Statistical analyses

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Green economy indicators in Poland 2022

Warsaw, Białystok 2022

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Statistics Poland
Statistical Office in Białystok

Warsaw, Białystok 2022

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Preface

We would like to present you with the fifth edition of the publication "Green economy indicators in Poland 2022". It is the third edition of the publication after the research "Green economy in Poland" has been included in the Statistical Surveys Program of Official Statistics.

Green economy is understood as such that supports economic growth and development while maintaining access to natural capital and ecosystem services, which, in turn, affect human well-being. This economy is inextricably connected with the concept of sustainable development.

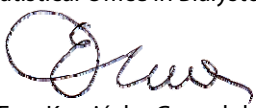
Information regarding green economy is presented in four thematic groups that are used in monitoring of the economy, i.e. natural asset base, environmental and resource productivity of the economy, environmental quality of life as well as economic opportunities and policy responses. Moreover, context indicators constituting the background and the source of basic information on the socio-economic state of the country are included so as to add another dimension to the issues covered by the publication.

Properly selected and current data from the scope of green economy may be used while introducing environment policies, implementing economic instruments or activities stimulating ecological innovations and investments in green technologies as well as monitoring the efficiency of these activities. The set of indicators presented in this report will be updated as new phenomena, instruments emerge or changes in data availability occur.

The suggested set of indicators to monitor the state of green economy includes, apart from public statistics information, extensive data from various national authorities and to compare data between European Union countries – from international organisations. To facilitate the use of data presented in the publication, a set of data has been included in an Excel file.

Presenting "Green economy indicators in Poland 2022", we would like to sincerely thank all institutions for the data and suggestions which have enriched the contents of this publication. We do hope that information will be useful for those interested in the subject-matter of this work, will also support decision-making process and will make it possible to follow changes taking place in environment, economy, and society in the light of green economy.

Director
Statistical Office in Białystok



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Warsaw, Białystok, December 2022

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Symbols

Symbol	Description
Hyphen (–)	magnitude zero
Zero (0,0)	magnitude not zero, but less than 0,05 of a unit
Dot (.)	data not available, classified data (statistical confidentiality) or providing data impossible or purposeless
"Of which"	indicates that not all elements of the sum are given
Comma (,)	used in figures represents the decimal point

Major abbreviations

Abbreviation	Meaning
µg	microgram
dam^3	cubic decametre
hm^3	cubic hectometre
dB	decibel
kgoe	kilogram of oil equivalent
toe	tonne of oil equivalent
Mtoe	megatonne of oil equivalent
GJ	gigajoule
MWh	megawatt·hour
DMC	domestic material consumption
PPS	Purchasing Power Standard
EEA	European Environment Agency
EMAS	Eco-Management and Audit Scheme
EMEP	European Monitoring and Evaluation Programme
EPO	European Patent Office
ESA	European System of Accounts
EU ETS	European Union Emissions Trading System
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
KOBiZE	National Centre for Emissions Management
NFR	Nomenclature for Reporting
PROW	Rural Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organization
WISL	National Forest Inventory

Executive summary

Poland, striving to make the economy greener and to reach sustainable development, is taking up various activities aimed at protecting the environment. Progress of these activities should be monitored, which can be done through indicators grouped in four thematic areas such as: natural asset base, environmental and resource productivity of the economy, environmental quality of life as well as economic opportunities and policy responses.

Natural asset base indicators describe the state of natural environment, i.e. existing natural resources and their changes. In 2021, surface of the terrestrial protected areas (including Natura 2000 areas) comprised 39.6% of the total area of the country, placing Poland among the top European countries in terms of the percentage of the terrestrial protected areas. In 2021, Forest Bird Index equalled 1.31, reaching its peak since the base year 2000, for which the value of 1 has been adopted. However, in the case of Farmland Bird Index, it reached the lowest value from 2000 – 0.72. In 2021, forest area in Poland was 9264.7 thousand hectares and forest cover indicator amounted to 29.6%. In 2002–2021, human activity brought about changes in land use. Built-up and urbanised areas increased (by 16.7%), forest land as well as wooded and bushy areas, including wooded and bushy areas on agricultural land (by 7.6%), as well as land under waters (by 3.2%), in lieu of other areas and agricultural land diminishing by 27.5% and 3.9% respectively.

Indicators of environmental and resource productivity of the economy, presenting the efficiency of natural resources use in economic processes, show that in many domains there is a relative and even absolute decoupling between economic growth and pressure on environment. This phenomenon should be viewed positively. In 2000–2021, water productivity index value increased. In 2021, its growth was observed in comparison with 2020 and 2000 by 5.4% and 316.8% respectively. Positive tendencies were noticed in the case of a primary energy productivity indicator. Since 2000 (excluding 2016), it gradually increased. In 2021 in relation to 2020 and 2000 it rose by 4.7% and 193.4% respectively. However, resource productivity index fluctuated. In 2021, it was higher than in 2020 and 2000 (by 5.4% and 171.1% respectively). In 2020, the share of renewable energy in gross final energy consumption was 16.1%, which means that Poland met the 15% target, established in accordance with EU commitments, exceeding it by 1.1 pp.

Environmental quality of life indicators are used to assess population access to basic services in the scope of water and sewage management aimed at environmental protection as well as to assess population exposure to pollutants and health conditions resulting from this exposure. Their values show improvement in the following: reduction of excessive noise (especially industrial one), access to sewage network and water supply network, and supply of water meeting quality requirements to population. On the other hand, some environmental quality of life indicators show excess in the emission limits for particulate matter. National $PM_{2.5}$ average exposure indicator in 2021 was 17 µg/m^3. The year 2021 was another one, in which there was a decrease in the national $PM_{2.5}$ average exposure indicator and the first year when the indicator did not exceed the national $PM_{2.5}$ exposure reduction target (18 µg/m^3), which had to be reached to 2020. Moreover, the value of the national average exposure indicator in 2021 was 15.0% below the exposure concentration obligation (20 µg/m^3), which is the air quality standard in force since 2015. Although the percentage of persons exposed to excessive road traffic noise dwindled, the situation is still far from satisfactory. As a result of rapid road infrastructure development as well as the growing number of vehicles used, in 2017, 43.5% of population of cities with over 100 thousand of inhabitants was exposed to excessive noise over 55 dB in day-evening-night time. In night-time 26.3% of the city population was exposed to noise exceeding 50 dB.

Economic opportunities and policy responses indicators relate to instruments affecting economy and society, which are used to create desired development trends aimed at making the economy greener. Organic farming is one of activities supporting the implementation of this idea. In 2021, both the number and the area of organic farms increased compared to the previous year, by 7.6% and 7.9% respectively. In 2021, payments received by farmers within the Rural Development Programme for farms carrying out

organic farming amounted to PLN 485.0 million. It was the highest amount of subsidies dedicated to organic farming in the 2004–2021 period. Another instrument of environment protection policy are environmental taxes. In 2020, revenues from environmental taxes in Poland constituted 7.0% of total revenues from taxes and contributions, and their share in relation to GDP amounted to 2.6%. Among environmentally related taxes, energy taxes were of greatest fiscal importance with 87.9% revenues and transport taxes with their 7.2% revenues. In the period of 2000–2020 the share of environmental taxes in total revenues from taxes and contributions as well as in relation to GDP remained fairly stable. Activities aimed at making the economy greener require, among others, implementing new technologies. In 2021, the Patent Office of the Republic of Poland granted 178 environmental technology patents. Their share in total number of patents amounted to 5.4% and was one of the highest since 2000. Environmental aspect is taken into consideration by institutions dealing with public procurement. According to data from the Public Procurement Office derived from contracting authorities, in 2021, 1.9 thousand public procurement contained ecological criteria and their share in the total number of public procurement equalled 1.5%. Total green public procurement value (excluding Value Added Tax) was PLN 7.5 billion, i.e. 4.1% of the total value of awarded public procurement.

Chapter 1

Socio-economic context

The state of environment in Poland is affected by many social and economic factors. Thus, progress in making the economy greener should be made with regard to socio-economic conditions of the country.

Poland occupies the 6th place in Europe in terms of area, which is 312 706 km^2. Land use structure is dominated by agricultural land (as of 1 January 2021 its share was 59.9% of total area of the country).

As of the end of 2021, population equalled 37.9 million, of which the majority lived in urban areas (59.7% of total population). The density showed 121 persons living in 1 km^2.

In 2021, natural increase amounted to minus 188006 persons reaching the lowest negative value since 2000. Although life expectancy in Poland was gradually elongating for many years, this trend has changed since 2020 due to the COVID-19 epidemic. In the analysed year life expectancy equalled 75.6 years, and it was longer for females (79.7 years) rather than for males (71.8 years).

Taking into consideration the division by economic groups of age, it can be noticed that in 2021 in relation to 2000, the share of persons at pre-working age and working age was reduced (by 6.0 pp and 1.7 pp respectively), while the percentage of post-working age population increased (by 7.7 pp). It is reflected in the age dependency ratio, which in 2021 was 69.

In 2021, in Poland there were 15.0 million persons employed, the majority in the group of industry section – 21.6% of total employed. A registered unemployment rate in 2021 has been one of the lowest ones since 2000 and equalled 5.8%.

In 2021, according to the LFS, 5.9% of young people at the age of 18–24 did not continue their education and the number of adults at the age of 25–64 in life-long learning to total population of the same age group was 5.4%. Public expenditure on education amounted to 4.71% GDP (since 2019 expenditure on education in relation to GDP has been presented together with expenditure on science due to the changes in the budget classification) and neared the level reached in 2000.

In 2021, in comparison to 2000, a gross real disposable income of household sector increased by 71.3%, however, at-risk-of-poverty rate after social transfers fell from 20.5% noted in 2005 to 14.8% in 2020.

In 2021, 92.4% of households and 98.5% of enterprises had access to the Internet.

Investment outlays in the national economy, which in 2021 amounted to PLN 341.6 billion in current prices, increased more than 2.5 times compared to 2000.

Gross domestic product (in current prices) per capita grew from PLN 19.6 thousand in 2000 to PLN 69.1 thousand in 2021 (as preliminary estimate shows). Gross value added, in other words, the value of goods produced by market and non-market national entities less intermediate consumption related with their production in 2021 equalled PLN 2282.5 billion (according to preliminary estimate). Industry, with the dominant share, comprised as much as 25.1% of gross value added.

Table 1. Major data on the country

Specification	2000	2005	2010	2015	2020	2021
Population[a] (as of 31.12.) in millions	38.3	38.2	38.5	38.4	38.1	37.9
urban areas	23.7	23.4	23.4	23.2	22.8	22.6
rural areas	14.6	14.7	15.1	15.3	15.3	15.3
Population[a] per 1 km^2 of total area (as of 31.12.)	122	122	123	123	122	121
Natural increase in thousands	10.3	–3.9	34.8	–25.6	–122.0	–188.0
Life expectancy	73.7	75.0	76.2	77.5	76.5	75.6
males	69.7	70.8	72.1	73.6	72.6	71.8
females	78.0	79.4	80.6	81.6	80.7	79.7
Population of a given age group in % of total population[a] (as of 31.12.):						
pre-working age	24.4	20.6	18.8	18.0	18.4	18.4
working age	60.8	64.0	64.4	62.4	59.4	59.1
post-working age	14.8	15.4	16.8	19.6	22.2	22.5
Age dependency ratio[a] (non-working age population per 100 persons of working age; as of 31.12.)	64	56	55	60	68	69
Employed persons[b] in thousands (as of 31.12.)	15488.8	12890.7	14106.9	14829.8	14789.1	15002.6
of which in % in:						
agriculture, forestry and fishing	.	16.6	16.8	16.1	7.7	7.6
industry	.	22.2	20.6	20.3	21.7	21.6
of which in water supply; sewerage, waste management and remediation activities	.	0.9	1.0	1.0	1.1	1.1
transportation and storage	.	4.9	5.0	5.2	6.3	6.3
Registered unemployment rate[c] (as of 31.12.) in %	15.1	17.6	12.4	9.7	6.8	5.8
Early school leavers[de] in %	.	5.3	5.4	5.3	5.4	5.9
Lifelong learning[df] in %	.	4.9	5.2	3.5	3.7	5.4
Public expenditure on education in relation to GDP[g] in %	4.70	5.10	4.70	4.40	4.92	4.71
Total gross real disposable income of households sector (2000=100)	100.0	104.8[h]	130.0[h]	143.6[h]	176.6	171.3
At-risk-of-poverty rate after social transfers[i] in %	.	20.5	17.6	17.6	14.8	.

a From 2020, the results of the National Population and Housing Census 2021 have been the basis for the population balance and structure. Therefore, the data and indicators relating to the size and structure of the population (sex and age groups) from 2020 have been recalculated in accordance with the balance prepared on the basis of the results of the Census 2021. b Including employed persons in budgetary entities conducting activity within the scope of national defence and public safety. c Data was compiled taking into account employed on individual farms in agriculture estimated on the basis of census results: in 2000 – the Agricultural Census 1996, in 2005 – the Population and Housing Census 2002 as well as the Agricultural Census 2002, in 2010 and 2015 – the Agricultural Census 2010, and from 2020 – the Agricultural Census 2020. Data are not fully comparable to those for previous years. d On the basis of the Labour Force Survey (LFS); the LFS results were generalized on the basis of the balance of population compiled: in 2005 using the results of the Population and Housing Census 2002, and since 2010 on the basis of the Population and Housing Census 2011, which implies that data are not fully comparable to those for previous years. e Percentage of the population aged 18–24 having completed at most lower secondary education, who do not continue education and do not attend vocational trainings to the total population of the same age group. f Percentage of the population aged 25–64 continuing education or attending vocational trainings to the total population of the same age group. g Due to the changes in the budget classification, since 2019, expenditure on education relative to GDP has been presented together with expenditure on science. h Data have been changed in relation to the data published in the previous edition. i The survey EU-SILC has been conducted in Poland since 2005 – as reference period for incomes is taken the year preceding the one under survey.

Table 1. Major data on the country (cont.)

Specification	2000	2005	2010	2015	2020	2021
Households[j] in % of total households equipped with:						
Internet access	.	30.4	63.4	75.8	90.4	92.4
broadband Internet	.	15.6	56.8	71.0	89.6	91.7
Enterprises[k] in % of total enterprises equipped with:						
Internet access	.	86.1	95.8	92.7	98.6	98.5
broadband Internet	.	42.3	69.0	91.9	98.6	98.5
Investment outlays (current prices) in million PLN	133160	131055	217287	271839	309458	341617
in %:						
public sector	34.8	34.9	43.5	37.3	36.2	35.0
private sector	65.2	65.1	56.5	62.7	63.8	65.0
Gross domestic product[l] (current prices) per capita[m] in PLN	19565	25957	37240	46768	61231	69069[n]
Gross value added[l] (current prices) in million PLN	664322	870463	1260546	1595387	2059056	2282544[n]
of which in %:						
agriculture, forestry and fishing	3.5	3.3	3.3	2.8	2.9	2.6
industry	24.2	25.0	25.6	26.4	24.7	25.1
of which water supply; sewerage, waste management and remediation activities	1.1	1.1	1.2	1.2	1.4	1.3
transportation and storage	5.2	5.8	6.1	6.8	6.7	6.6

j Data concern households with at least one person aged 16–74 having the Internet access at home. k Data concern economic entities employing more than 9 persons. l Data for the period 2010–2021 were revised in October 2022. The detailed description of changes regarding revised estimates of annual GDP, is found in news releases of the Statistics Poland: https://stat.gov.pl/en/topics/national-accounts/annual-national-accounts/information-of-the-statistics-poland-on-the-revision-of-national-accounts-in-2010-2020,10,1.html. m Since 2020 indicator has been calculated on the basis of the number of people compiled on the results of the National Population and Housing Census 2021. n Preliminary estimate.

Chapter 2

Natural asset base

2.1. Biodiversity

Biodiversity means diversity of all living organisms inhabiting the Earth in terrestrial, marine and freshwater ecosystems as well as ecological complexes, of which they are a part. It concerns diversity within a scope of species (genetic diversity), among different species as well as diversity of ecosystems.

Biodiversity plays a vital role in many fields of human activity. Maintaining biodiversity to protect ecological value is a key factor in ecological and economic terms at, both national and international levels. Ecosystem biodiversity loss is a threat to proper functioning of our planet, and then, in turn, to population and economy.

Establishing areas of special nature value under legal protection is a form of ecosystem protection against uncontrolled human pressure on environment. In 2021, these areas comprised 10.1 million hectares, i.e. 32.3% of the total area of the country. In comparison to the previous year, the percentage remained the same, and in relation to 2000, it decreased slightly by 0.2 pp. There were 2667 m^2 of areas under legal protection per capita. The biggest share in their structure had protected landscape areas (69.5%) and landscape parks (25.8%).

According to the Eurostat database, in 2021, terrestrial protected areas (including Natura 2000 areas) in 27 countries of the European Union was 1115.4 thousand km^2 and constituted 26.4% of the total area of EU. The following countries were in the group of states with the highest share of protected area: Luxembourg (51.5% of total area of the country), Bulgaria (41.0%), Slovenia (40.5%) and Poland (39.6%). Countries with the lowest share, however, were Finland (13.2%) and Ireland (13.9%).

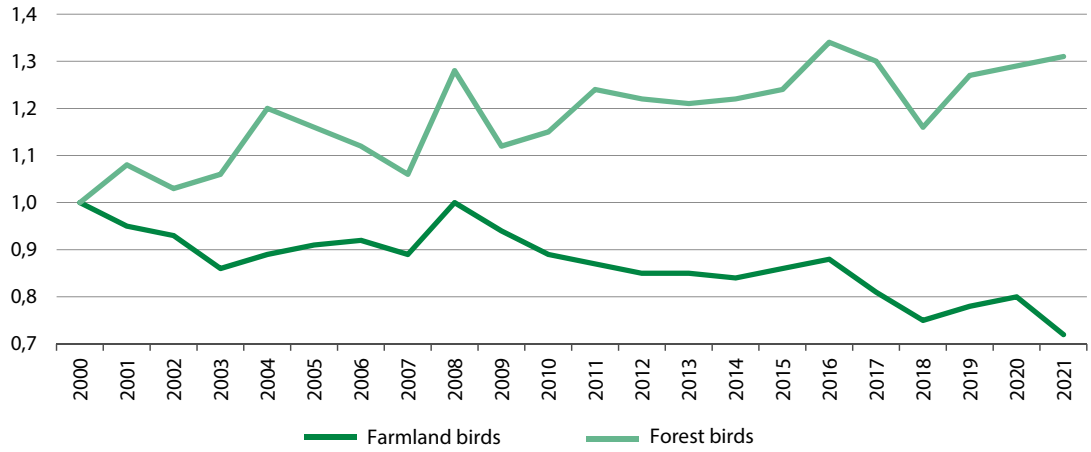
The environment state of ecosystems related to agricultural and forest land may be evaluated on the basis of aggregated Farmland Bird Index (FBI) and Forest Bird Index. Changes in the bird population on a regional or national level are important factors providing information concerning either the improvement, homeostasis or the deterioration of environment quality. The index value for the year 2000 (base year) was 1 (100%).

Farmland Bird Index (FBI) is one of official environment state indices in the member states of the European Union, used to assess farmed environment. Farmland Bird Index is an aggregated index of population number of 22 farmland bird species. In Poland to calculate FBI the following bird species are taken into consideration: the White Stork, the Kestrel, the Lapwing, the Godwit, the Turtledove, the Hoopoe, the Crested Lark, the Skylark, the Barn Swallow, the Meadow Pipit, the Western Yellow Wagtail, the Winchat, the Stonechat, the Common Whitethroat, the Red-Backed Shrike, the European Starling, the Tree Sparrow, the Seedeater, the Linnet, the Yellowhammer, the Ortolan Bunting and the Corn Bunting.

Forest Bird Index is used to describe the population of birds (avifauna) typical of national forest ecosystems. Forest Bird Index aggregates changes in the number of population for 34 most common bird species connected with forest areas: the Stock Dove, the Black Woodpecker, the Middle Spotted Woodpecker, the Woodlark, the Tree Pipit, the Eurasian Wren, the Dunnock, the European Robin, the redstart, the Common Blackbird, the Song Thrush, the Mistle Thrush, the Eurasian Blackcap, the Wood Warbler, the Chiffchaff, the Willow Warbler, the Goldcrest, the Common Firecrest, the Red-breasted Flycatcher, the European Pied Flycatcher, the Long-tailed Tit, the Marsh Tit, the Willow Tit, the European Crested Tit, the Coal Tit, the Great Tit, the Wood Nuthatch, the Eurasian Treecreeper, the Short-toed Treecreeper, the Eurasian Jay, the Chaffinch, the Eurasian Siskin, the Bullfinch, the Hawfinch.

In the years 2001–2003 there was a decrease in farmland bird population number by about 14% (chart 1). In the years that followed (apart from 2007) their number increased and in 2008 it reached the reference state from the year 2000. Since 2009 the index has been 6–28% lower than in the base year, which means that the population number at this time has been ranged from 72% to 94% of the 2000 year value. The lowest Farmland Bird Index in the history of the survey was noted in 2021. It was lower by 28.0% than in the base year.

Chart 1. Farmland Bird Index and Forest Bird Index



Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring.

Changes in the number of common species of forest birds indicate the reverse tendency, their populations are in good condition and their number is increasing in general. Since 2000, the highest value of the indicator in relation to the reference year was recorded in 2016 at 1.34. In 2021, the value of forest bird index equalled 1.31 and was one of the highest in the history of the survey.

According to Eurostat estimates, on the basis of data compiled in accordance with the European Bird Census Council (EBCC) under the Pan-European Common Bird Monitoring Scheme (PECBMS), in the period 2001–2020, aggregated Farmland Bird Index for the European Union (EU=27) decreased steadily in comparison with the base year (2000=100) and in 2020 amounted to 75.6%. In the case of aggregated Forest Bird Index in 2001–2017 the values were lower than the reference value for the year 2000. From 2018, the index was above the base figure for the year 2000. In 2020 it reached its peak, exceeding the base year value by 3.3%.

