe, which survived transformation into forestry, and floristically rich meadows that have not become overgrown with bushes and have not been ploughed.

The new municipalities in the areas covered by the extended / new National Parks: Bircza, Ustrzyki Dolne, Fredropol (in Turnicki National Park) and Hajnówka, Dubicze Cerkiewne (in Białowieski National Park) and Lutowiska (in Bieszczadzki National Park) will report similar or slightly higher inflows to the budget, despite the introduction of stricter nature protection measures in these municipalities. The local community will take advantage of the opportunities created by the above-average natural values and the national park brand.

By 2050, thanks to the establishment of additional national parks (Mazurski, Stobrawski, Jurajski, the Lower Oder National Park and the Central Oder National Park[198]) further areas of great natural value will be protected, and Poland will be closer to the European Union average when it comes to the ratio

196 Resolution of the Council of Ministers No. 239 of 3 December 2011 (Monitor Polski Official Gazette of 2012, item 252).
197 Resolution of the Council of Ministers of 6 November 2015 (Monitor Polski Official Gazette of 2015, item 1207).
198 **As cited in:** 2030 concept of spatial development of the country and the Program for Protection and Sustainable Utilization of Biodiversity along with the 2015-2020 Action Plan.

of the area of national parks to area of the country.

The establishment of new national parks will also bring immeasurable benefits. Thanks to the appropriate preservation of habitats and the expansion of the areas covered by parks, the recreational values offered to Poles will increase.

BENEFITS UNDER THE FOR GENERATIONS SCENARIO

Well-Being

- Maintaining or strengthening the benefits generated by ecosystem services, valued at PLN 120 billion per year in 2018
- Protected areas generate increased stream of ecosystem services with higher economic and social value
- Reduction of losses from unprofitable forest management carried out in natural value areas (in 2017 the Białowieża Forests were subsidized by PLN 22.9 million, and in 2010-2017 about PLN 600 million was paid in subsidies to the Regional Directorate of State Forests in Krosno)
- Increasing the potential of local development by creating national parks

Health

- Taking advantage of the recreational values of the national parks
- Future generations have at their disposal a refuge of peace and tranquility

Freedom

- The most valuable natural habitats and species preserved in adequate condition for future generations
- Possibility of enjoying natural forests and forests slightly modyfied by man
- The Turnicki National Park is the first national park in the area of the Polish foothills

Recommendations

To ensure an adequate level of protection of the most valuable natural areas in Poland, we should fully implement the general principles contained in the National Spatial Development Concept 2030 and the Program for Protection and Sustainable Utilisation of Biodiversity with the Action Plan 2015–2020, and the following should take priority:

- expanding the area covered in Poland by the national parks by 2050, so as to ensure effective protection, especially for areas of special importance for biodiversity and provision of ecosystem services including in particular:
  - expanding by 2020 the Białowieski National Park to cover the entire Białowieża Forest,
  - expanding by 2020 the area of the Bieszczadzki National Park to ensure effective protection of natural processes, biodiversity and ecosystem services provided by the Bieszczady Mountains area,
  - by 2020, to set up the Turnicki National Park in the Przemyskie Foothills, the first national park in Poland in the foothills, in accordance with the current social project,
  - by 2030, assess the degree of representativeness of the network of nature reserves and conduct wildlife inventories indicating a need to establish new nature reserves. New nature reserves are established using available data in highly valuable natural areas, which due to the small area are not suitable for a national park establishment.
- Improving the management of protected areas (including National Parks, nature reserves, Natura 2000 sites) by 2030 to ensure conservation effectiveness, ecological representativeness (mountain, forest, and sea ecosystems as well as river valleys and wetlands) and the functioning of protected areas as a coherent system,
- strengthening the resilience of ecosystems and biodiversity conservation by restoring at least 15% of degraded ecosystems by 2030, thus contributing to the mitigation and adaptation to climate change and minimising extreme weather events (floods, droughts),
- achieving, by 2050 at least the European average in terms of the ratio of the area of national parks to the area of the country, creating, in addition to Turnicki National Park, Jurajski National Park, Mazurski National Park, Stobrawski National Park, Lower Oder Valley National Park and Central Oder National Park,
- developing and implementing a set of best practices and supporting mechanisms that help local communities maximize the benefits of living in the vicinity of national parks,
- Improving the effectiveness of protected area management by improving capacities and working conditions of personnel, including competitive remuneration systems.