Many species of animals and plants are endangered due to natural reasons or human activity. So as to keep record of the number of these species, Red Data Book of Plants and Red Data Book of Animals were created. According to OECD database, among all species existing in Poland, endangered animals covered, among others, 480 vascular plant species (15% of total vascular plants), 1156 animal species, including 1081 invertebrates (3% of total invertebrates) and 75 vertebrate species: 13 mammal species (12% of total mammals), 34 bird species (7% of total birds), 3 reptile species (25% of total reptiles) as well as 25 fish species (20% of total fish).

On the basis of OECD database, the greatest percentage of endangered species of mammals among European Union countries (for which data are available) was noticed in Slovenia (38%) and Germany (36%). In the case of endangered bird species with habitats in a given country, their highest share was in the Czechia (49%) and Estonia (41%), and endangered reptiles – in Slovenia (75%) and the Netherlands (71%). Hungary (43%) and Austria (39%) were among countries with the highest share of endangered fish. The highest percentage of endangered vascular plants was observed in Czechia (40%) and Austria (33%).

2.2. Land use

Land use means the land classified into the following categories: agricultural land, forest, wooded and bushy land, land under waters, built-up and urban area, ecological area, wasteland and various areas.

Land, apart from air and water, is a basic element of environment and natural resources. It plays an important role for society, providing it with room for settlement, with raw materials necessary for food production, with biomass as well as helping to conserve biodiversity and ecosystem productivity. The land use, then, affects soil coverage and soil quality in terms of its richness in nutrients and carbon storage as well as influences greenhouse gas emissions. It has an impact on water and air quality, soil erosion risk, moreover, it plays an important role in flood protection.

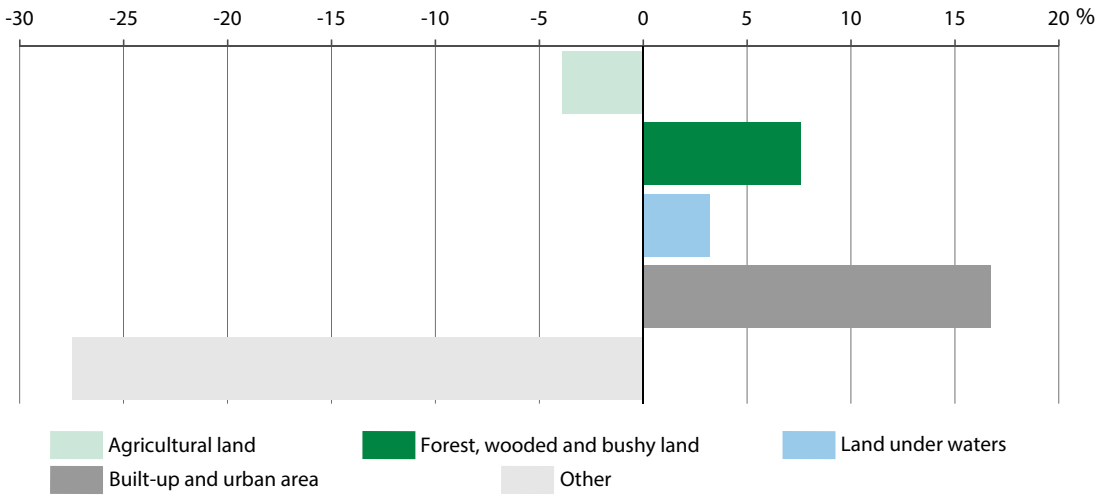
According to a geodesic inventory, in 2021, the largest part, i.e. 59.9% comprised agricultural land (18.7 million hectares), followed by forest, wooded and bushy land – 30.5% (9.5 million hectares), and built-up and urban areas – 5.7% (1.8 million hectares) out of the total area of the country, equalling 31.3 million hectares.

Following data from the Food and Agriculture Organization of the United Nations (FAO) database, it can be stated that in 2020, in EU Member States (EU=27), the total area of agricultural land within agricultural holdings amounted to 164.0 million hectares, which constituted 38.5% of total EU area. Among European Union countries the one with the highest share of agricultural land within agricultural holdings in total country area was Ireland – 64.2%, and with the lowest share in Sweden– 5.7%. Poland, with its share of agricultural land within agricultural holdings equalling 46.2%, ranked 9th among EU countries.

Man influences biodiversity and the ecosystem state by changes in land use. As built-up and urban areas are growing, there is a loss of natural functions of soil, fertile agricultural land and semi-natural land. Moreover, new emerging built-up land on areas outside already existing residential areas leads to traffic increase and land fragmentation.

In the years 2002–2021 an increase was noted in built-up and urban areas (by 16.7%), forest, wooded and bushy land, including wooded and bushy land on agricultural land (by 7.6%), as well as land under waters (by 3.2%) to the detriment of other areas and agricultural land, for which there was a decrease by 27.5% and 3.9% respectively (chart 2).

Chart 2. **Land use changes in the years 2002–2021**[a]

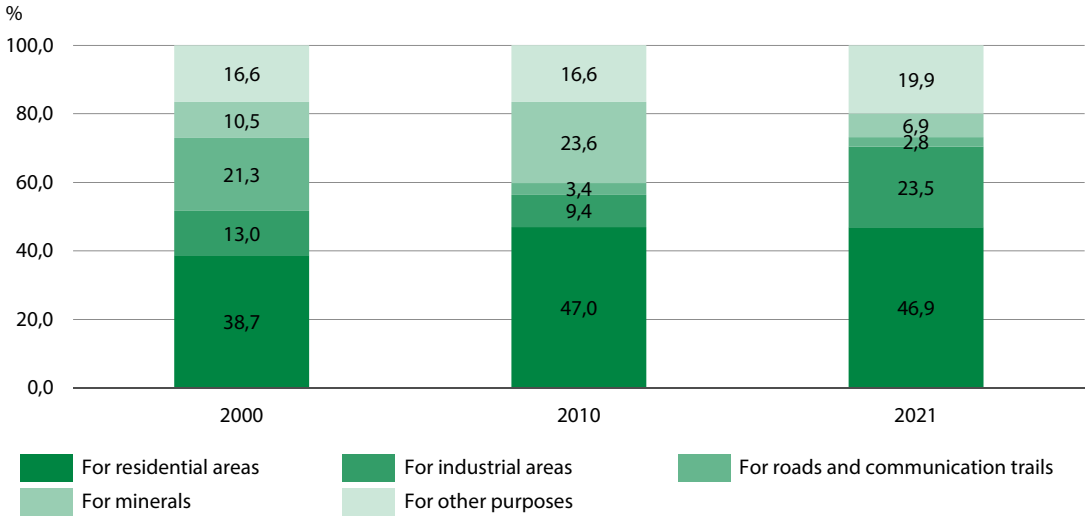


a In order to maintain data comparability, data for 2021 regarding wooded and bushy land on agricultural land were included in forest, wooded and bushy land.

Source: data of the Head Office of Geodesy and Cartography.

In 2021, 6.5 thousand hectares of agricultural and forest land were designated for non-agricultural and non-forest purposes, which is an increase in relation to the previous year and the year 2000 by 25.2% and 123.6% respectively. The highest proportion of excluded land was designated for residential areas – 46.9% and industrial areas – 23.5% (chart 3).

Chart 3. **Structure of agricultural land designated for non-agricultural purposes and forest land designated for non-forest purposes**[a]



a According to the existing legal regulations on the protection of agricultural and forest land; excluding agricultural land designed for afforestation.

Source: with regard to: agricultural land – data of the Ministry of Agriculture and Rural Development, forest land – data of the Ministry of Climate and Environment.

Land which has lost its utility value due to human activity or other factors or which utility value was lowered due to the deterioration of natural conditions may be reclaimed and managed. Land reclamation is

the creation or restoration of the utility or the natural value for degraded or devastated land through proper formation of the area topography, improvement of physical and chemical properties, regulation of water conditions, and restoration of soil, reinforcement of slopes and reconstruction or construction of necessary roads. Reclaimed land is subject to management i.e. agricultural, forest or other type of utilization. In 2021, devastated and degraded land comprised in total 62.3 thousand hectares. Out of these only 2.2 thousand hectares belonged to reclaimed land, of which land for agricultural purposes comprised 1.2 thousand hectares. Managed land equalled 0.6 thousand hectares, of which the majority was also designated for agricultural purposes – 0.4 thousand hectares. Until now the degree of reclamation and management of devastated and degraded land has been low for many years. In 2021, it accounted for 3.6% and 0.9% of total devastated and degraded land respectively.

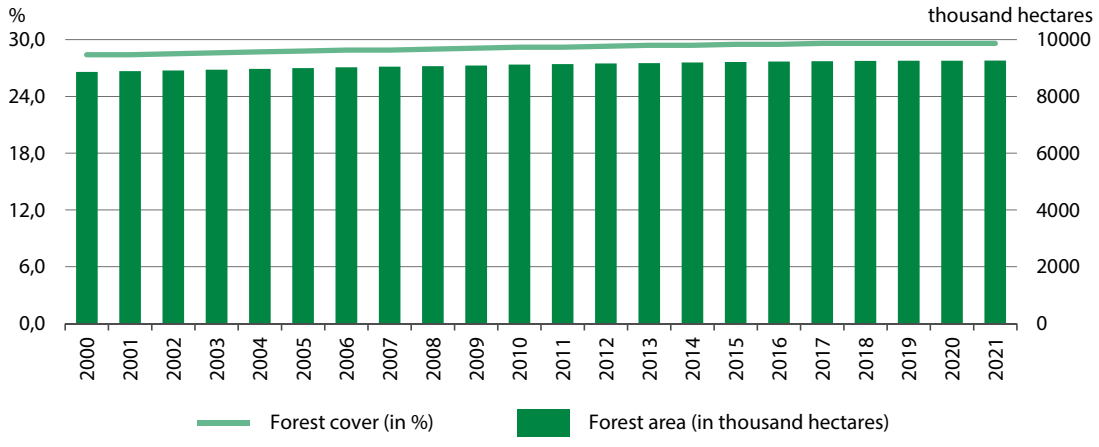
2.3. Forest resources

Forest is a land of compact area of at least 0.10 ha, covered by forest vegetation (wooded area) or temporarily devoid of forest vegetation (felling sites, blanks, irregularly stocked open stands, coniferous tree and bush plantations, hunting grounds). These are lands designated for silviculture production, constituting a nature reserve or integral part of a national park or registered as monuments of nature.

Forests are the most natural environmental formation and have been inextricably linked to Polish landscape for ages. They are of an undeniable ecological importance and perform a wide scope of ecosystem functions – not only do they provide natural habitat for plant and animal wildlife, but also protection against soil erosion and floods, carbon dioxide sequestration, climate regulation. They also fulfil important social functions – they provide favourable conditions for health and recreation, and perform productive functions – they supply wood and other forestry products. They constitute an indispensable part of environment sustainability and green economy.

In 2021, forests in Poland covered 9264.7 thousand hectares, which means that their area remained almost the same in comparison to 2020 and increased by 4.5% in relation to 2000 (chart 4). Forest cover (percentage ratio of forest area to the total area of the country) in 2021 was 29.6% and did not change in comparison to the previous year, but grew in relation to 2000 (by 1.2 pp). The increase of forest area in Poland is a result of the state forest policy, which plans the state forest cover to increase to 31%[1] by 2030.

Chart 4. Forest cover and forest area



[1] According to the 2030 National Environmental Policy – the Development Strategy in the Area of the Environment and Water Management.

According to FAO database, in European Union countries (EU=27) in 2020, the share of forest land in land area amounted to 39.8%. Countries with its highest value were Finland (73.7%), Sweden (68.7%) and Slovenia (61.5%), and the country with the lowest one was Malta (1.4%). Poland, with the value of 31.0%, held 18th position among 27 EU Member States.

Apart from the state forest cover, growing stock plays an important role in characterizing forest condition and implementing forest policy of the country. The main source of information on growing stock of standing wood in Poland from 2009 is the National Forest Inventory (NFI) carried out continuously (in a full cycle of 5 years) by the Bureau for Forest Management and Geodesy. According to the measurements of the NFI in the years 2017–2021, growing stock reached the volume of 2669.0 million m^3 of gross timber (a 15.8% increase in comparison to the measurements in the years 2005–2009), of which 72.8% referred to coniferous trees and 27.2% – to broadleaved trees.

On the basis of FAO database, in 2020, the estimation of wood resources of the European Union (EU=27) amounted to 27228.8 million m^3 of timber. Among EU countries, Poland was placed in the group of countries with the highest share of wood resources, following Germany (3663.0 million m^3 of timber), Sweden (3653.9 million m^3) and France (3055.8 million m^3).

As a result of a constantly growing both forest area and growing stock, it is possible to gradually increase removals (timber and slash). In 2021 in Poland, removals amounted to 42.2 million m^3, which is more than in the previous year and in 2000 by 6.5% and 52.7% respectively. The biggest share (96.3%) of removals was timber, which amounted to 40.7 million m^3. It was by 6.9% more than a year before and by 56.4% more than in 2000. It is important to keep the balance between the volume of timber increment and removals to preserve forest heritage for future generations.

As Eurostat estimates show, in 2020, European Union countries harvested 488.6 million m^3 of wood, most in Germany (84.1 million m^3) and Sweden (74.4 million m^3). Poland ranked 5th (40.6 million m^3) among 27 EU Member States.

While analysing forest resources, their health state cannot be overlooked. The area of damaged forests (in damage classes above 20%) in Poland in 2021 equalled 3102.7 thousand hectares, which constituted 33.5% of their total area. The dominant reasons of damage included, apart from "other agents" category (comprising 27.0% of total forest area), the categories as follows: damage caused by game (3.3%), fungi (1.7%), wind (0.8%) as well as insects (0.7%).

2.4. Freshwater resources

Water resources mean resources of surface waters and underground waters, available or those which may be available for use in the region, marked with the quantity and quality, in the given period.

Water is one of the most important resources on the Earth, playing a vital role for all forms of life. It has an impact on civilization development of a country, constituting a significant factor affecting the population standard of living. Freshwater resources sufficient in terms of quantity and quality are crucial for ecosystem development, human life, and for undertaking various economic activities.

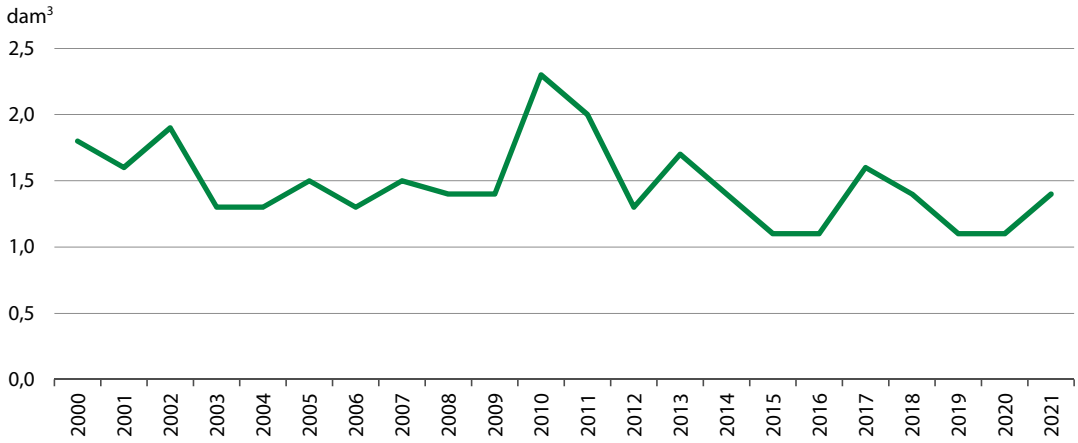
Agriculture, industrial infrastructure, urbanization and individual needs of growing population lead to the increase in freshwater demand, therefore it is important both to monitor its quantity and quality as well as to use it in an effective way.

Poland is a country of limited freshwater resources. Most of them are surface water resources. As Eurostat data show, freshwater resources in Poland equal 60.6 billion m^3 (as a long-period average). It is less than 1.6 dam^3 water per capita, which places Poland together with Malta (0.2 dam^3), Cyprus (0.5 dam^3) and Czechia (1.6 dam^3) in the group of EU countries mostly threatened by a shortage of water. The top EU countries with the highest freshwater resources are France (206 billion m^3), Sweden (197 billion m^3) and

Germany (188 billion m^3). Freshwater resources per capita are the highest in Croatia (26.5 dam^3), Sweden (22.2 dam^3), Finland (21.3 dam^3) and Slovenia (16.1 dam^3).

The most commonly used measurement for establishing the amount of water resources is the indicator of surface water availability. It states the per capita amount of surface water run-off (from Polish territory, including foreign tributaries) within a year. In 2021, the indicator was 1.4 dam^3, compared to 1.1 dam^3 noted the year before, and 1.8 dam^3 in 2000. The indicator of waters availability in the years 2000–2021 peaked in 2010 and reached 2.3 dam^3 (chart 5).

Chart 5. Indicator of surface water availability per capita



Source: data of the Institute of Meteorology and Water Management – National Research Institute.

Surface waters are the main source of providing national economy with water. Surface water withdrawal in 2021 (excluding irrigation in agriculture and forestry) was 7484.7 hm^3, accounting for 80.8% of total withdrawal. Surface water abstraction from rivers and lakes is used mainly for production purposes – in 2021 it represented 81.3%.

Underground waters as waters of much better quality are mainly treated as drinking water supplies. Exploitable resources of underground waters at the end of 2021, amounted to 18604.7 hm^3, which is more than in 2020 and 2000 by 0.9% and 15.9% respectively. Their withdrawal was 1738.3 hm^3 (18.8% of total withdrawal), so it decreased by 0.5% in comparison to the previous year, but increased by 1.1% in relation to 2000.

To illustrate the entire water country demand in relation to available water resources Water Exploitation Index (WEI) is used. It presents the share of mean annual total abstraction of freshwater in the long-term average of freshwater resources. WEI value exceeding 20% implies that there is water stress, i.e. stress caused by water shortage. According to the Eurostat database, in 2020, Poland had this index at 15.1%, and since 2000 it reached 20% in 2006 (20.5%). Among the EU countries, the worst situation in this respect in 2020 was recorded in Cyprus (72.1%) and Malta (48.9%).

2.5. Mineral resources

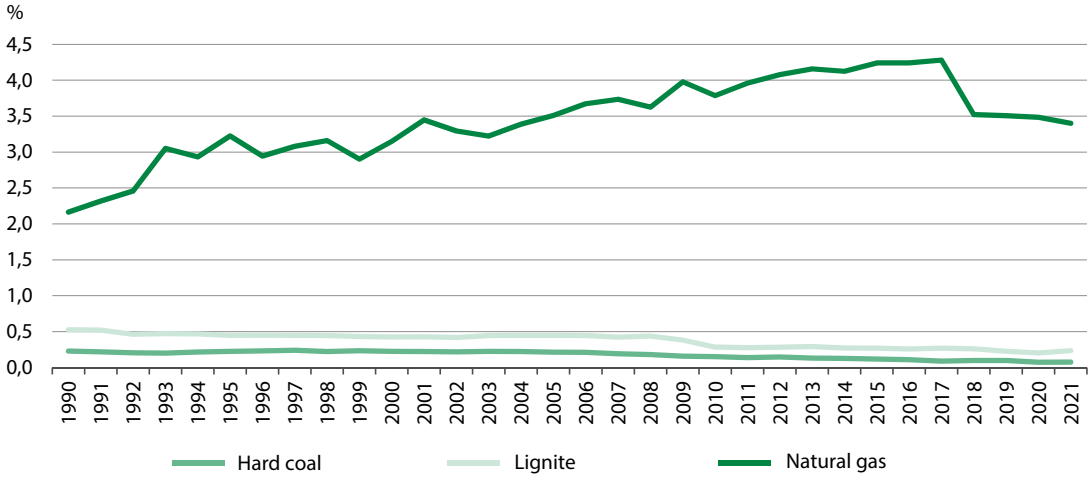
Mineral resources, belonging to the group of non-renewable natural resources, are minerals constituting elements of the natural environment: earth's crust, hydrosphere, biosphere and atmosphere, separated from them and adapted for use by a certain field of technique or a specific technology.

A key role to ensure a high standard of living in developed countries and to maintain constant economic growth is taken by fossil fuels and non-metallic minerals. They safe-guard access to energy, warmth, building material resources and, moreover, they constitute a basis for industry and technological development.

As we are facing a problem of limited and diminishing resources (e.g. hard coal, lignite, and natural gas) when we aim to achieve green economy objectives, we should ensure meeting the needs of not only present but also future generations. Keeping a relative balance between the volume of non-renewable resources and their extraction is an important factor affecting the stability of economic growth and green growth.

In 1990–2021 geological resources of hard coal (balance-sheet and off-balance-sheet) diminished from 86.0 billion tonnes to 77.9 billion tonnes (by 9.4%), which was mainly caused by exploitation of deposits and changes in balance criteria. Its annual exploitation fell from 151.3 million tonnes in 1990 to 49.5 million tonnes in 2021 (by 67.3%). In 2021, the share of extraction in balance-sheet resources of hard coal was 0.1% and fell by 0.1 pp in relation to 1990 (chart 6).

Chart 6. Share of extraction in balance-sheet deposit resources of selected minerals



Source: data of the Polish Geological Institute – National Research Institute.

According to Eurostat data, in 2021, the total of 57.2 million tonnes of hard coal were mined in Member States of the European Union, i.e. by 79.4% less than in 1990. Since the last decade of the 20th century, the number of Member States with active mining also decreased from 13 in 1990 to 2 in 2021 (Poland and Czechia). The share of Polish hard coal mining in total EU coal mining extraction increased from 53.2% in 1990 to 96.2% in 2021.

Lignite, in comparison to hard coal, is a lower ranking type of coal, with a much lower calorific value. In 2021, its geological resources (balance-sheet and off-balance-sheet) were 26.7 billion tonnes, which

means that they increased by 56.0% in relation to 1990. The increase was mainly connected with the documentation of new deposits. Due to the fact that the presence of coal matter, which is located on the Polish territory, is identified to a great degree, it can be assumed that the chances for finding new large lignite resources are limited, however, it is still possible to discover small and medium deposits of economic significance in the area of carbon deposits. The volume of annual lignite extraction fell in the years 1990–2021 from 67.7 million tonnes to 54.9 million tonnes (a decrease by 19.0%). In 2021, the share of lignite extraction in its balance-sheet resources was 0.2% (in 1990 – 0.5%).

As Eurostat data show, in 2021, lignite was extracted in 9 from 27 countries of the European Union with the amount equalling 274.7 million tonnes. Countries with the greatest extraction were Germany (126.3 million tonnes) and Poland (52.4 million tonnes). Their share in the total extraction of EU countries was 65.0%.

Natural gas, due to its high calorific value, unchangeable chemical composition (the possibility of even combustion), the ease to regulate the source, smoke-, soot- and ash-free combustion, is the most valuable fuel. It is used in many branches of industry and in households. It is also used to produce electric energy, as fuel for engines, and it is an important raw material for chemical industry. Geological resources of natural gas (balance-sheet and off-balance sheet) diminished since 1990 from 164.1 billion m^3 to 145.3 billion m^3 in 2021, i.e. by 11.5%. Ecological properties of gas, as well as the wide scope of its use resulted in the increase in the annual gas extraction by 40.7% (from 3.5 billion m^3 recorded in 1990 to 4.9 billion m^3 noted in 2021). The share of extraction in balance-sheet resources of natural gas was 3.4% in 2021 (in 1990 – 2.2%).

Eurostat data show that in 2020 natural gas was produced by 18 among 27 EU countries. The production amounted to 55.7 billion m^3. The highest production was reported in the Netherlands (24.1 billion m^3) and Romania (8.9 billion m^3). Poland ranked 4th among EU countries producing natural gas, with its share rising from 2.5% noted in 1990 to 10.0% – in 2020.

Chapter 3

Environmental and resource productivity of the economy

3.1. Water productivity

Water productivity is calculated as the gross domestic product (in constant prices) divided by the consumption of water for needs of the national economy and population. The indicator presents GDP per water consumption unit and is used to assess the efficiency of water management.

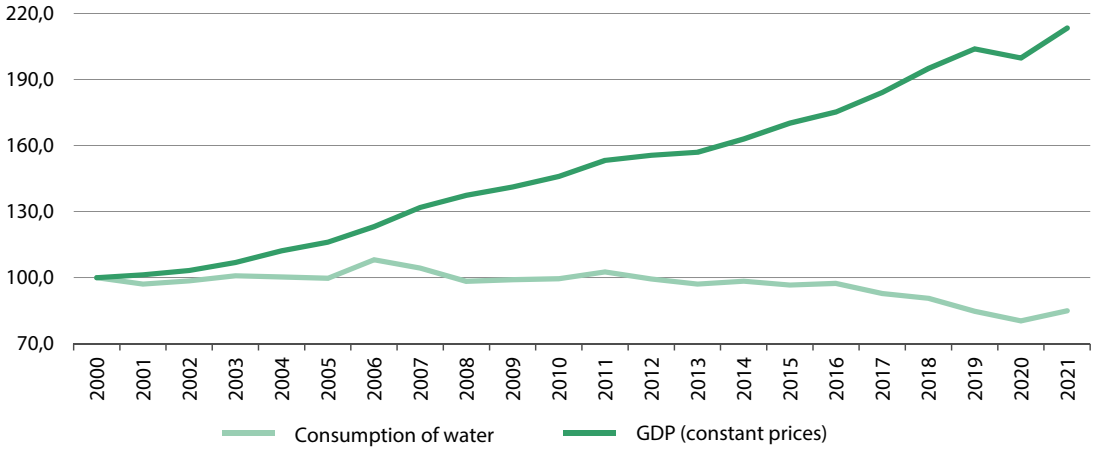
Water plays an important role in processes taking place in ecosystems, constituting an abiotic component of environment, vital for ecosystem functioning. It is a very valuable, distinctive and renewable material, whose resources vary in time. It fulfils different functions in economic activity, therefore it is necessary both to protect water against pollution and to ensure its rational and efficient use. Water resources are unevenly distributed in the country area and are subject to seasonal and yearly fluctuations, which makes it necessary to monitor their consumption.

In 2021, consumption of water for needs of the national economy and population (excluding irrigation in agriculture and forestry) was 8845.0 hm^3, of which for industrial purposes – 6370.7 hm^3 (72.0% of total water consumption), exploitation of water supply network – 1632.8 hm^3 (18.5%), as well as fishing (i.e. filling and completing fish ponds) – 841.4 hm^3 (9.5%). In relation to 2000, positive changes took place in industry, with the decrease in water consumption by 16.1% and with the fall in the case of exploitation of water supply network – by 6.9%. The decrease was also noted in water consumption for the needs of national economy and population per capita (from 272.1 m^3 in 2000 to 232.8 m^3 in 2021).

Main factors affecting the quantity of used water are production intensity together with the volume and patterns of individual consumption. The analysis of the dynamics of consumption of water and GDP in the years 2001–2021 in relation to 2000 may lead to the observation of a positive trend – almost a steady water consumption level (excluding 2006 and 2007, when a relatively high increase of water consumption was noted in comparison with 2000), followed even by its decrease noted in recent years, both accompanied by a constant gradual GDP increase (chart 7).

Chart 7. Dynamics of consumption of water for needs of the national economy and population as well as GDP[a]

2000=100



a Consumption of water for needs of the national economy and population – since 2019 excluding irrigation in agriculture and forestry; GDP for 2021 – preliminary estimate.

Efficient water consumption constitutes a base for proper water management. In the years 2000–2021 water productivity index[1] was becoming more and more favorable. In 2021, the ratio of GDP to cubic meter of water consumed was 282.39 PLN/m^3, which is an increase both to the year 2020 and 2000 by 5.4% and 316.8% respectively.

According to Eurostat data, for 15 countries of European Union with available data, the highest value of water productivity index in 2020 was noted in Luxembourg (where the value of generated GDP was 1048.9 PPS[2] units per cubic meter of freshwater abstracted) and Malta (363.1 PPS/m^3) and the lowest in Greece (19.8 PPS/m^3) and Bulgaria (22.5 PPS/m^3). Poland with 95.2 PPS/m^3 was in the 10th position.

To assess the effectiveness of water management, apart from water productivity index, it is possible to use water intensity indicators, such as water use intensity of industry (illustrating the ratio of industry water consumption to gross value added of industry) or water use intensity of households (the ratio of consumption of water from water supply system in households to gross value added of households).

Since 2000 there have been positive tendencies in Poland in terms of both indicators. The water use intensity of industry was gradually decreasing (excluding the following three years: 2002, 2006 and 2011, when a slight increase was observed in relation to the preceding year). In 2021, it reached 12.2 m^3/thousand PLN, i.e. was lower in comparison to 2020 and 2000 by 1.0% and 75.7% respectively. Household sector was also characterized by a much lower water use intensity index. In 2021, it was 2.2 m^3/thousand PLN, i.e. it decreased in relation to 2020 and 2000 respectively by 3.5% and 65.9%.

3.2. Domestic material consumption

Domestic material consumption (DMC) includes the total amount of materials directly used in economic processes for the needs of the economy. It is the sum of raw materials extracted from the domestic territory of the total economy, plus all physical imports minus all physical exports.

Domestic material consumption is a basis for economy functioning and is also an important source of both income and employment. However, all these three: the extraction, processing and the consumption of produced goods result in multidimensional pressure on all components of environment. Therefore it is important to make the resource management process in the entire life of a product as little harmful and as efficient as possible and to ensure access to these resources to future generations.

According to preliminary data of Eurostat, domestic material consumption in 2021 in Poland was 681.7 million tonnes. It was higher in relation to the previous year and 2000 by 5.7% and 30.6% respectively. Yearly domestic material consumption per capita amounted to 18.0 tonnes.

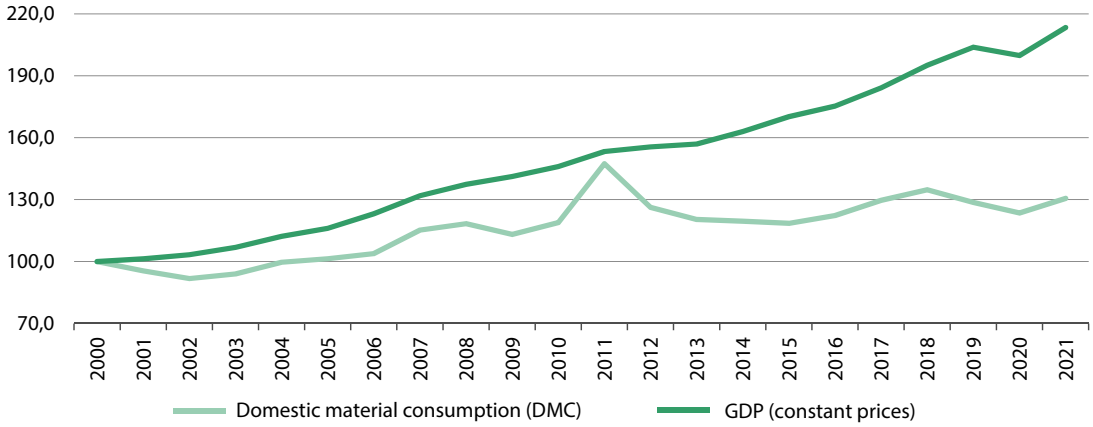
Domestic material consumption in 27 Member States of the European Union in 2021 reached 6321.2 million tonnes, and per capita in the EU – 14.1 tonnes. The highest material consumption per capita was in Finland (35.0 tonnes) and Estonia (29.4 tonnes), and the lowest in the Netherlands (7.4 tonnes) and Italy (8.9 tonnes).

In DMC structure, the biggest share in Poland had non-metallic minerals (51.6%), whose consumption in the analysed year was 351.8 million tonnes. The share of remaining materials, i.e. biomass, fossil energy materials/carriers and metal ores in the total consumption was 22.2%, 21.2% and 5.8% respectively. In relation to 2000, the consumption of non-metallic minerals increased the most, by 105.5%. It is largely connected with the realisation of infrastructure projects, among others financed from European Union funds.

[1] When calculating the indicator, since 2019 consumption of water for needs of the national economy and population does not include irrigation in agriculture and forestry.
[2] Purchasing Power Standard (PPS) – the artificial common reference currency unit used in the European Union to express the volume of economic aggregates for the purpose of spatial comparisons in such a way that price level differences between Member States are eliminated.

In the period 2001–2021, the dynamics of DMC fluctuated in comparison with 2000. However, in the entire analysed period, apart from the years 2001–2004, it was higher than in the base year, with a constantly growing GDP (chart 8). It proves a relative decoupling between GDP and material consumption.

Chart 8. Dynamics of domestic material consumption (DMC) and GDP[a]
2000=100



a DMC and GDP for 2021 – preliminary estimate.
Source: data regarding domestic material consumption – Eurostat database (access date 7 November 2022).

To measure the efficiency of material consumption in economy, resource productivity index is used, i.e. a relation of gross domestic product (in constant prices) to domestic material consumption. The higher the value of this index, the fewer resources are used to produce a unit of GDP. In the years 2000–2016, the efficiency of resource use gradually increased from 1.35 PLN/kg to 2.90 PLN/kg (except for the years: 2004, 2007 and 2011, when the analysed indicator assumed lower values compared to the preceding year). In the year that followed the resource productivity index slightly decreased and since 2018 it has begun to grow from 2.99 PLN/kg to 3.66 PLN/kg in 2021.

According to preliminary estimates of Eurostat, w 2021, the resource productivity index in countries of the European Union was 2.3 PPS/kg. The Member States with the highest index were the Netherlands (5.7 PPS/kg), Luxembourg (3.6 PPS/kg) and Italy (3.4 PPS/kg), and the country with the lowest one – Bulgaria (0.8 PPS/kg). Poland with the index value of 1.4 PPS/kg ranked 22nd among 27 countries of European Union.

3.3. Waste management

Waste is any substance or object which the holder discards or intends or is required to discard. It comprises waste generated in production processes (excluding municipal waste) and municipal waste.
Municipal waste is defined as waste generated in households, excluding end-of-life vehicles or generated by other waste producers (excluding hazardous waste) which on the account of its character and composition is similar to waste from households.

Waste management can significantly affect environment and human health. Limiting waste generation in the era of increasing production and consumption is an important condition of reducing a negative effect on environment and one of the challenges of today's world. Waste recovery through landfilling is an example of inefficient resource management, leading, additionally, to pollutant emissions to air, land and water, to wasting areas on landfilling sites or damaging the natural beauty of landscape. Only the reuse of waste, its recovery or recycling make it possible for the waste to become a resource-to-be, helping

to reduce the use of raw materials for the production of goods, and to more efficient resource management.

In 2021, 121.4 million tonnes of waste were produced, of which 88.7% was waste other than the municipal one.

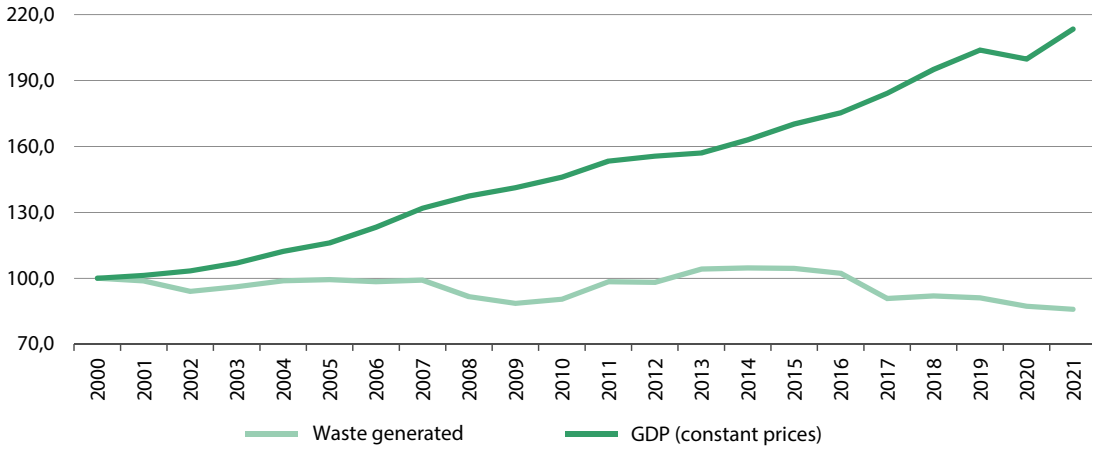
Waste (excluding municipal waste)

In the period 2000–2021 the largest amount of generated waste (excluding municipal waste) was noted in the year 2014 (131.3 million tonnes), while the lowest amount – in 2021 (107.7 million tonnes), followed by the year 2020 (109.5 million tonnes). In 2021, in comparison with 2020 and 2000, the amount of waste decreased by 1.6% and 14.2% respectively. The decrease recorded in the last two years may have been related to the epidemic state in Poland, when economic entities operated under temporary restrictions. The main source of waste generation were entities belonging to the following sections: mining and quarrying (57.4% of total amount of generated waste excluding municipal one), manufacturing (20.4%), as well as electricity, gas, steam and air conditioning supply (11.8%).

Recovery processes play a meaningful role in waste management. In 2021, recovered waste by waste producer on his own as well as transferred to other recipients for recovery processes was 51.2 million tonnes, which accounted for 47.5% of total generated waste (in 2020 – 48.4%).

Analysing the dynamics of the amount of generated waste and GDP in the period of 2001–2021 in relation to 2000, one can observe a positive trend (chart 9), namely a constant growth of GDP with a stable dynamics of the amount of generated waste, below the base year value 2000=100 (apart from the years 2013–2016).

Chart 9. Dynamics of waste generated (excluding municipal waste) and GDP[a]
2000=100



a GDP for 2021 – preliminary estimate.

Municipal waste[3]

The most important tasks in municipal waste management, resulting from the need to protect the environment, boil down to minimising waste production and to maximizing their management as well as to limiting to the necessary minimum waste landfilling in the environment.

[3] From 2014 municipal waste collected as a result of changes in the municipal waste management system (from 1 July 2013 gminas covered all real-estate owners with the system) comprises waste collected from all inhabitants and is considered as waste generated.

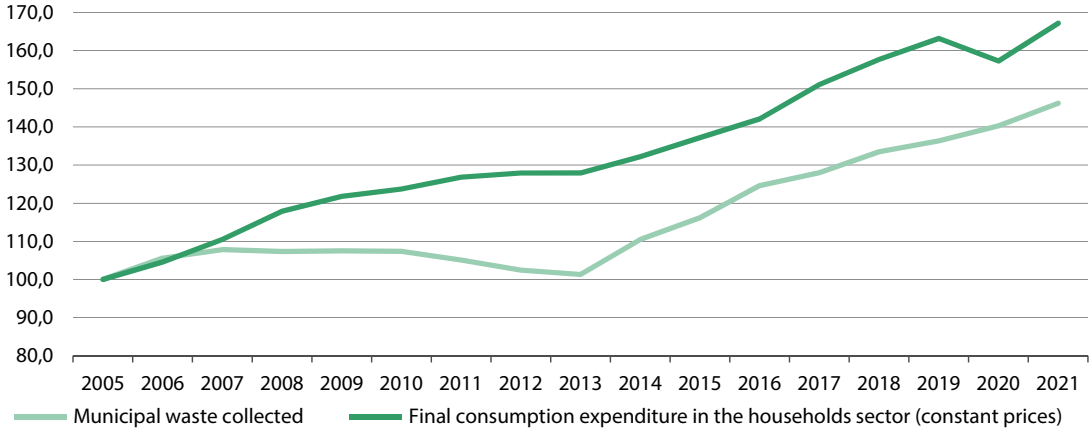
In 2021, 13.7 million tonnes of municipal waste were collected, which is an increase both in relation to 2020 and 2005 by 4.2% and 46.2% respectively. In 2021 in Poland, waste per capita amounted to 359.9 kg, which is more in comparison with the previous year and 2005 by 4.8% (by 16.4 kg) and 46.9% (by 114.9 kg).

Eurostat data show that in 2020 the amount of municipal waste per capita in Poland (346 kg) was decisively lower that the European Union (EU=27) average (517 kg) and was one of the lowest (preceded only by Romania – 287 kg) in EU countries. The highest analysed value was recorded in Austria (834 kg), Denmark (814 kg), and Luxembourg (790 kg).

In Poland in the years 2006–2021 the dynamics of the amount of municipal waste collected and final consumption expenditure in the households sector (chart 10) was above the base year level (2005=100). Since 2007, the growth rate of generating municipal waste has been lower than the growth rate of consumption in the households sector. In 2021, it was respectively at 46.2% and 67.2%, which shows a relative decoupling between the amount of generated municipal waste and consumption in a households sector.

Chart 10. Dynamics of municipal waste collected and final consumption expenditure in the households sector[a]

2005=100



a Final consumption expenditure in the households sector for 2021 – preliminary estimate.

One of the main methods of reducing the amount of waste is recycling, whose main aim is to re-use of materials. Selective waste collection is necessary to facilitate recycling processes. In 2021, 5.4 million tonnes of municipal waste were collected separately. The proportion of waste collected separately in the total mass of collected municipal waste from 2003 gradually grew, reaching 39.8% in 2021. This positive trend may result from, among others, a steady rise of ecological awareness of population, the implementation of programmes of managing municipal waste as well as from the pricing policy of gminas in the field of waste collection. Yet, although the amount of waste collected non-selectively is falling, it still has a high share (in 2021 – 60.2%).

According to Eurostat data, recycling rate of municipal waste (share of waste designated for recycling and biological treatment in total municipal waste) in European Union countries (EU=27) in 2020 was 48.2%. Germany (68.3%), Austria (61.8%) and Slovenia (59.3%) had the highest value of the indicator and Malta (10.5%) – the lowest. Poland with the recycling rate of municipal waste at 38.7% was 15th among EU countries.

3.4. Nitrogen and phosphorus balances

Gross nitrogen and phosphorus balance is the difference between the quantity of nitrogen/phosphorus introduced on agricultural land and obtained from agricultural land. Gross nitrogen balance sheet consists of, apart from emission of its compounds to land and water, gas "losses" in the form of ammonia and nitric oxide, in the livestock production processes, including the processes of storage and application of manure, as well as mineral nitric fertilizers.
A negative balance, i.e. the difference between the inflow and outflow of components indicates their shortage, while a positive one – an excess of components.

Modern agriculture has a significant effect on environment. Therefore, it is important to keep the balance between nature protection and economic benefits so as to ensure the restoration of natural resources necessary for further production activities. Agricultural activity interferes in natural nutrient cycles, thus creating the risk of ecosystem imbalance.

Biogenic compounds of nitrogen and phosphorus that remain unused are among the most serious dangers generated by agriculture. They can be released to groundwater and open water and in the case of nitrogen compounds – they can be released to air. Their deficit can, in turn, lead to a lower productivity and soil degradation.

Nowadays it is difficult to imagine agriculture without fertilizing. Fertilizer application is a main yield factor, influencing agricultural production development. Economic effects are largely dependent on the amounts of fertilizers used. However, overdosing and improper application of fertilizers lead to the accumulation of harmful components in soil and their transmission to animal and human food chain.

Consumption of nitric fertilizers (in pure ingredient – N) in the economic year 2019/2020 (i.e. from 2 June 2019 to 1 June 2020 inclusive) was 1.0 million tonnes and was higher in relation to the previous economic year (i.e. from 1 July 2018 to 30 June 2019) and to the economic year 1999/2000 by 3.9% and 19.9% respectively. The figure of nitrogen fertilizers per 1 ha of agricultural land in the year 2019/2020 was 69.1 kg, while a year before – 67.7 kg, and in the economic year 1999/2000 – 48.4 kg.