TIMELINE: BIODIVERSITY

Only 23 National Parks protect the most valuable areas of biodiversity

For Generations 2050

2020

The Turnicki National Park was established, and the Bieszczadzki National Park and the Białowieski National Park were expanded

2040

Other reserves and national parks are created, for example the Jurajski National Park, the Mazurski National Park and the Oder Valley National Park

2050

The ratio of national park area to the area of Poland is above the European average

Base 2050

2020

No significant activities to expand protected areas, including national parks

2040

The condition of large portion of the habitats is gradually deteriorating due to the lack of extension of protection by national parks and reserves

2050

Poland lags behind Europe in terms of protected areas

Closing remarks

Our analyses have shown that the joint efforts undertaken to reduce CO_2 emissions, and to protect river, land and sea ecosystems, have a real impact not only on nature around us, but above all on our society and economy.

Currently, the most important problem regarding civilization that affects the entire globe is that of climate change driven by greenhouse gas emissions. Poland, together with other countries, must make every effort to slow down and stop the growth of mean global temperatures in the future.

Air and water pollution, and too much human interference with the natural environment, will not cause a catastrophe in Poland in the next 30 years, but may lead to irreversible changes. On the other hand, the Polish economy and society will lose billions of zlotys every year as a result of damages caused by extreme events, incorrect decision-making by public authorities, shaky natural balance, and diseases caused among other things by air pollution.

Climate and air: In the coming decades, mean temperatures in Poland and around the world will continue to rise, causing more and more losses. Due to air pollution, over 40,000 people die prematurely in Poland each year. It is thus very important to quickly and effectively implement appropriate measures that will reduce greenhouse gas emissions and dust. To reduce the scale of these problems, above all novel and bold measures are needed in the fields of power engineering, thermal efficiency improvement, and transport.

Rivers: Excessive regulation of rivers will cause among other things the disappearance of alluvial forests and rare species of animals and plants. Negligence and excessive exploitation of rivers for the sake of transformation of inland waterway transport and flood protection is a threat to inhabitants of riverside areas and nature (habitats and species dependent on water). A separate problem related to rivers is the lack of an effective prevention plan against floods in Poland, which repeatedly bring disastrous consequences to the economy, society and nature.

The solution is to start work on railway development as soon as possible. This has much less impact on the natural environment than inland navigation. A new approach to river and valley management is also needed. Local governments should cease regulation of these areas artificially. They also need to focus more on initiating and using open, social dialogue, leading to the development of a flood prevention program. Another task for local authorities is to bar development in flood risk areas.

The Baltic Sea: In the brackish waters of the Baltic Sea, valuable species of fish may become extinct if too much nitrogen and phosphorus enter the seawater, proper fishing limits are not implemented, ghost fishing nets continue to cause by-catch and other pollutants, including plastic waste are allowed to accumulate. Information from the Chief Inspectorate for Environmental Protection indicates that in all three basins of the Baltic Sea affected by the Polish economy, the level of nitrogen still exceeds the limits, and the level of phosphorus remains near the permissible limit. This is a problem leading not only to the formation of harmful “dead zones” in the sea, but also creating a favourable environment for algal and cyanobacterial blooms, the presence of which prevents sea bathing.

An additional threat for the Baltic Sea includes excessive fish catches, leading to the disappearance of cod and herring species (salmon have already met a similar fate), which in such a situation do not manage to regenerate at an appropriate pace.

The cure for this potentially disastrous situation is primarily the consistent reduction of phosphorus and nitrogen emissions into the sea (currently caused by excessive fertilization of agricultural land and

poorly stored fertilizers, which is contrary to good agricultural practice and EU principles) and the introduction and monitoring of fishing limits. It is also necessary to fight pollution, including monitoring the scale of unreported losses of fishing nets that have polluted the sea waters for years.

Biodiversity: Without further enlargement of the area covered by the national parks and strict nature reserves, we are at risk of losing natural forests. Natural forests are threatened by forest management, which leads to them being cut down and transformed into forest monocultures or plantations. The most valuable forest areas should be protected by excluding them from forest management. The areas of existing national parks, which currently occupy only 1.1% of the area of Poland (that is 315 thousand ha) have to be enlarged. This statistic puts Poland at a remote 26th place in Europe. The average for European countries is 3.4%.

To improve this situation, the list of 23 Polish national parks should be extended at least by adding the first national park in Poland located in the foothills, the Turnicki National Park. The Białowieski and Bieszczadzki National Parks should also be enlarged.

Assuming that all the remedial actions mentioned in this report in the optimistic forecasts of the For Generations scenario will continue or be taken, Poland not only has the chance to avoid the risk of its most valuable natural habitats deteriorating, but by 2050 may also create the conditions for preserving the most valuable components of the natural heritage of Poles as well as for its regional development based on natural potential.

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