In the case of phosphoric fertilizers in the economic year 2019/2020 (i.e. from 2 June 2019 to 1 June 2020 inclusive), their use amounted to 0.4 million tonnes (in pure ingredient – P_2O_5). It means that there was an increase in relation to the previous economic year and to the economic year 1999/2000 by 4.4% and 20.8% respectively. In the analysed year, the use of phosphoric fertilizers per 1 ha of agricultural land was 24.0 kg, in the previous year – 23.4 kg, and in the economic year 1999/2000 – 16.7 kg.

Nitrogen and phosphorus balances, as an example of many agri-environmental indicators, are a very important source of information on agricultural influence on environment conditions. A comprehensive evaluation of gross nitrogen and phosphorous balances is carried out on the basis of at least a 3-year cycle, which is to reduce data variation caused by weather conditions.

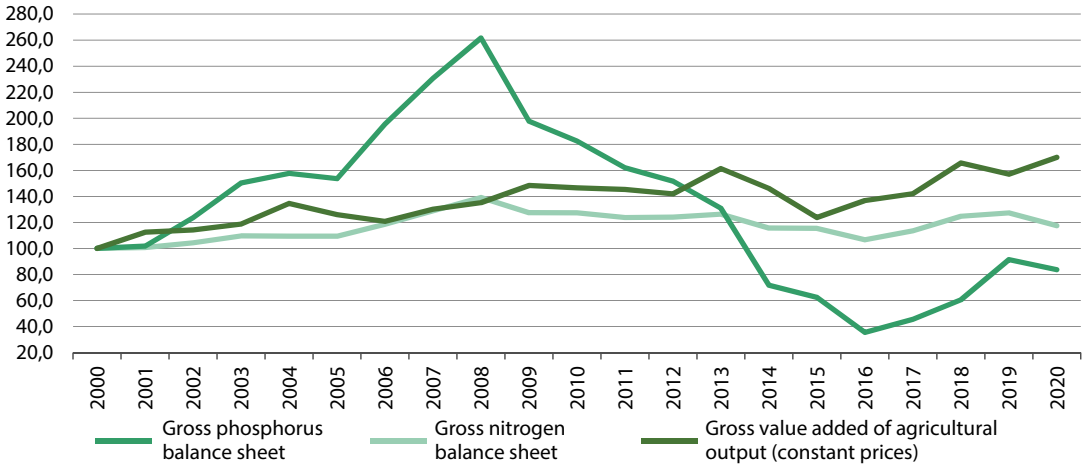
In nitrogen plant fertilization, nitrogen balance is in general disturbed, due to inevitable losses to air or leaching nitrates to lower levels of soil and groundwater. It is assumed that because of the yield and the quality of groundwater, the gross nitrogen balance sheet should amount to 30–70 kg per 1 ha of agricultural land.

While analysing data concerning last 20 years, it can be noted that the average gross nitrogen balance per 1 ha of agricultural land grew from 41.1 kg in the period of 1998–2000 to 48.3 kg in 2018–2020. This value is, however, kept at a safe level – below 70 kg per 1 ha of agricultural land.

In the years 2001–2020 the dynamics of gross nitrogen balance in relation to 2000 was lower (except for 2008) than the growth rate of gross value added of agricultural output (chart 11), which is indicative of a relative decoupling between agricultural output and gross nitrogen balance.

Chart 11. Dynamics of gross nitrogen and phosphorus balance sheet[a] as well as gross value added of agricultural output

2000=100



a Data for given years are calculated as 3-year averages, e.g. for the year 2000 as an average for the years 1998–2000.

Source: data regarding gross nitrogen and phosphorus balance sheet prepared by the Institute of Soil Science and Plant Cultivation – National Research Institute (Jerzy Kopiński, Beata Jurga), within the framework of 2.1 PW IUNG-PIB 2016–2020 task according to "Nutrient Budgets" methodology OECD/Eurostat.

As Eurostat database shows, in 2019 among 16 European Union Member States, for which data are available, the average gross nitrogen balance sheet per 1 ha of agricultural land was between minus 24.9 kg in Romania and 165.8 kg in the Netherlands.

Phosphorus balance is a basic measure to assess the following: efficiency of plant output, making use of limited phosphate resources and environmental protection. As Polish soil is poor in this element, its supplementation in the form of fertilization is necessary. It is assumed that phosphorus balance, with an average phosphorus soil content should be nearing zero, however, with a low phosphorus soil content – to 5 kg per 1 ha of agricultural land.

Within the last 20 years, an average gross phosphorus balance per 1 ha of agricultural land decreased from 3.0 kg in the period of 1998–2000 to 2.5 kg in the years 2018–2020.

Gross phosphorous balance sheet dynamics in 2001–2013 was above the level of the year 2000, and since 2014 below the level of the base year (2000=100). However, the dynamics of gross value added of agricultural output from 2001 to 2020 was above the level of the year 2000. Although at the beginning there was a relation between gross value added of agricultural output and phosphorous balance sheet, since 2014 there has been an absolute decoupling between these two values.

On the basis of Eurostat data, in 2019 among 16 European Union Member States, for which data are available, the average gross phosphorous balance sheet per 1 ha of agricultural land was from minus 6,1 kg in Romania to 5.8 kg in Portugal.

3.5. Energy productivity

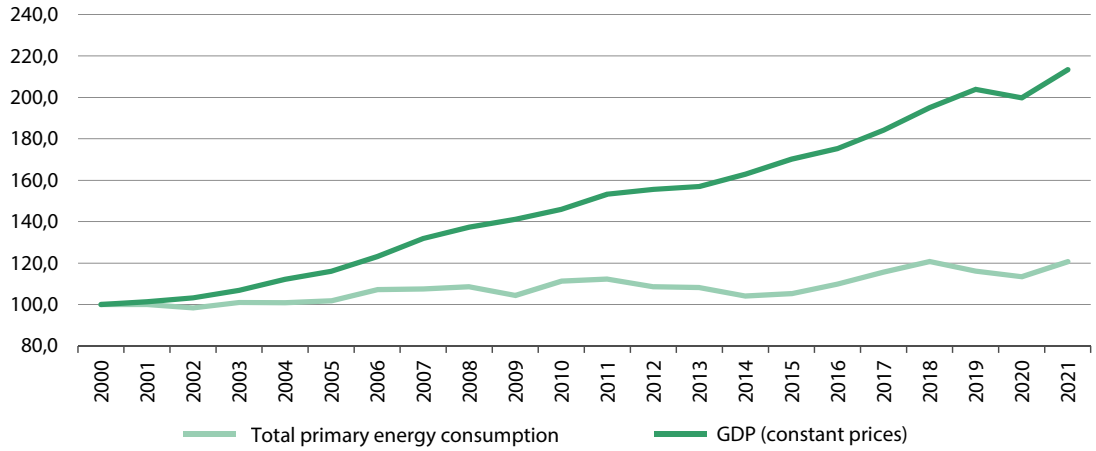
Primary energy is energy embodied in the primary energy carriers that are acquired directly from renewable and non-renewable natural resources, necessary to cover the demand for final energy, having regard to the efficiency of the entire chain of processes related to production, conversion and transport to final costumer.
Total primary energy consumption (gross inland consumption of energy) expressed in tonnes of oil equivalent (toe) is the sum of consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources.
Toe – tonne of oil equivalent (conventional) is the energy measurement unit from different energy carriers, using conversion rates, and used in international balances. It means the amount of energy that can be produced by burning one tonne of crude petroleum. One tonne of conventional oil equals 41.868 GJ (11.63 MWh).

Energy is used in production processes and in households. Its efficient use in economy constitutes an important factor influencing production costs and product competitiveness on an international market. Careless use of energy leads to problems with the pollution of natural environment (through greenhouse gas emissions) and to energy resources depletion. Energy demand is constantly growing, therefore objectives of green economy include, among others, the need for improvement of energy efficiency and the need for the efficient use of existing energy resources.

In 2021, total primary energy consumption was 109.0 Mtoe and was higher in relation to the previous year and in comparison to 2000 by 6.4% and 20.7% respectively. Among primary energy carriers in 2021, hard coal and lignite held a dominating position (46.7% of total consumption). Their share in the total consumption in relation to 2020 and 2000 was reduced by 2.7 pp and 18.0 pp respectively.

In the years 2001–2021, dynamics of total primary energy consumption in the economy in relation to 2000 assumed values above the level of the base year (except for 2002). However, it was much lower than GDP growth rate. This indicates a relative decoupling between economic growth expressed in GDP and energy consumption (chart 12).

Chart 12. Dynamics of total primary energy consumption and GDP[a]
2000=100



a GDP for 2021 – preliminary estimate.

To assess the energy policy of the country a primary energy productivity indicator, which is a relation between gross domestic product (constant prices) and total primary energy consumption, can be used. A higher value of the indicator means a lower energy consumption to produce a GDP unit. In 2021, this measure was 22.91 PLN/kgoe and grew in relation to 2020 and 2000 by 4.7% and 193.4% respectively, which is a positive fact.

Eurostat data show that the primary energy productivity indicator in European Union countries (EU=27) in 2020 was 9.7 PPS/kgoe. EU countries with the highest primary energy productivity were Ireland (22.4 PPS/kgoe), Denmark (14.3 PPS/kgoe) and Romania (12.8 PPS/kgoe). The lowest indicator was noted in Malta (5.1 PPS/kgoe), Finland (5.8 PPS/kgoe) and Bulgaria (6.4 PPS/kgoe). Poland, having reached 8.4 PPS/kgoe was in the 17th place among 27 EU Member States.

In the period 2000–2021, changes in the structure of final energy consumption, i.e. the one used by final customers (exclusively for energy purposes without processing into other energy carriers) took place in Poland. In 2021, the biggest consumer was a transport sector with a 31.7% share, followed by households – 29.8%, industry – 22.1%, services – 11.4% and agriculture – 5.1%. In relation to 2000, the largest decrease in the share of final energy consumption was recorded in industry (by 9.6 pp), which can result, among others, from this sector restructuring and introducing new energy-efficient technology. On the other hand, the greatest increase in the share of final energy consumption structure was noted in transport (by 14.7 pp), i.a. as a result of dynamic development of road transport and services.

Final energy intensity indices, being the relation between final energy consumption in economy and GDP, can also be used to assess an energy policy of a country.

During the years 2000–2015 a gradual decrease of final energy intensity of Polish economy was observed from 76.8 kgoe/thousand PLN to 34.4 kgoe/thousand PLN (except for the year 2010), which was a positive development as the share of energy necessary to produce the same amount of GDP decreased. In the next two years a slight increase was noted in this respect and from 2018 to 2021 a decrease to 29.8 kgoe/thousand PLN occurred again. In relation to 2020 and 2000 it decreased by 5.0% and 61.2% respectively.

In the case of households, the final energy intensity of this sector, depicting the relation between final energy consumption in households and gross value added (constant prices) produced in this sector, was gradually falling from 2000, except for 2010, 2016, 2018 and 2021 when small increases were recorded in relation to the previous year. In 2021, the analysed indicator amounted to 38.8 kgoe/thousand PLN and was higher by 2.8% in relation to 2020, but lower by 54.2% in comparison with 2000.

In the period of 2000–2016 (except for 2013) also in industry there were positive trends such as the decrease in the final energy intensity indicator of this sector, presenting the relation between final energy consumption in industry and gross value added (constant prices) of this sector. After an increase of the indicator in 2017, in subsequent years it fell again to 31.3 kgoe/thousand PLN in 2021. It means that in comparison with the previous year and 2000, its decrease was noted by 5.1% and 72.3%.

Final energy intensity of transport is measured as a relation of final energy consumption of transport sector to GDP (constant prices) and in 2021 it was 9.4 kgoe/thousand PLN. It was lower in relation to 2020 and 2000 by 3.0% and 27.6% respectively.

3.6. Renewable energy

> **Renewable energy** is the energy derived from natural, repetitive environmental processes, obtained from renewable non-fossil energy sources (energy: hydro, wind, solar heat, geothermal heat, waves, sea currents and tides and energy obtained from solid biofuels, biogas, liquid biofuels) as well as natural environment energy used by heat pumps.

Growing demand for energy, resulting from civilizational growth and care for environment, leads to the increase of renewable energy consumption.

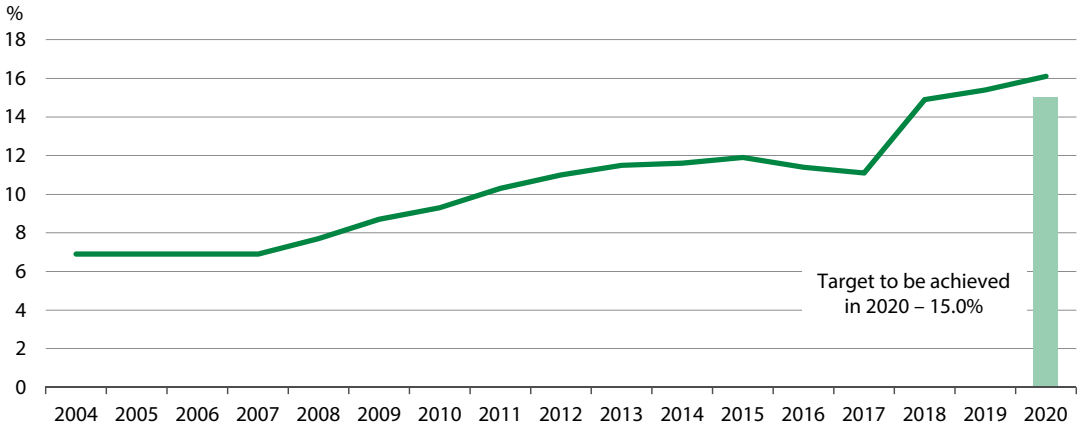
In recent years, renewable energy sources (RES) have been used as an alternative to traditional energy resources. The main reason for their growing popularity is the fact that they can be treated as inexhaustible and, at the same time, decisively less dangerous to environment than traditional energy carriers, primarily because of the reduced emission of harmful substances. Energy generation with the use of traditional sources is regarded as one of the causes of alarming climate changes, and global resources of traditional carriers are constantly diminishing.

Within the last 16 years there was a constant increase in the amount of renewable energy, from 4.3 Mtoe in 2004 to 12.5 Mtoe in 2020. Solid biofuels occupied the first position in Poland (71.6%) in the structure of energy generation with the use of renewable sources by type of carriers. The share of remaining carriers was as follows: wind energy (10.9%), liquid biofuels (7.8%), biogas (2.6%) as well as heat pumps (2.4%).

The increase in the share of renewable energy in gross final energy consumption is a part of energy policy of the European Union, Poland included. For the latter the goal concerning this issue was established at 15% to be achieved in 2020[4]. What is more, it was assumed that the share of renewable energy in all means of transport by the year 2020 would constitute at least 10% of final energy consumption in transport.

In 2020, the share of renewable energy in gross final energy consumption was 16.1%, which is indicative of an increase in relation to the previous year and 2004 by 0.7 pp and 9.2 pp respectively (chart 13). It means that Poland achieved the 15% target set, in line with EU commitments.

Chart 13. Share of renewable energy in gross final energy consumption



Source: Eurostat database (access date 12 November 2022).

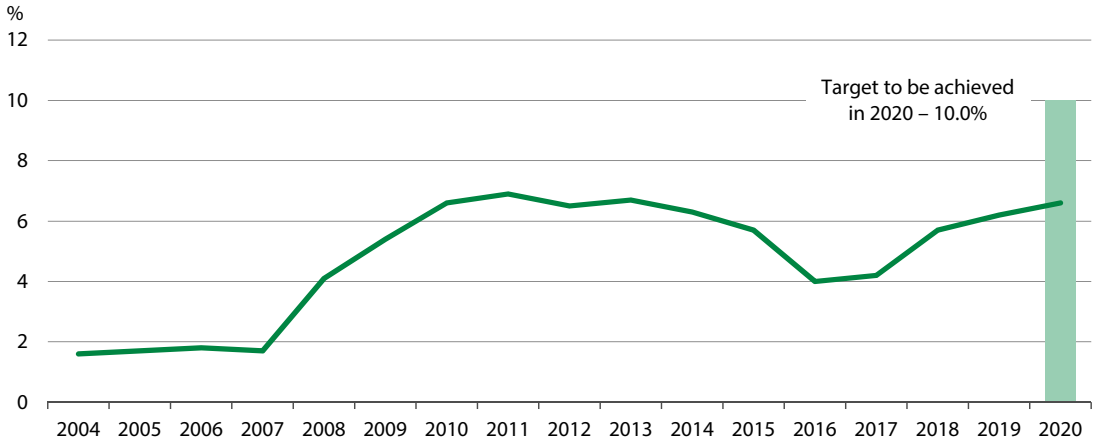
Eurostat database provides such information that in 2020 the share of renewable energy in gross final energy consumption was 22.1% in European Union countries (EU=27). The highest value of the indicator was noted in Sweden (60.1%), Finland (43.8%), Latvia (42.1%) and Austria (36.5%), the lowest, however, in Malta (10.7%), Luxembourg (11.7%) and Belgium (13.0%). Among EU countries, Poland ranked 22nd.

The growth of the number of cars and the development of the transport sector lead to the growing demand for energy, including crude oil. It generates problems connected with the increase in natural environment pollution and with petroleum depletion, additionally, makes it necessary to enhance alternative fuels (i.a. liquid biofuels) use in transport.

In the period 2004–2011, in Poland a constant increase of the share of renewable energy in fuel consumption of transport was noted and its highest level (6.9%) was reached in 2011 (chart 14). In the years 2013–2016, the share gradually decreased from 6.7% to 4.0%, and then started to increase year on year to 6.6% in 2020. It means that Poland did not reach the set target of 10% by 2020.

[4] On the basis of Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources.

Chart 14. Share of renewable energy in transport



Source: Eurostat database (access date 12 November 2022).

Liquid biofuel production for transport grew from 13.4 thousand toe in 2004 to 975.1 thousand toe in 2020. In the structure of energy generation from liquid biofuels, from 2004 a dominating position belonged to biodiesel (in 2020 – 86.4% of the total energy production from liquid biofuels), the remaining part – to bioethanol (13.4%) and other biofuels (0.2%).

Inferring from Eurostat data, in 2020 the share of renewable energy in transport in European Union countries (EU=27) equalled 10.2%. Among EU countries, 12 countries exceeded the 10% target. The biggest share was achieved by Sweden (31.9%) and Finland (13.4%), and the smallest one – by Greece (5.3%). Among EU countries Poland ranked 25th.

3.7. Greenhouse gas emissions

Greenhouse gases are gases preventing the emission of infrared radiation from Earth, causing surface warming. They are emitted to atmosphere as a result of natural processes and human activity. According to the Kyoto Protocol greenhouse gases (the Kyoto basket) refer to carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

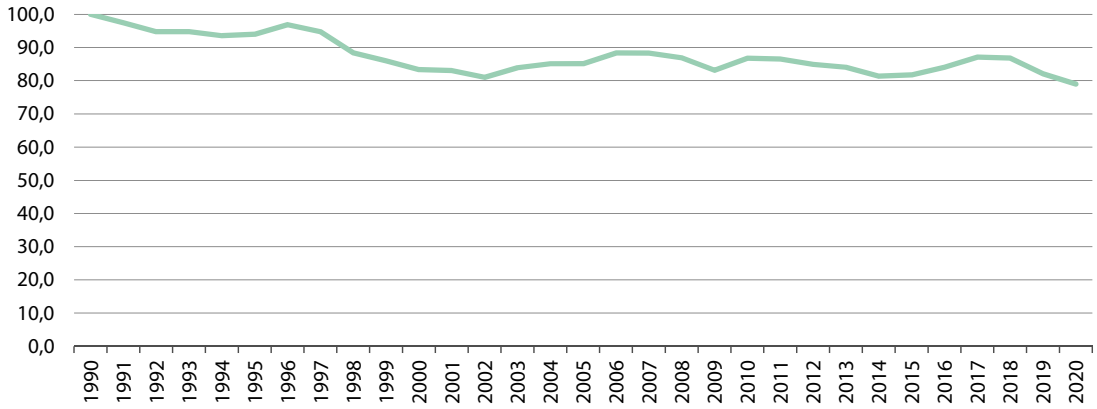
The Republic of Poland has entered international activities aiming at preventing climate change by ratifying in 1994 the United Nations Framework Convention on Climate Change (1992) as well as in 2002 the Kyoto Protocol (1997). One of the main obligations arising from signing the Kyoto Protocol by Poland was the greenhouse gas emission reduction in the years 2008–2012 by 6% in relation to the base year, which was the year 1988 for Poland. In 2012, greenhouse gas emission in Poland was 404.2 million tonnes of CO_2 equivalent[5], which means a significant fall by 30.2% in comparison to 1988 (graph 15). This reduction was substantially larger and exceeded the Polish obligation.

It is necessary, however, to reduce greenhouse gas emissions further on. According to the Doha amendment and "Europe 2020" strategy in the period of 2013–2020, countries jointly with European Union planned to reduce the emission by at least 20% in relation to the base year (for the majority of countries it was 1990). In 2020, according to the data of KOBiZE (the National Centre for Emissions Management), in Poland greenhouse gas emissions (excluding emissions from international aviation and maritime

[5] The equivalent is understood as one megagram (1 Mg) of CO_2 or the amount of any other greenhouse gas being an equivalent of 1 Mg of carbon dioxide, calculated using an appropriate warming potential. Global warming potential for carbon dioxide is – 1, for methane – 25, nitrous oxide – 298.

transport and land use, land use change and forestry) amounted to 376.0 million tonnes of CO_2 equivalent. It means that their emissions were reduced compared to 1990 by 21.0% (chart 15).

Chart 15. Dynamics of greenhouse gas emissions
1990=100

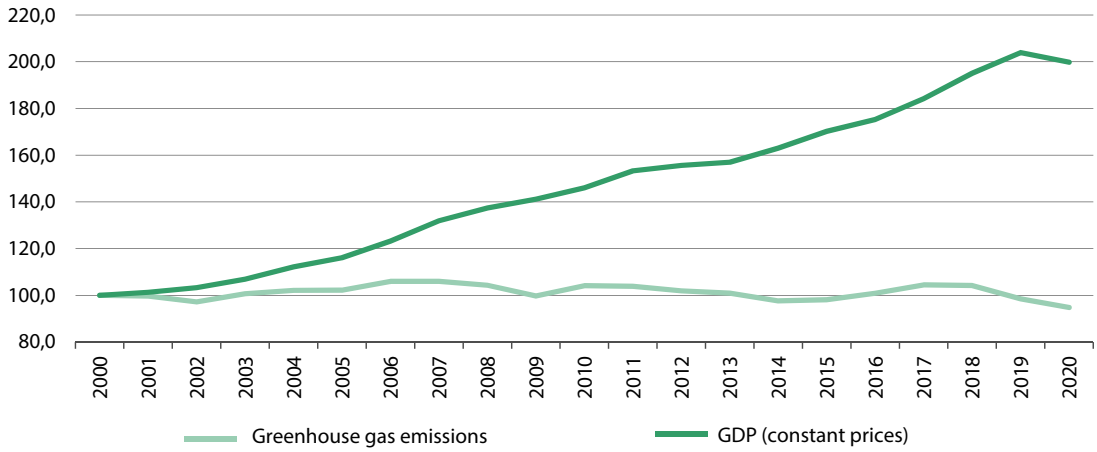


Source: own elaboration on the basis of data of the National Centre for Emissions Management (access date 14 November 2022).

Eurostat database shows that in 2020 greenhouse gas emission (excluding emissions from international aviation and maritime transport and land use, land use change and forestry) in 27 EU countries equalled 3298.2 million tonnes of CO_2 equivalent and was by 31.9% lower than in 1990. The greatest decrease in this emission in comparison with 1990 was observed in Estonia (by 71.2%), Latvia (by 59.6%) and Lithuania (by 57.8%). Two EU countries experienced an increase in their emissions, i.e. Cyprus (by 59.0%) and Ireland (by 6.1%).

During the years 2001–2020 in Poland the GDP growth rate in comparison to 2000 was decisively faster than the greenhouse gas emission rate. It was a positive phenomenon, because it indicated a limited correlation between economic growth measured by GDP and pressure on the environment caused by greenhouse gas emissions (chart 16).

Chart 16. Dynamics of greenhouse gas emissions and GDP
2000=100



Source: data regarding greenhouse gas emissions – the National Centre for Emissions Management (access date 14 November 2022).

In 2020, the largest share of greenhouse gas emission in Poland had carbon dioxide (80.7% of total emission), followed by methane (11.8%), nitrous oxide (6.1%) and fluorinated gases (1.4%).

In accordance with the classification prepared by Intergovernmental Panel on Climate Change (IPCC), in 2020 the sector most responsible for greenhouse gas emission was the energy one (81.2% of total emission) and in a smaller scope – agriculture (9.1%), industrial processes and product use (6.7%) followed by waste management (3.0%). Carbon dioxide emission, as the dominant greenhouse gas, was mainly affected by energy sector (93.0%), industrial processes and product use (6.3%).

In 2007, the European Commission presented the so-called 2020 climate and energy package, which, among others, diversifies greenhouse gas emission reduction targets in 2020 in relation to emission levels in 2005 for sectors in and not in the European Union Emissions Trading System. For sectors not covered by the ETS, the so-called non-ETS sectors[6], for Poland there was a proposal of a 14% increase in the greenhouse gas emissions in 2020 in comparison to 2005 (the EU average – a 10% reduction). According to Eurostat data, in 2020, the total greenhouse gas emissions expressed in CO_2 equivalent in non-ETS sectors in Poland were 202.0 million tonnes, which is a 12.1% increase in comparison with 2005.

[6] Non-ETS emissions include the following sectors: transport, agriculture, waste, industrial emissions outside the EU ETS and the municipal and housing sector with buildings, small sources, households, services, etc.

Chapter 4

Environmental quality of life

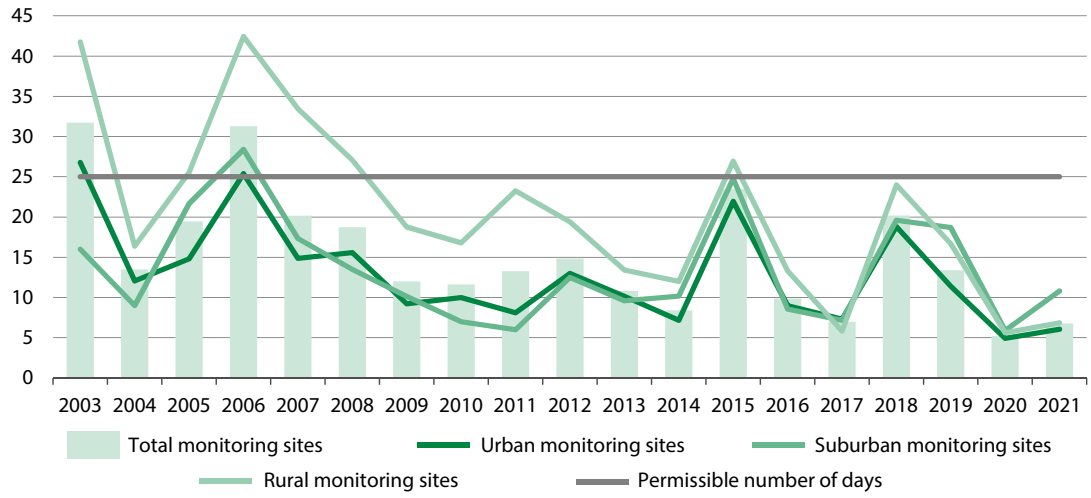
4.1. Gaseous air pollutants

Tropospheric ozone (ground-level O_3) is secondary pollution, released in the ground level of the atmosphere as a result of photochemical transformations (upon exposure to solar radiation) in the air polluted with the so-called ozone precursor substances: nitrogen oxides, carbon oxides (CO), methane (CH_4), non-methane volatile organic compounds (NMVOCs). Ozone concentration level is also affected by such weather conditions as: high air temperature, high insolation and a lack of precipitation.

Air pollution is one of the main causes of threat to environment. It affects all these: the environment, health condition and quality of life of population. It cannot be restricted by area, so that it can contaminate vast distance areas. One of the most important negative results of air pollution in Poland is the increase in tropospheric ozone concentration in the ground layer of the atmosphere (ground-level O_3), especially in a summer season.

Due to health protection, the target value determined for ozone amounts to 120 µg/m^3 and is calculated on the basis of maximum daily 8-hour mean of ozone concentration from all monitoring sites. 25 days exceeding the target value within a calendar year are allowed. In 2021, the average number of days with the exceeded target value calculated on the basis of measurements taken at all sites that were used to assess ozone air pollution amounted to 7 and was higher than one noted in 2020 – 5 days (chart 17). The years with the highest number of days exceeding the limit were 2003 – 32 days, 2006 – 31 days and 2015 – 24 days.

Chart 17. Average number of days with exceeded value of 120 µg/m^3 by 8-hour ozone concentration by type of monitoring site[a]

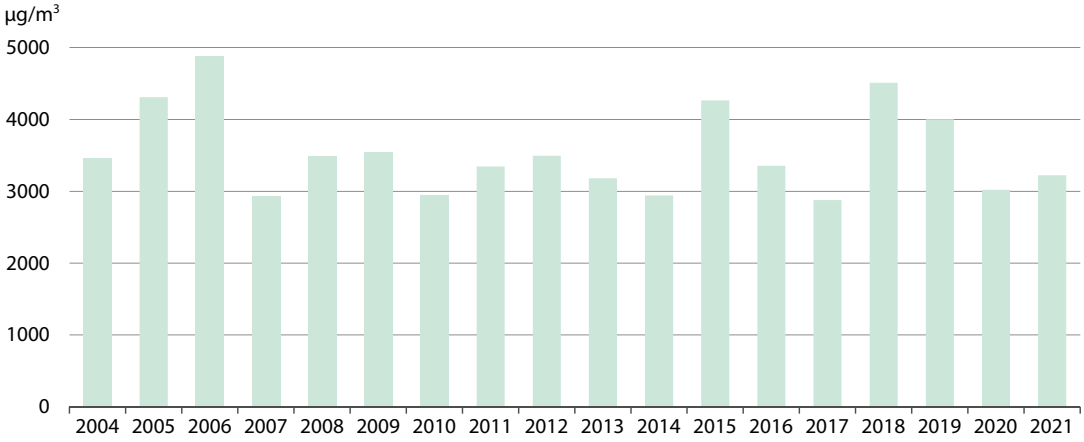


a Data from full data series from monitoring sites obtained under the State Environmental Monitoring.

Source: own elaboration on the basis of data of the Chief Inspectorate of Environmental Protection.

The exposure of city residents to ozone can also be assessed on the basis of SOMO35 indicator. It presents the yearly sum of means of daily 8-hour O_3 concentrations over 70 µg/m^3. The accepted value of this indicator is not stated, however, the higher the level, the higher the threat to human health. In 2021 this indicator equalled 3224,4 µg/m^3 and it was higher than in 2020, but lower than in 2004 (chart 18).

Chart 18. Urban population[a] exposure to air pollution by ozone (SOMO35)



a In agglomerations over 250 thousand inhabitants.

Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring.

Exposure of humans (especially children, the elderly, and people spending much time outdoors) to high concentrations of tropospheric ozone causes numerous negative health conditions. It can lead to eye irritation, increased susceptibility to infections, reduced lung capacity, deterioration of asthma and other lung disorders, moreover to premature mortality. The European Environment Agency estimated (on the basis of SOMO35 indicator) that air pollution with ozone caused 1.7 thousand premature deaths in Poland in 2020. Among European Union countries (EU=27), the worst situation in this respect occurred in Italy (5.1 thousand) and Germany (4.6 thousand), while the best in Luxembourg, Estonia and Malta (0.0 thousand each).

4.2. Particulate air pollutants

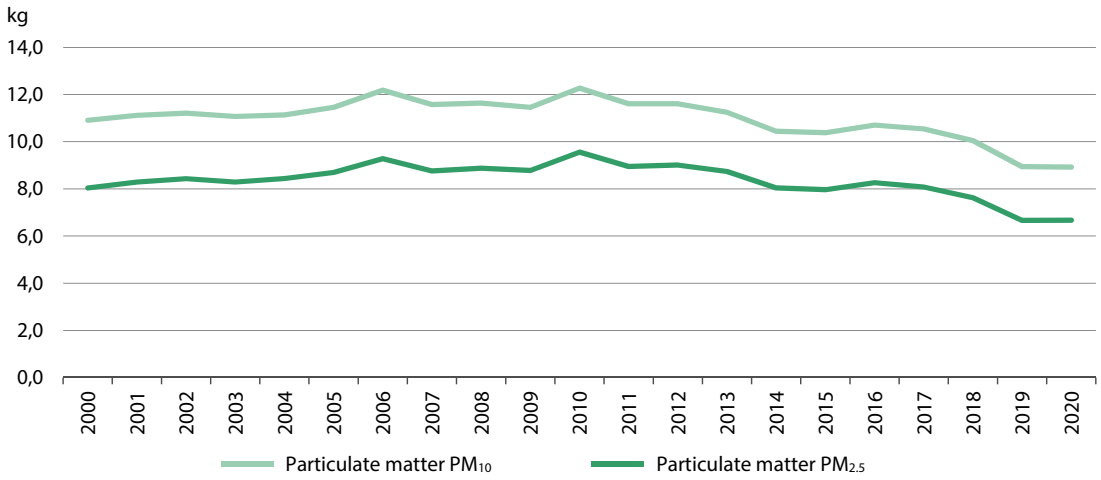
Particulate matter is air pollution that is a mixture of fine solid and liquid particles, consisting of both organic and inorganic compounds. The surface of particulate matter is a carrier of chemical compounds toxic to human health, such as heavy metals (arsenic, nickel, cadmium, lead) and polycyclic aromatic hydrocarbons (e.g. benzo(a)pyrene).

A serious problem connected with air quality in Poland is exceeded norms for particulate matter, especially in a winter season, which mainly influences comfort of living of population of inner-city areas of big cities and agglomerations. Particulate matters come from direct emission (primary particles) or as a result of reaction between substances in the atmosphere (secondary particles). Secondary particle precursors are mainly sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia. Particulate matter contains the fraction of grains below 10 micrometres (PM_{10}), including the fraction below the diameter of 2.5 micrometres ($PM_{2.5}$). The PM composition largely depends on where it comes from, the season of the year and weather conditions.

In 2020, PM_{10} emission amounted to 340.4 thousand tonnes and was lower in relation to the previous year and 2000 by 0.8% and 18.4% respectively. In the case of $PM_{2.5}$, its emission equalled 254.5 thousand

tonnes and decreased compared to 2019 and 2000 by 0.4% and 17.2% respectively. Per capita in 2020, the emission of PM_{10} was 8.9 kg, of which $PM_{2.5}$ – 6.7 kg and the figures for these were the lowest in relation to the ones noted since 2000 (chart 19).

Chart 19. Emissions of PM_{10} and $PM_{2.5}$ per capita



Source: data concerning particulate matter emission – the National Centre for Emissions Management – the Institute of Environmental Protection – National Research Institute.

In the European Union countries (EU=27), on the basis of the European Monitoring and Evaluation Programme (EMEP) data, the indicator in 2020 was 4.0 kg for PM_{10} and 2.6 kg for $PM_{2.5}$ respectively. The highest PM_{10} emissions, including $PM_{2.5}$ per capita, were recorded in Latvia (13.7 kg and 8.8 kg respectively) and Croatia (12.7 kg and 7.0 kg), while the lowest ones in the Netherlands (1.6 kg and 0.8 kg) and Germany (2.2 kg and 1.0 kg).

In 2020, in Poland the highest direct emission of PM_{10} was caused (according to the Nomenclature for Reporting) by fuel combustion processes, which were responsible for 78.6% of the national PM_{10} emissions. Among these processes, the emissions from "other sectors" category (i.e. from institutions, trade, services, households, fuel combustion in agriculture, forestry and fishing) were dominant – their share in the national PM_{10} emissions amounted to 65.0%. Emissions of this particulate matter came mainly from heating of buildings with hard coal and wood by households. In 2020, other significant sources of PM_{10} emissions were industrial processes and product use, which generated 8.7% of total emissions of particulate matter of this kind, as well as agriculture sector (8.7%).

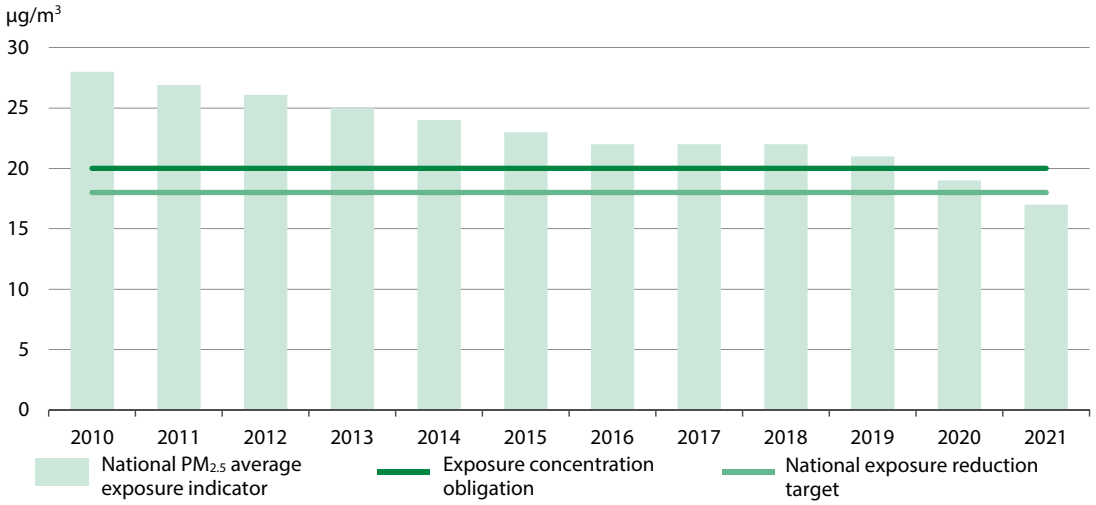
$PM_{2.5}$ particulates (just like PM_{10}) were mostly emitted during fuel combustion processes, which accounted for 93.1% of their total emission in 2020. Within this combustion processes the biggest share was in "other sectors" category (78.1% of the total $PM_{2.5}$ emission), manufacturing industries and construction came next with 9.2%, followed by transport with its 4.3% share.

The indicator of population exposure to PM_{10} reflects the average level of PM_{10} in the air determined on the basis of measurements carried out in urban background areas, and its permissible level for the mean annual concentration is 40 $\mu g/m^3$. According to Eurostat, in 2019, the indicator in Poland was 27.0 $\mu g/m^3$ and was the lowest one since 2000. However, it significantly exceeded the European average of 20.5 $\mu g/m^3$. Among European Union countries (EU=27), higher value than in Poland was noted only in Croatia (30.9 $\mu g/m^3$), Bulgaria (30.4 $\mu g/m^3$) and Greece (27.5 $\mu g/m^3$), while the lowest in Finland (10.2 $\mu g/m^3$) and Estonia (10.8 $\mu g/m^3$).

The national $PM_{2.5}$ average exposure indicator is determined on the basis of measurements obtained under the State Environmental Monitoring in cities over 100 thousand inhabitants and agglomerations. It

reflects the population exposure to air pollution by $PM_{2.5}$ and is calculated as the arithmetic mean of the average annual $PM_{2.5}$ concentrations from three years. In 2021, the indicator amounted to 17 µg/m^3 (chart 20). The year 2021 was another one when the national $PM_{2.5}$ average exposure indicator decreased and the first year when the indicator did not exceed the national exposure reduction target (18 µg/m^3) planned to be achieved until 2020. In addition, the value of the national average exposure indicator in 2021 was 15.0% below the exposure concentration obligation (20 µg/m^3), which is the air quality standard to be provided since 2015.

Chart 20. National $PM_{2.5}$ average exposure indicator



Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring.

According to Eurostat, in 2019 Poland (with $PM_{2.5}$ average exposure indicator at the level of 19.3 µg/m^3) ranked second after Bulgaria (19.6 µg/m^3) among European Union countries (EU=27) in terms of urban population exposure to $PM_{2.5}$. The indicator significantly exceeded the average for the European Union (12.6 µg/m^3). The least exposed to air pollution by $PM_{2.5}$ was the urban population of Estonia (4.8 µg/m^3) and Finland (5.1 µg/m^3).

Atmospheric pollution most harmful for human health is $PM_{2.5}$. Grains of such minute size can reach upper airways, lungs and enter blood, and as a result of a longer exposure to high concentration, they can have considerable influence on the course of heart diseases (hypertension, heart attack) or on the increase of the risk of contracting cancer diseases, especially the lung one. The European Environment Agency estimated that in 2020 $PM_{2.5}$ exposure led to 36.5 thousand premature deaths in Poland. Among European Union countries, higher values were recorded only in Italy (52.3 thousand). The least premature deaths due to this reason occurred in Estonia, Finland and Luxembourg (0.1 thousand each).

4.3. Noise[1]

Noise is defined as every sound that causes nuisance, is undesirable or harmful to human health, caused by means of transport in road, rail, and air traffic as well as coming from an economic activity area.

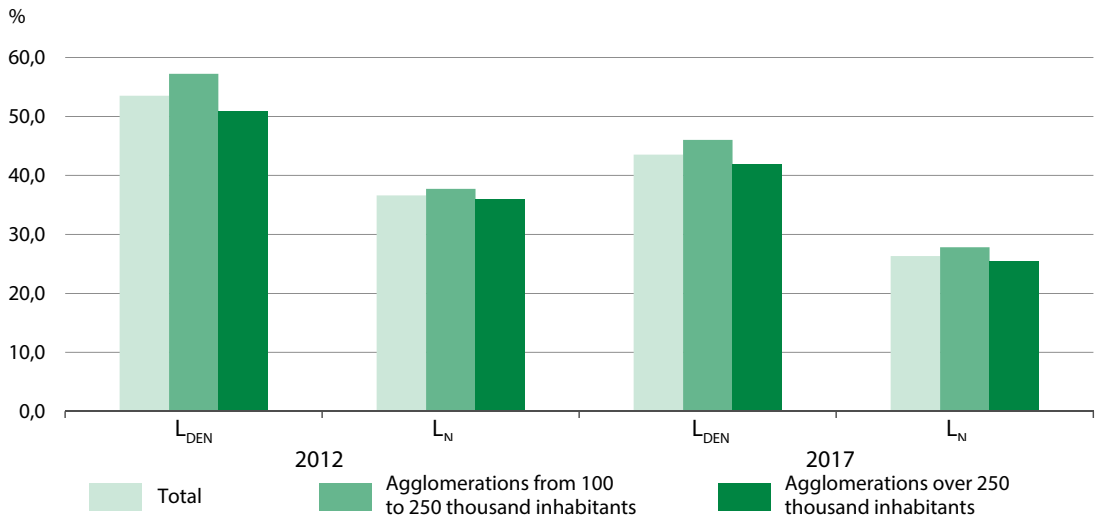
Noise is one of the main environmental factors affecting the quality of life and comfort of living. The problem of excessive noise in environment, especially the urban one, is increasing and leading to human fatigue, stress, cardiovascular diseases, the weakening of both the immune system and the autonomic nervous system.

Reducing noise in environment is a long-term process. Limitation of noise to the permissible levels is one of the greatest challenges that Poland is facing.

Road traffic noise

Road traffic noise is a nuisance for residents, especially in urban areas. As a result of rapidly developing transport infrastructure, and the road network and the growth in the number of vehicles used in particular, in 2017, 43.5% of population of cities[2] over 100 thousand inhabitants was exposed to exceeding noise over 55 dB in the day-evening-night time (L_{DEN} indicator) (chart 21). In the night-time (L_N indicator) the situation was a bit better, although still unsatisfactory as 26.3% of city population was exposed to the noise exceeding 50 dB. In comparison to 2012, the situation improved, as both in day-evening-night time and in night time, the percentage of people exposed to excessive noise decreased by 10.0 pp and 10.3 pp respectively.

Chart 21. Percentage of population exposed to road traffic noise in agglomerations over 100 thousand inhabitants

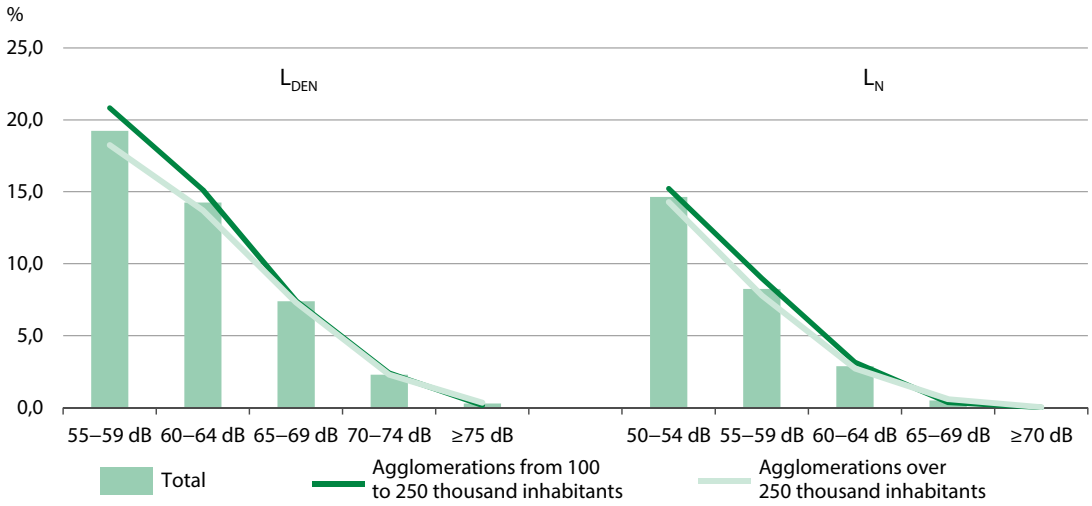


Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring based on acoustic maps.

[1] The assessment of the acoustic state of the environment and the observation of changes is carried out obligatorily every 5 years as part of the State Environmental Monitoring (PMŚ) by the Chief Inspectorate of Environmental Protection. The last assessment took place in 2017.
[2] The study based on acoustic maps in 2012 and 2017 covered respectively 35 and 37 agglomerations out of 39 ones with over 100 thousand inhabitants.

Monitoring of road traffic noise in agglomerations carried out in 2017 proves that the highest percentage of population was exposed to noise exceeding the norm by up to 5 dB in day-evening-night time – 19.2% and in night time – 14.7% (chart 22). In relation to 2012, this percentage decreased by 1.2 pp in day-evening-night time and by 2.8 pp in night time.

Chart 22. Percentage of population exposed to road traffic noise in agglomerations in particular classes of noise levels in 2017



Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring based on acoustic maps.

Railway noise

Railway noise, after road traffic noise is one of the most common type of traffic noise, the most troublesome for city inhabitants.

Based on data from acoustic maps obtained in 2017, 231.4 thousand population in the area of 37 agglomerations over 100 thousand inhabitants was exposed to excessive noise above 55 dB in day-evening-night time and in night time – 143.7 thousand. They constituted 2.2% and 1.4% of total population of the analyzed cities respectively. In relation to 2012 (this percentage was at the level of 4.0% and 3.1%) the situation improved, which may be the result of railway lines and rolling stock modernization.

Aviation noise

Aviation noise concerns a relatively small number of population of Poland, residing in the zones located near airports, yet, it seems to be causing most disturbance.

Aviation noise pollution identified in 2017 on acoustic maps concerned 6 agglomerations with an airport located within their boundaries (5 agglomerations in 2012). The number of population exposed to this type of noise was significantly dependant on the part of the day. In day-evening-night time 52.1 thousand population suffered noise exceeding 55dB (i.e. 1.5% of total population of the analysed agglomerations) whereas in night-time (the noise over 50 dB) – 5.9 thousand population (i.e. 0.2%). A comparison of these data and data from 2012 shows an improvement in day-evening-night time because the number of population exposed to aviation noise decreased by 14.7%. The situation reversed in the case of noise pollution in night-time as the number of population exposed to this kind of noise increased by 40.5%.

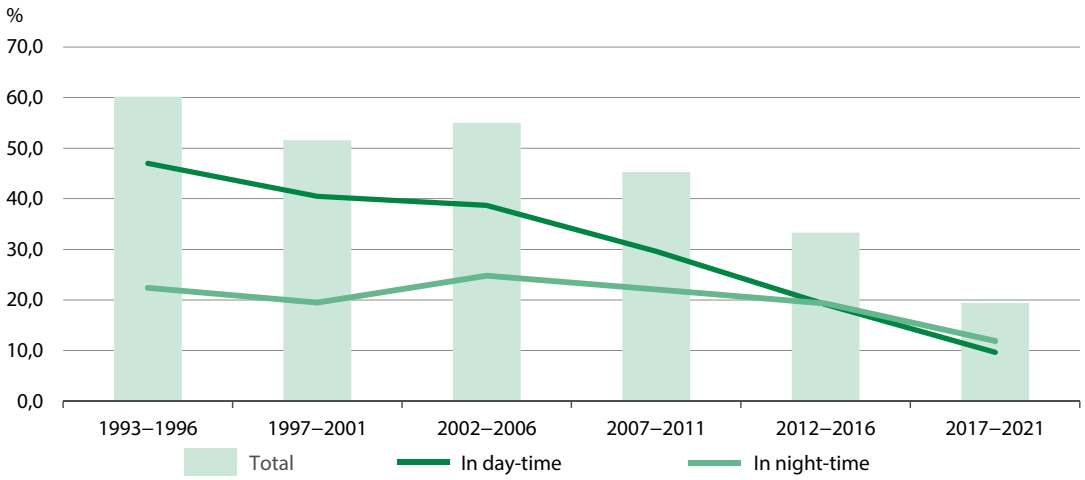
Industrial noise

Industrial noise measurement is performed mainly as a response to residents' complaints about activity causing disturbance, mainly by the entertainment, recreation and sports, service and industry sectors carried out by both small district businesses as well as medium and large plants.

According to the data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring based on acoustic maps in 2017, 21.6 thousand population noted industrial noise exceeding 55dB in day-evening-night time in 37 agglomerations in Poland. In night-time the noise above 50 dB caused disturbance to 9.5 thousand of population, which is a relatively small percentage of total population of the analysed agglomerations (0.2% and 0.1% respectively).

In the case of entities exceeding industrial noise limits, in the years 1993–2021, positive trends were noted in terms of the share of these entities in total number of inspected companies (chart 23). In each period of noise monitoring leading to the assessment of acoustic climate changes, a significant fall in this percentage was noted (from 60.2% within the years 1993–1996 to 19.4% in the period from 2017 to 2021), in day-time in particular (similarly – from 47.0% to 9.7%). In night-time, the percentage of units exceeding the permissible sound levels decreased from 22.4% to 11.9%.

Chart 23. Share of entities exceeding industrial noise limits in total number of inspected companies[a]



a Included in the central register of acoustic climate control of the Institute of Environmental Protection.
Source: data of the Chief Inspectorate of Environmental Protection obtained under the State Environmental Monitoring.

Data from the European Union Statistics on Income and Living Conditions (EU-SILC) may provide complementary information on noise. This survey specifies, among others, the percentage of households experiencing subjectively, in relation to their place of residence, excessive noise in their flats, coming from neighbours or from the street (caused by road traffic, industrial plants or economic activity).

The results of this survey show that in Poland the percentage of households affected by excessive noise is diminishing year by year (from 21.4% in 2005 to 12.6% in 2019), which can be indicative of the fact that population is getting used to surrounding noise or the noise is effectively eliminated. It is noteworthy that households with dependent children experience noise in a lesser degree than households without dependent children – the former – 21.0% in relation to the latter – 22.1% in 2005 and the former – 11.4% in relation to the latter – 14.1% in 2019.

According to Eurostat estimates, in 2020, in European Union countries (EU=27) 17.6% of households suffered from excessive noise (no data for Poland for 2020). The lowest, most favorable value of the indicator was recorded in Estonia (8.0%), Croatia (8.1%) and Bulgaria (8.8%). In contrast, the highest percentage of such households occurred in Malta (30.8%), the Netherlands (25.5%) and Portugal (25.1%).

4.4. Access to drinking water

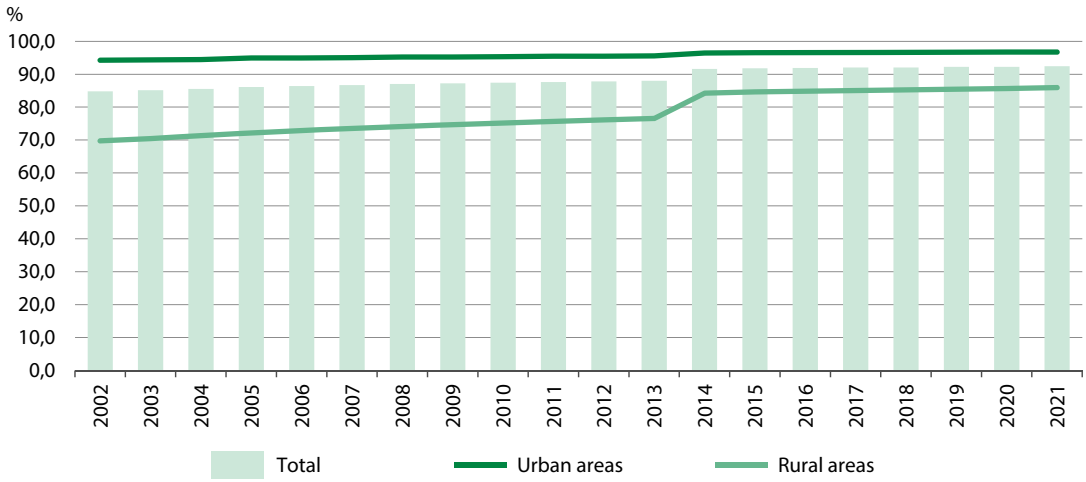
Population using water supply network concerns the estimated number of population inhabiting residential buildings and collective accommodation facilities connected to water supply network as well as population using water supply systems via street and yard outlets (devices installed to street water supply conduits).

Water, as one of the main constituents of natural environment, plays an economic, environmental and social role. Universal access to water from water supply network is one of the basic human needs and greatly influences health and quality of living.

Basic measurement of assessing changes towards making the economy greener in terms of water management is the indicator concerning population using water supply network.

In 2021, 92.4% of population used water supply network, which is an increase in relation to 2020 and 2002 by 0.2 pp and 7.6 pp respectively (chart 24).

Chart 24. Percentage of population using water supply network



In the period of 2002–2021 a positive trend in using water infrastructure was noted, especially in rural areas. In 2002, water supply network was used by 94.2% of urban population and only 69.7% of rural population. In 2021, the indicator in mind equalled 96.7% and 85.9% respectively, so the disparity between the city and the country was greatly reduced.

From the point of view of the living conditions of population, not only does access to water play an important role, but also this water quality. Water supplied to population must meet the requirements of drinking water and production purpose standards. Water supply plants have an obligation of constant quality control of delivered water so as to minimize the risk of its polluting. During the years 2002–2021 positive changes were noted in terms of water quality. There was an increase in the percentage of population supplied with water meeting requirements from 89.5% in 2002 to 99.5% in 2021.

In 2020, among European Union countries (with the exception of Croatia, for which data is not available), according to the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene data, the lowest percentage of the population using safely managed drinking water services was recorded in Romania (82.0%), Hungary (92.6%) and Latvia (94.9%). The best situation in this regard was recorded in Greece, the Netherlands, Germany and Malta, where the discussed indicator was at the level of 100%. Based on WHO/UNICEF estimates, 98.3% of the population in Poland used safely managed drinking water services.

4.5. Municipal sewage treatment

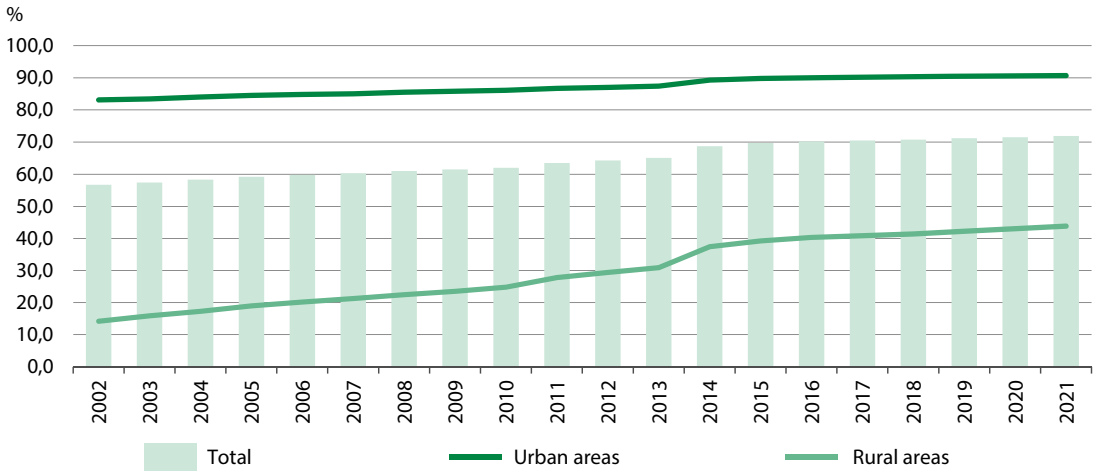
Population using sewage network concerns the estimated number of population inhabiting residential buildings and collective accommodation facilities connected to sewage network as well as population using sewage system via sewage inlets.

Sewage treatment plays an environmental, social, and economic role. Sewage produced by population is one of the main sources of environmental pollution. It can affect the quality of drinking and public bath water and additionally contribute to the loss of biodiversity. Insufficient access to sanitary installations can influence health and well-being of population. One of the challenges connected with environmental protection is ensuring sufficient public availability of sewage treatment.

The assessment of changes towards making the economy greener in terms of sewage management can be made, among others, on the basis of data concerning the percentage of population using sewage network.

In the period 2002–2021 the percentage of population using sewage network (chart 25) grew constantly. In 2021, 71.9% of population used this form of sewage disposal and in comparison to 2002, the share increased by 15.2 pp. Greater changes were noted in rural rather than urban areas. In 2021, this indicator in the cities amounted to 90.7% and was by 7.6 pp higher than in 2002. In rural areas the percentage of population using sewage network increased more than threefold over the last 19 years, from 14.2% in 2002 to 43.8% in 2021.

Chart 25. Percentage of population using sewage network



In case of a lack of possibility of connecting sanitation to a residential building, e.g. in dispersed housing areas, there are other solutions to be used. Population can use cesspools (i.e. collect wastewater in leak-proof septic tanks) or wastewater treatment facilities (so as to treat waste on their own). Using the other of these solutions enables the environmentally friendly neutralisation of harmful waste at the place of its production and offers greater comfort for the user as it does not require so many operational activities as in the case of cesspools. It is worth noting that the number of wastewater treatment facilities increased from 51.9 thousand pieces in 2008 to 371.0 thousand pieces in 2021. This number calculated per 1000 population not using sewage network grew over 8 times (from 3.49 in 2008 to 28.14 in 2021).

Based on the data from the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, in 2020, EU countries with the lowest percentage of population using safely managed sanitation services were Croatia (67.8%) and Slovenia (71.5%), while the highest: Austria (99.6%) and the Netherlands (97.5%). According to WHO / UNICEF estimates, Poland was 13th among 27 EU countries with a ratio of 90.5%.

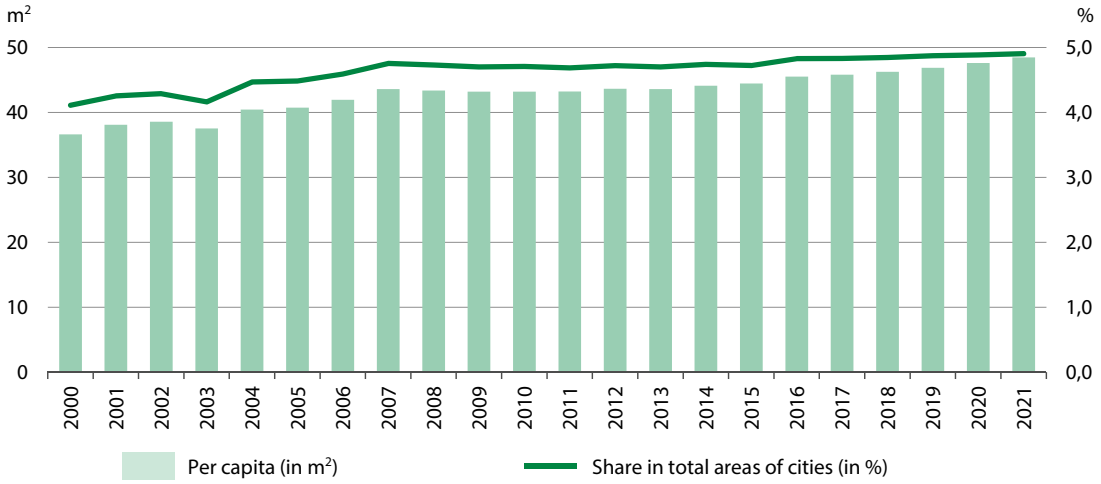
4.6. Green areas

Green areas in cities are gmina forests within cities as well as green areas including technical infrastructure and adjacent auxiliary buildings, covered with plants, which fulfil aesthetic, recreational, therapeutic or protective functions and in particular: strolling-recreational parks, lawns, green areas near municipal communication infrastructure, green areas of the housing estate, cemeteries as well as other ones.

Green areas have a positive and long-term influence on health and the quality of living of population. A problem with access to these areas affects mainly city residents, whose quality of living and health state is greatly dependent on the quality of urban environment. They are exposed to increased air pollution emission connected with car transport intensification and accumulation of economic activity in urban areas.

Green areas in cities, in this context, play an important role, as they provide many environmental, social and economic benefits, fulfilling, among others, protective, health, recreational or aesthetic functions. These areas improve the local quality of air by absorbing CO_2 and releasing oxygen to the atmosphere, affect inhabitants' general well-being in a positive way, reduce stress and annoyance caused by noise, they are a place of recreation and contribute to the creation of job places.

Chart 26. Green areas in cities[a]



a Since 2004 together with other areas, which include, i.a. greenery along railway tractions, airport and industrial facility greenery, and since 2005 – cemeteries.

In 2021, green areas in cities amounted to 109.6 thousand hectares. It means there were 48.5 m^2 of green areas per capita (chart 26), i.e. by 11.9 m^2 more than in 2000. The increase was mainly a result of enhancing street greenery and lawns as well as of the inclusion of cemeteries into green areas since 2005. In 2021, the share of urban green area in the total city area equalled 4.9% and was by 0.8 pp higher than in 2000.

Chapter 5

Economic opportunities and policy responses

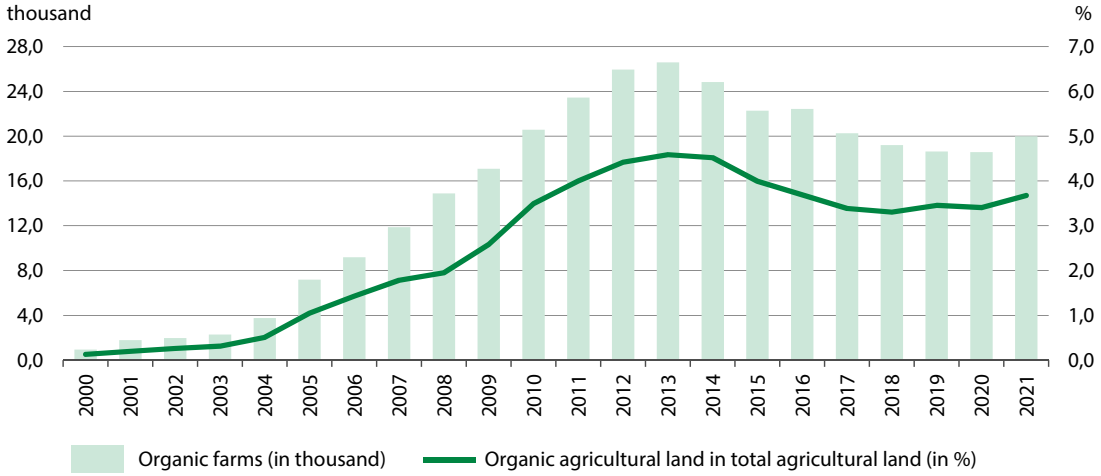
5.1. Organic farms

Organic farm is an agricultural holding, which has a certificate granted to it by a certification body after the conversion period and during the conversion period to organic methods of agricultural production under the control of the certification body.

Organic farming is environmentally friendly sustainable agricultural output. Due to controlled production methods and producing crops without synthetic fertilizers and chemical plant protection products it exerts a positive effect on natural environment – it helps to maintain biodiversity and to protect natural resources. It is also a response to consumers' demand of high-quality food produced in an organic farm system in accordance with ecological production methods.

In 2021, in Poland there were 20.0 thousand organic farms. They operated on 549.4 thousand hectares of agricultural land, i.e. 3.7% of total agricultural land. In relation to the previous year, their number and area increased by 7.6% and 7.9% respectively (chart 27). The average size of an organic farm was 27.5 hectares and was the highest since 2000. In the period from 2000, the largest number, as much as 26.6 thousand organic farms operated in 2013 on an area of 670.0 thousand ha of agricultural land.

Chart 27. Organic farms and organic agricultural land



Source: data regarding number of organic farms and organic agricultural land – Agricultural and Food Quality Inspection (IJHARS).

According to Eurostat estimates, in 2020, the total area of agricultural land on which organic production was carried out in 27 countries of European Union amounted to 14725.1 thousand hectares and accounted for 9.1% of total agricultural land in European Union. Among EU countries, the highest share of organic agricultural land in the total agricultural area of a given country was recorded in Austria (25.7%), and the lowest – in Malta (0.6%). In this respect, Poland ranked 23rd among 27 EU countries. In 2020, the largest number of organic farms operated in Italy (71.6 thousand), and the fewest in Malta (0.0 thousand).

Organic farming development may have been affected by, among others, aid granted to farmers since 2004 from the Rural Development Programme (RDP 2004–2006, RDP 2007–2013 and RDP 2014–2020), financed by the European Agricultural Fund for Rural Development and co-financed by the national budget, aiming at stimulating market organic output.

According to the data of the Agency for Restructuring and Modernisation of Agriculture, in 2021, the amount of payment for farms carrying out organic farming was PLN 485.0 million (as of 10 November 2022) and it was the highest amount of subsidies dedicated to organic farming in 2004–2021 . It increased in relation to the previous year by 39.3% and more than 13.5 times in comparison with 2004, when RDP 2004–2006 came into operation. Its share in the total amount of subsidies for farms (realising an agri-environment-climate actions and organic farming under RDP 2014–2020) equalled 31.5% and was by 2.8 pp higher in relation to 2020.

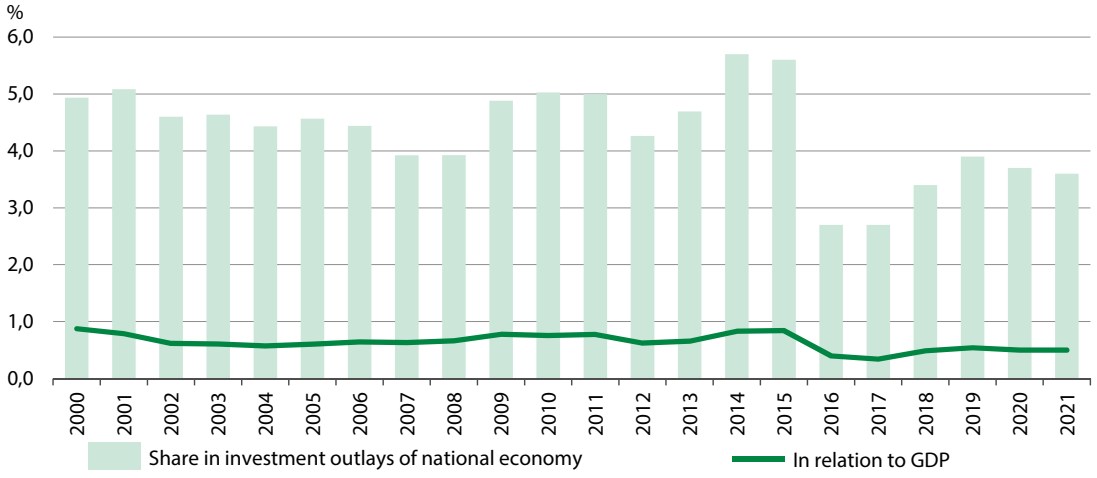
5.2. Outlays on environmental protection

Outlays on environmental protection is the sum of outlays on fixed assets for environmental protection and current costs borne by public and economic sectors as well as by households.

The intensification of natural resource exploitation by a man, connected with progressive urbanization, growing consumption, industrial and agricultural production, and transport development lead to resource depletion and to environment deterioration. Making use of environment and its resources requires incurring outlays, whose fundamental objective is to reduce the negative impact of humans on environment. From the point of view of green economy, monitoring outlays on fixed assets (investment outlays), which constitute a financial base for environmental protection, is very important.

In 2021, outlays on fixed assets for environmental protection (in current prices) amounted to PLN 12.4 billion, which is a decrease in relation to 2020 and 2000 by 8.2% and 88.4% respectively. In 2021, their share in relation to GDP (in current prices) equalled 0.5% (chart 28).

Chart 28. Outlays on fixed assets for environmental protection[a] (in current prices)



a GDP for 2021 – preliminary estimate.

In 2021, the share of outlays on fixed assets for environmental protection in investment outlays of national economy equalled 3.6% and it decreased in relation to 2020 and 2000 by 0.1 pp and 1.3 pp respectively.

In 2021, economic entity own funds were prevailing in the financing structure and amounted to 55.0% of total outlays on fixed assets for environmental protection, the next financing sources were, among others,

funds from abroad – 15.3%, ecological funds – 11.6%, domestic credits and loans – 9.5%. The majority of financial means were allocated to wastewater management and protection of water (46.0%), protection of air and climate (35.5%) as well as waste management (7.9%).

Households also incur expenditures on environmental protection. They are not subsidised and as a whole constitute a burden on a household budget. In 2021, the expenditures (in current prices) amounted to PLN 46.4 billion. Per capita they equalled 1223 PLN and were lower by 9.2% than in 2020 and over 3 times higher than in 2000.

According to Eurostat, in 2019, national expenditures on environmental protection in European Union countries (EU=27) amounted to EUR 282.1 billion. In relation to GDP they accounted for 2.0%. Poland was among the top EU countries with the highest share of this type of expenditure in GDP at the level of 2.8%, and followed Austria (3.5%) and Belgium (3.2%). Ireland had the lowest share (0.7%).

5.3. Environmental taxes

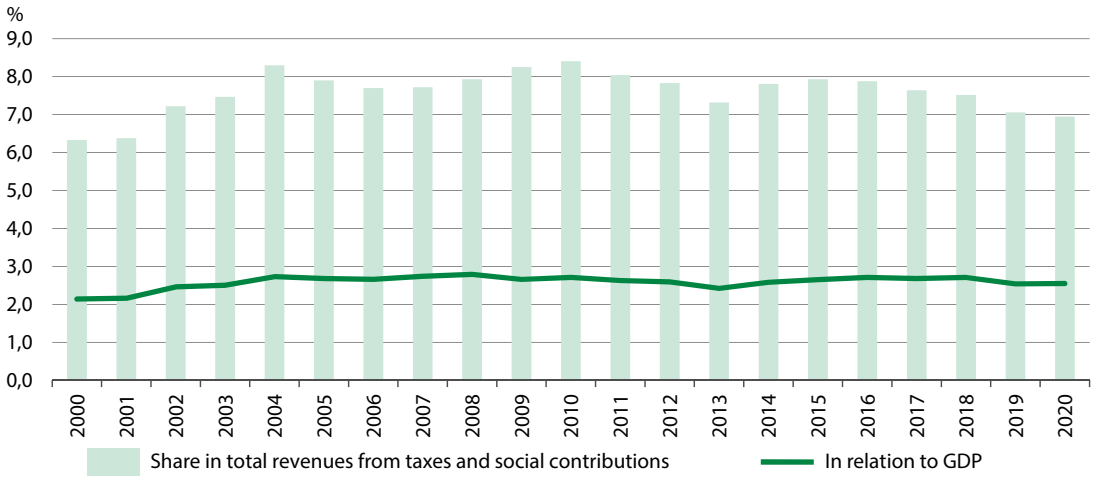
Environmental tax is a tax whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment, and which is identified in ESA 2010 as a tax.

Taxes related to environment (environmental taxes) are a basic economic instrument of environmental protection policy. Apart from their fiscal function ensuring tax revenue, they are to stimulate legal persons and society to undertake specified activities to reduce excessive pressure on the environment. According to a Eurostat methodology, environmental taxes distinguish four different categories of taxes in division by type, i.e. energy, transport, pollution and resources.

In 2020, revenues from environmental taxes amounted to PLN 59.2 billion and constituted 7.0% of the total revenue from taxes and social contributions (chart 29). They were lower in relation to the previous year (by 0.1 pp), but higher than in the year 2000 (by 0.7 pp). In the analyzed year, the ratio of environmental taxes to GDP was 2.6% and decreased compared to the previous year (by 0.1 pp), but increased in relation to 2000 (by 0.5 pp).

Among environmental taxes, the major fiscal impact exerted energy taxes, which contributed 87.9% of revenue from environmental taxes, and transport taxes – 7.2% of the revenue.

Chart 29. Environmental taxes



Source: Eurostat database (access date 2 November 2022).

According to Eurostat data, in 2020, in European Union countries (EU=27) the total amount of environmental taxes was EUR 299.9 billion. Their share in total revenues from taxes and social contributions amounted to 5.4%, and in relation to GDP – 2.2%. In the structure of taxes by type, energy taxes dominated, representing 77.5% of total environmental taxes, followed by transport taxes (19.0%).

The leading countries of EU with the highest share of environmental taxes in total revenues from taxes and social contribution were Bulgaria (9.9%) and Latvia (9.7%). The lowest share was noted in Luxembourg (3.5%) and Germany (4.1%). In relation to GDP the highest share of these taxes was recorded in Greece (3.8%) and Croatia (3.3%), while the lowest in Luxembourg (1.4%). Poland was 10th among EU countries in this respect. In all Member States, energy taxes prevailed among environmental taxes – their highest percentage was recorded in Czechia (93.6%) and Romania (92.4%), and the lowest in Malta (48.3%) and Denmark (52.2%).

5.4. Research and development (R&D) activity

Research and development activity (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.
Expenditures on R&D activity comprise all expenditures for R&D performed within statistical unit or sector of the economy during a specific period, whatever the source of funds. They include current expenditures and capital expenditures on fixed assets connected with R&D activity, excluding depreciation of fixed assets.

Research and development activity (R&D) plays an important role not only in economic growth but also in making the economy greener, because, apart from driving innovation and economy competitiveness forward, it can encourage, among others, activities aiming at improving efficiency of resource use in economy or reducing a negative impact of human activity on environment.

In 2021, intramural expenditures on R&D activity amounted to PLN 37.7 billion and increased by 16.3% in relation to 2020 and more than 7 times compared to 2000.

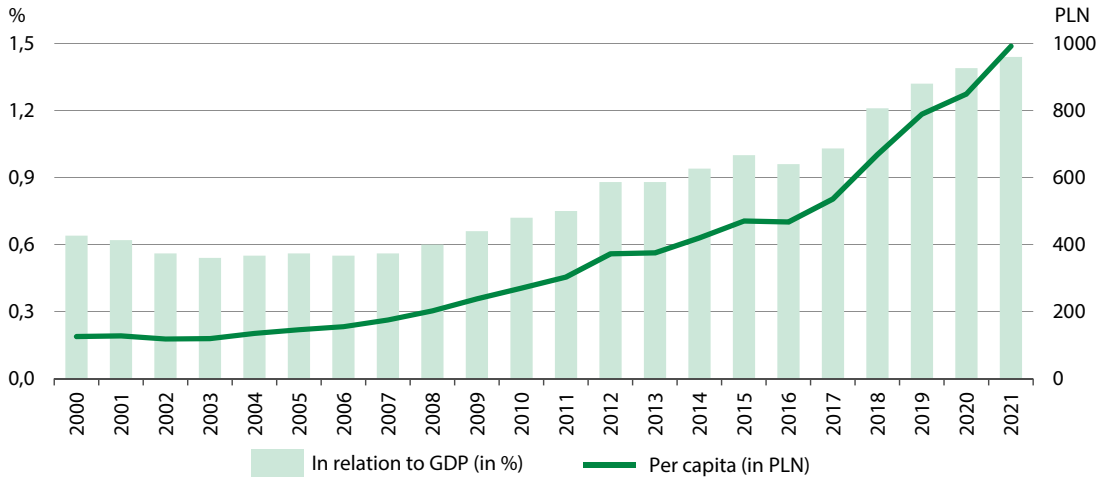
Entities in R&D are grouped in four sectors of performance, i.e. business enterprise, government, higher education and private non-profit. In 2021, the highest value of funds for R&D was allocated by the business enterprise sector – 63.1% of total expenditure in this category, whereas the share of higher education sector was 34.7%.

In 2021, as in previous years, the main sectors funding R&D activity were the business enterprise sector and the government sector, whose funds accounted for 50.9% and 37.4% of total internal expenditure on R&D respectively.

Research and development intensity, measured by the percentage ratio of research and development expenditure to GDP, is relatively low in Poland, but it shows a growing trend (chart 30). In the years 2000––2021, the minimum value of the indicator was recorded in 2003 (0.54%), while the maximum in 2021 (1.44%).

According to preliminary Eurostat data, in 2020, research and development intensity in 27 EU countries amounted to 2.31%, and among individual Member States ranged from 0.47% in Romania to 3.49% in Sweden. Poland, with the indicator at the level of 1.39%, took 17th position among EU countries.

Chart 30. Research and development (R&D) expenditure[a]



a Intramural, excluding depreciation of fixed assets.

While analysing R&B expenditure per capita, since 2003 a growing tendency has been noted in Poland (except for 2016). In 2021, it amounted to 992 PLN, i.e. by 16.8% more than in the previous year and almost 8 times more in comparison with 2000.

According to preliminary Eurostat data, in 2020, gross domestic expenditure in research and development activity (GERD) per capita in European Union (EU=27) was EUR 693.1. The highest expenditure of this type per capita was recorded in Sweden (EUR 1623.8) and Denmark (EUR 1589.5), while the lowest in Romania (EUR 53.1) and Bulgaria (EUR 75.3). Poland, with index value of EUR 192.1, took 20th place among 27 Member States.

Activity to protect environment so as to restore or maintain environmental sustainability require financial means. In 2020, within expenditures on fixed assets for environmental protection it was spent as much as PLN 5.3 million on research and development activity in Poland. They were higher by 38.9% than in the previous year but lower by 47.7% than in 2000.

5.5. Inventions and patents

Patentable invention is a new solution of a technical problem which involves an inventive step (i.e. it is not directly derived from the state-of-the-art – it is not obvious) and is industrially applicable. **Patent** is the exclusive right granted for inventions by a competent international body (e.g. the European Patent Office) or a national authority (in Poland – by the Patent Office of the Republic of Poland).

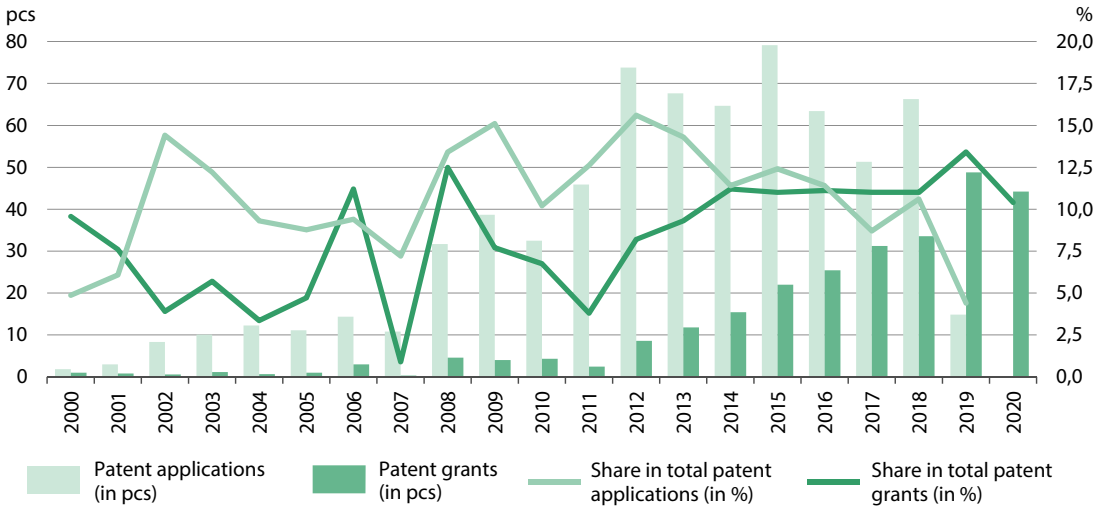
Patent applications and grants are classified according to the International Patent Classification. They are presented also by fields of technology based on WIPO IPC-Technology Concordance Table, on the basis of which environment-related technologies comprise such fields that are within the scope of, among others, air and water pollution abatement, waste management, soil remediation, environmental monitoring, renewable energy generation, capture, storage, sequestration or disposal of greenhouse gases, climate change mitigation technologies related to transportation and buildings.

Inventions in environment-related technologies play an important role in green economy, being a significant green growth factor. They contribute to the use of natural resources in an efficient way, reduction of negative influence of production and services on environment, and they can also lead to the creation

of new products, job places, technology innovations, and as a result of these, to the increase in the economy competitiveness. Patents, however, constitute a basis for efficient knowledge management in technology and support development potential of innovative economy.

In 2019, according to OECD database, Polish residents filed 15 patent applications within the field of environment-related technologies to the European Patent Office (EPO) (chart 31). Since 2000, the best result achieved by Poland was in 2015 and it amounted to 73 patent files. The percentage of patent applications in environment-related technologies in comparison to the total patent applications filed by Polish residents in 2019 comprised 4.4% and was lower than in the previous year and in the year 2000 by 6.2 pp and 0.5 pp respectively.

Chart 31. Patent applications and grants in environment-related technologies[a] – the European Patent Office



a The indicator is based on fractional counting to eliminate multiple counting of patent applications/grants with several inventors from different countries (e.g. a patent application submitted by two authors, one of whom is a Polish resident, is counted in the data as 0,5). Data on inventions are presented according to the application date of the invention to the EPO, and in the case of patents – according to the date of grant of the patent at the EPO.

Source: data of the European Patent Office/OECD Statistics (access date 2 November 2022).

In 2019, residents of EU countries (EU=27) filed 2.9 thousand patent applications within the field of environment-related technologies to the European Patent Office, which accounted for 10.7% of total number of inventions. The most active countries in this respect were Germany, with 1317 inventions of this type, i.e. 45.8% of total patent applications reported within the field of environment-related technologies in European Union, France – 545 (19.0%) and Italy – 229 (7.9%). Poland, with a share of 0.5% of the total number of patent applications within the field of environment-related technologies in the EU, came 12th.

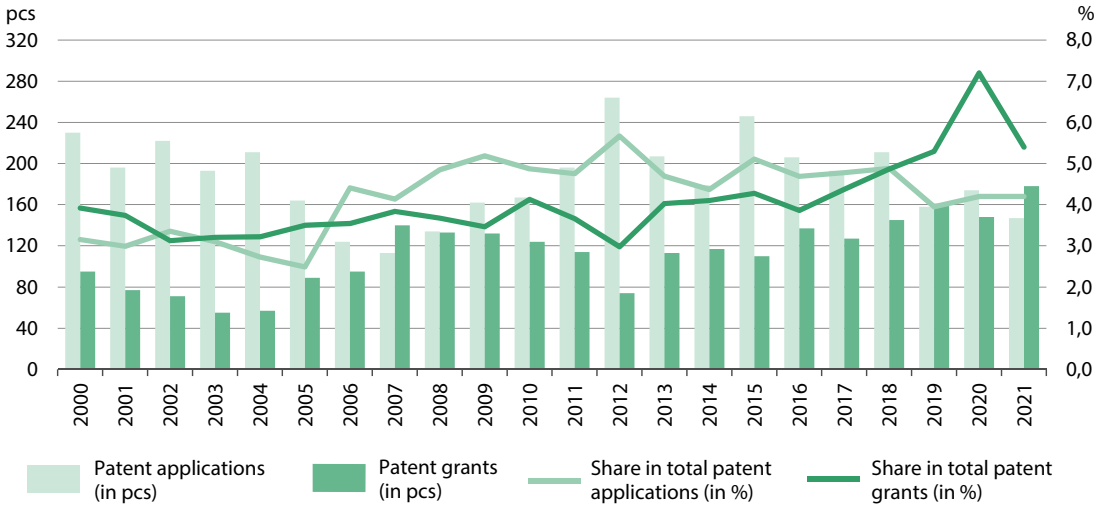
In 2020, the European Patent Office granted 44 patents in environment-related technologies to Polish residents. These patents constituted 10.4% of the total number of patents granted to Polish residents. In relation to the previous year their share decreased by 3.0 pp, but increased in comparison with the year 2000 by 0.8 pp.

In 2020, in European Union (EU=27) EPO granted 6.2 thousand patents in environment-related technologies, which accounted for 12.6% of the total number of patents. Most of them were granted to Germany – 2547, i.e. 41.1% of all patents granted in environment-related technologies in European Union as well as to France – 1158 (18.7%). Poland, with a share of 0.7% of the total number of patents in environment-related technologies in the EU, achieved 11th position among EU Member States.

From the perspective of the development of Polish green economy, patent applications filed to the Patent Office of the Republic of Poland and patents granted by this authority seem equally important (chart 32).

In 2021, the total number of patent applications in environmental technologies submitted to the Patent Office of the Republic of Poland equalled 147, which constituted 4.2% of total patent applications. It is a decrease in relation to the previous year and to the year 2000 by 15.5% and 36.1% respectively. From 2000 to 2021 the highest number of this type of inventions was noted in 2012 – 264 (5.7% of total patent applications). The greatest number was submitted by domestic entities – 253.

Chart 32. Patent applications and grants in environmental technologies – the Patent Office of the Republic of Poland



Source: data of the Patent Office of the Republic of Poland (according to the database as of 27 October 2020).

The Patent Office of the Republic of Poland, in 2021, granted 178 environmental technology patents, of which 172 ones to domestic entities. It was the highest score since 2000. Compared to the previous year and 2000, their number increased by 20.3% and 87.4%. Their share in total patent number constituted 5.4%.

5.6. Eco-innovation[1]

Eco-innovation is a new or significantly improved product (goods or service), process, organizational or marketing method, which brings benefits to environment.

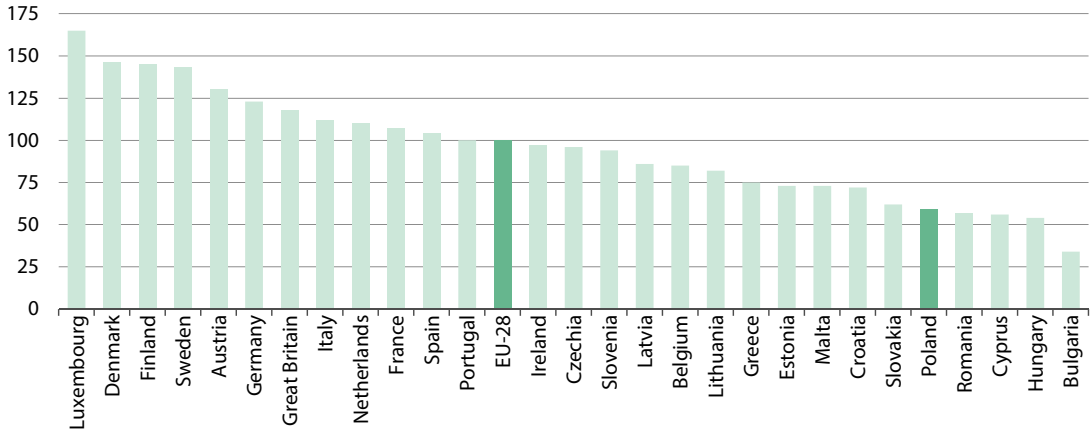
Eco-innovations help to improve efficiency of resource use in economy and to reduce the negative impact of human activity on environment. Apart from the ecological aspect, there is also an important economic aspect – eco-innovation application helps to reduce operating expenses, to use new development possibilities, to create a positive image of an entity, and, as a result of these, to increase competitiveness of the entity.

[1] Latest available data.

So as to make it possible to compare various aspects of eco-innovation, the eco-innovation index, the so-called the Eco-Innovation Scoreboard, was established, on the basis of 16 indicators grouped according to 5 thematic fields. It comprehensively compares eco-innovation results achieved by individual EU-28 countries with the EU average (EU-28=100).

According to the ranking presented in the chart, Poland is one of the countries with the lowest eco-innovation index among the EU-28 Member States (chart 33). In 2019, it came in 24th position (with a score of 59) in the eco-innovation ranking of EU countries. Together with Bulgaria, Hungary, Cyprus, Romania, Slovakia, Croatia, Malta, Estonia, Greece and Lithuania, it was classified to the group of "countries catching up in eco-innovation", achieving results below 85% of the EU average.

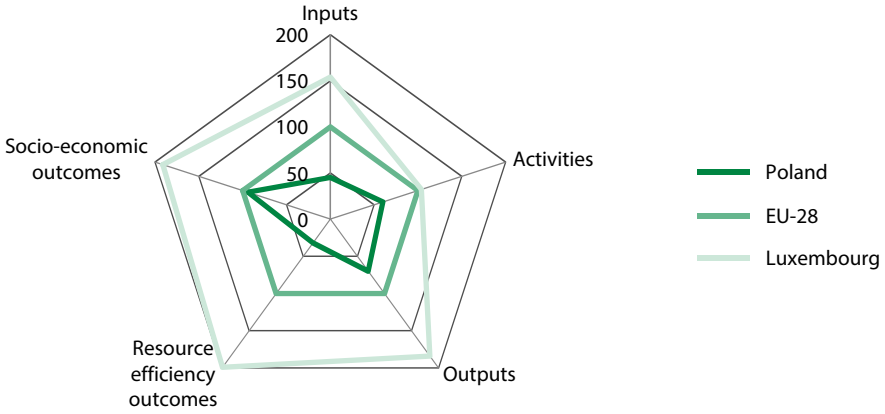
Chart 33. Eco-innovation index for the EU-28 Member States in 2019



Source: data of the European Commission – https://ec.europa.eu/environment/ecoap/indicators/index_en (access date 19 October 2020).

While analysing the results in the individual indicator groups that are generated for Poland (chart 34), it can be stated that, in 2019, the relatively strongest point of Polish eco-innovation against the background of EU countries was socio-economic outcomes, being the result of introducing eco-innovations (13th position with a score of 94). In the case of four remaining areas, i.e. within achieved eco-innovation outputs – Poland was ranked 18th (with a score of 70), within eco-innovation inputs – 22nd (with a score of 45), within resource efficiency outcomes – 26th (with a score of 32), whereas within eco-innovation activities – 25th (with a score of 60).

Chart 34. Poland against the background of the EU-28 Member States and the country with the highest eco-innovation index in 5 thematic areas in 2019



Source: data of the European Commission – https://ec.europa.eu/environment/ecoap/indicators/index_en (access date 19 October 2020).

The unfavourable position of Poland in this ranking can be a result of many factors, among others, financial barriers encountered by entrepreneurs and consumers, together with their insufficient awareness of the benefits coming from introducing eco-innovations, innovative technologies or insufficient government inputs on R&D, including the environmental one.

5.7. Green technology

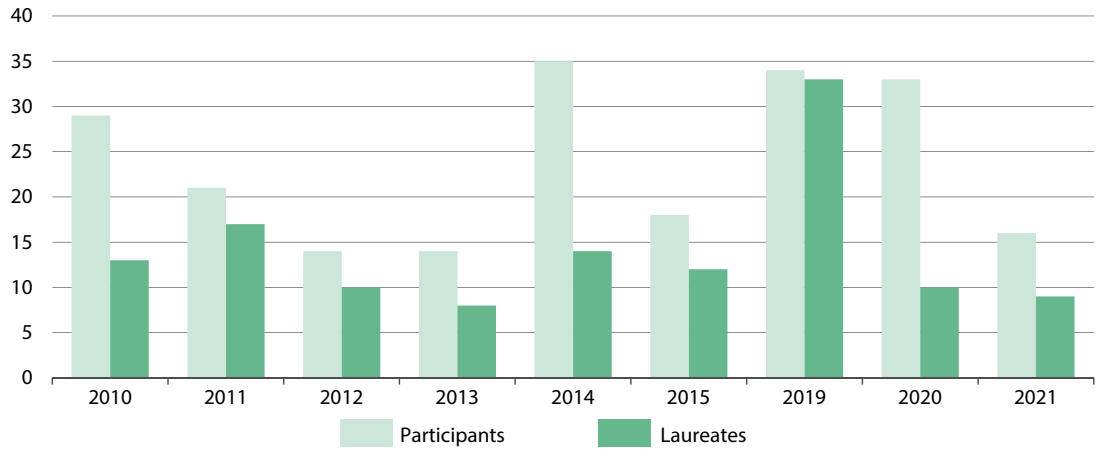
Green Technology Accelerator (GreenEvo) is an innovative project of the Ministry of Climate and Environment whose aim is both to promote the development of environment protection technology sector offered by Polish entrepreneurs and to transfer green technologies within Poland and abroad.

The main aim of the Accelerator is to create conditions to improve environment by encouraging the programme participant activity and by promoting environmental technologies offered by the project laureates within Poland and abroad. Entities taking part in the Accelerator are given aid catering for their substantial and educational needs, such as participation in free trainings and the possibility for the laureates to present eco-technologies during national and foreign economic endeavours. This programme essence is to spread global technical concepts so as to create conditions to support sustainable development and to build green economy.

Until 2015, entities could apply for funds to cover the costs of these activities within the available instruments supporting export, offered by the former Ministry of Economy and the Polish Agency for the Enterprise Development. Since 2018, the GreenEvo program has been financed by the National Fund for Environmental Protection and Water Management.

In 2018, the Ministry of Environment resumed the implementation of the GreenEvo program– Green Technology Accelerator. The 7th edition of the program was intended only for the laureates of the previous GreenEvo editions and was aimed at using the existing potential of proven technologies of entrepreneurs who, together with the Ministry of Environment, had built the GreenEvo brand. In 2019, 34 participants took part in the competition (launched in 2018) and 33 laureates were selected, while in 2020 – 33 and 10 respectively (chart 35).

Chart 35. Participants and laureates of Green Technology Accelerator



Source: data of the Ministry of Climate and Environment.

In 2021, in the new 9th edition of the GreenEvo program – Green Technology Accelerator, the Ministry of Climate and Environment prepared the competition to select new environmental technologies from nine areas of green technologies covered by the program, such as: renewable energy sources, environmentally friendly solutions for the mining industry, solutions supporting energy efficiency, systems supporting monitoring, gathering and analysing information on the natural environment, on the processes and dependencies of sustainable development factors, technologies supporting air protection, technologies supporting the circular economy and waste management, water and sewage technologies, low-emission technologies and technologies supporting the protection of biodiversity and based on natural resources. The competition was addressed to entrepreneurs who were laureates of the 7th or 8th edition of the Programme, as well as to new entrepreneurs who had not yet participated in the competition. 16 participants joined the program. The jury of the competition selected 9 laureates of modern solutions with a high potential for foreign growth and a positive environmental effect.

5.8. Eco-Management and Audit Scheme (EMAS)

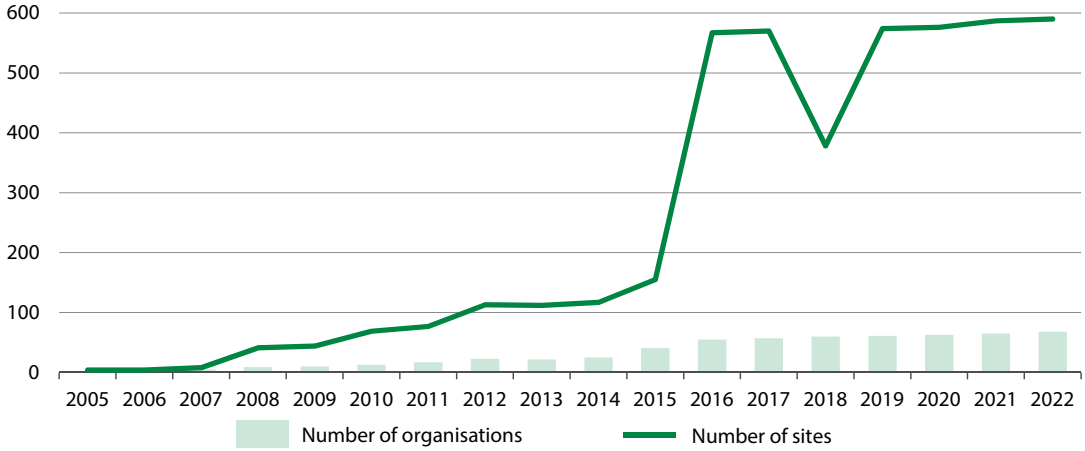
EMAS – Eco-Management and Audit Scheme is a European Union environmental protection management system integrated with ISO 14001 – the environmental quality management. Organisations that are willing to achieve best results in improving natural environment protection can participate in the scheme voluntarily.

EMAS is an important tool for environmental protection aiming at the constant improvement of environmental activity of an organisation in compliance with European Union and national laws on environmental protection. It assumes active participation of employers in the process of improving relations between the organisation and the environment, and informing the public about the results of the works carried out by the entities obliged to prepare annual environmental declarations. EMAS can be joined by entities of all economy sectors, i.e. entities and companies carrying out production and service activity, public and self-government administration authorities, as well as non-profit institutions.

Due to the implementation of this system requirements, organisations optimise resource and energy use and confirm that they abide laws within environment protection and minimise the risk of fines for non-compliance with the laws. They also create their own "green image", confirmed with a trustworthy certificate, in Poland issued by the General Director for Environmental Protection.

According to the EMAS register of the European Commission, as of 30 November 2022, 68 organisations and 590 sites of these organizations operated in the EMAS Eco-Management and Audit Scheme in Poland, i.e. 3 organisations and 3 sites more than at the end of 2021 (chart 36). It was the largest number of organisations and sites in the years of operation of the EMAS system in Poland since 2005.

Chart 36. Organisations and their sites with Eco-Management and Audit Scheme (EMAS) registration[a]
As of 31 December



a Data for 2022 – as of 30 November.

Source: the EMAS register of the European Commission, https://webgate.ec.europa.eu/emas2/public/registration/list and the EMAS register of the General Directorate for Environmental Protection, https://www.gov.pl/web/gdos/rejestr-emas (access date 30 November 2022 r.).

Based on data from the EMAS register of the European Commission, in European Union countries (EU=27), as of the end of 2021, there were 4.0 thousand organisations and 13.8 thousand objects of these organisations operating in the Eco-Management and Audit Scheme. Most organisations of this type were registered in Germany – 1.2 thousand (2.3 thousand sites of these organisations) and in Italy – 1.0 thousand (6.1 thousand sites), while in the Netherlands and Latvia such units were not recorded at all. Organisations in the EMAS system in Poland constituted 1.6% of their total number in European Union countries and their sites – 4.2% of total number of sites in EU.

5.9. Green public procurement

Green public procurement is the one in which public entities include ecological criteria and/or requirements to the purchase process (procedures of conduction public procurement) and aim at solutions that minimize the negative impact of products/services on the environment.

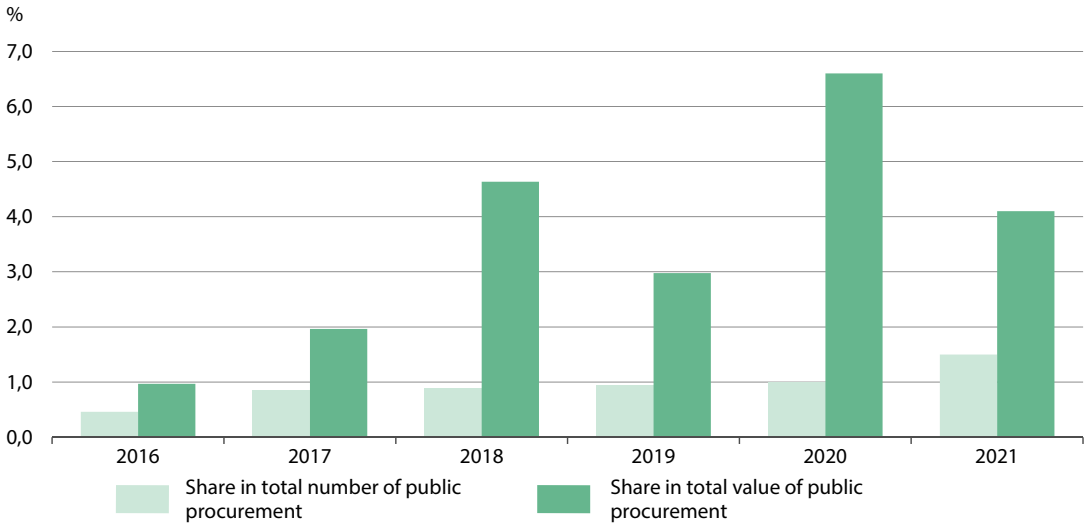
Green public procurement is an important instrument to encourage entrepreneurs to produce new, greener products and to deliver services that take into account environmental aspects. It should lead to the purchase of products or services that are environmentally friendly, namely such that exert a smaller negative effect on natural environment than other similar conventional products/services that fulfil the same functions. On the other hand, they can contribute to the financial savings of public entities contracting them, especially when taking into account the costs of products or services throughout the life cycle.

Public procurement sets production and consumption trends. Paying more attention to the environmental criteria in public procurement may support putting into practice the state environmental policy. A significant demand of public authorities on greener products can lead to the creation or to the growth of environmentally friendly product and service market.

Since 2016, data on green public procurement are obtained by the Public Procurement Office from information contained in annual reports on awarded public procurement[2]. Until 2015, they were set on the basis of the analysis of public procurement advertisement (a random sample) published in the national official publication – the Polish Public Procurement Bulletin, and in the European Union official publication – the Supplement to the Official Journal of the European Union. Therefore, the data since 2016 are incomparable with the data for previous years and the scope of data presentation was limited to 2016––2021.

According to the data provided by contracting authorities to the Public Procurement Office, in 2021, 1.9 thousand green public procurement, i.e. taking into account environmental aspects, were awarded. Their share in the total number of public procurement was 1.5% (chart 37). Compared to the previous year and 2016, their number increased by 38.1% and more than 3 times respectively.

Chart 37. Green public procurement



Source: data of the Public Procurement Office.

The total value of green public procurement (excluding value added tax) amounted to PLN 7.5 billion, i.e. 4.1% of total value of awarded public procurement. It means that despite the increase in the number of green public procurement in relation to the previous year, its value decreased by 37.6%. Compared to 2016, this value increased more than 7 times.

[2] National Action Plan on sustainable public procurement for 2017–2020, Public Procurement Office, Warsaw 2017.

Methodological notes

Polish public statistics on the basis of achievements of Organization for Economic Co-operation and Development (OECD) and other environmental organisations, such as United Nations Environment Programme (UNEP) and European Environment Agency (EEA) has tried to adjust the term of green economy to Polish circumstances. The term **green economy** means such economy that supports economic growth and development while maintaining access to natural capital and ecosystem services, which, in turn, affect human well-being. Green economy, inextricably linked to green growth, cannot replace sustainable development – it has a narrower scope. Green economy is connected with operational targets, which should lead to clearly specified activities within the fields of economy and environment protection to create such conditions that would foster innovations and investments. These latest, then, can lead to the creation of new sources of economic development while making efficient use of environment resources. That is why green economy makes it possible to reach the state of sustainable economy.

The research of green economy concerns mainly the assessment of natural environment state and economy efficiency. The social factor is, however, treated in a narrower sense – solely in this part that directly concerns either environment or economy. It is directly reflected in the objective scope of the research and the proposed set of measurement indicators.

Elements of green economy (environment, economy, and society) are interrelated and these relations have enabled Polish public statistics, just like OECD, to establish 4 areas to monitor green economy state in Poland, i.e.:

1) **natural asset base** – describing the state of natural environment,
2) **environmental and resource productivity of the economy** – depicting relations between natural environment and economy,
3) **environmental quality of life** – presenting relations between natural environment and society,
4) **economic opportunities and policy responses** – comprising instruments affecting economy and society, creating such desired trends in development that aim at greening the economy.

Natural environment performs three basic functions in green economy:

- productive (supplying) constituting a resource base of renewable resources (e.g. wood) and non-renewable ones (e.g. fossil fuels) for economy and society,
- pollution absorption and landfilling,
- other, which can be divided into services:
  - regulatory, including, i.a., climate regulation, amortization of extreme weather events, regulation of water cycles, erosion prevention, monitoring of soil fertility and nutrient cycles, pollination and biological control of growing crops, flood prevention activities,
  - cultural, which are not vital for life but improve its quality, i.e. bring non-material benefits, which people gain while coming into contact with ecosystems, e.g. aesthetic stimuli, possibilities of recreation and tourism, inspiration for culture, arts, and spiritual experiences,
  - living space for humans, fauna and flora; maintaining biodiversity.

Natural environment is a source of natural resources vital for economy and society, which can be described as natural asset base. **Natural asset base** comprising natural renewable and non-renewable resource stocks plays a fundamental role in green economy and pressure on making use of it is inevitable. Constant overexploitation of the Earth may lead to an irreversible loss and then may upset the balance of its ecosystem. Green economy is to provide economic growth with sufficient renewable and non-renewable resources and other ecosystem services, while minimising the negative effect on environment, caused by the acquisition, exploitation, and processing of natural asset base. Therefore, it is im-

portant to monitor the state and the changes of different kinds of resources, i.a.: mineral, fauna, flora and freshwater ones. A set of indices proposed to monitor natural asset base is shown in table 2.

Table 2. Indicators of natural asset base

Objective scope	Variable/indicator
Biodiversity	Share of legally protected area in total country area Farmland Bird Index Forest Bird Index Share of endangered species in total number of species
Land use	Agricultural land designated for non-agricultural purposes and forest land designated for non-forest purposes Degree of reclamation/management of devastated and degraded land
Forest resources	Forest cover Forest growing stock Timber removals Share of damaged forest stands area in total forest area
Freshwater resources	Indicator of surface waters availability per capita Exploitable underground water resources Water exploitation index (WEI)
Mineral resources	Share of extraction in hard coal resources Share of extraction in lignite resources Share of extraction in natural gas resources

The production section and its relations with natural environment are a starting point for setting up another area of green economy research – environmental and resource productivity of the economy. Exploitation of natural resources, making use of labour and capital take part in production processes to make goods and to provide services. The side effects are the residue of pollutants and waste and thus environment is used as a site of their absorption and landfilling.

Changes towards a greener economy may be monitored by comparison of generated production to environmental pressure and the observation of whether the link between them is broken. Breaking the link (decoupling) between them may be either relative or absolute. Relative decoupling occurs when the growth rate of the values reflecting the pressure on the environment increases, but slower than the growth rate of the variable reflecting economic growth, e.g. GDP. The ultimate goal of the green economy is to achieve absolute decoupling, i.e. the state when production increases and the variables reflecting the environmental pressure remain stable or show a decrease.

The growth of environmental and resource productivity is a necessary condition to make the economy greener. The efficient use of natural resources and waste should lead to the reduction of a negative impact on environment. This efficiency is measured by indices belonging to the group of **environmental and resource productivity of the economy**, which are presented in table 3.

Table 3. Indicators of environmental and resource productivity of the economy

Objective scope	Variable/indicator
Water management	Consumption of water for needs of the national economy and population per capita Water productivity Water intensity of industry Water intensity of households
Domestic material consumption	Resource productivity (GDP/DMC) Domestic material consumption per capita
Waste management	Share of waste recovered in waste generated Municipal waste generated per capita Municipal waste collected separately in relation to total municipal waste Recycling rate of municipal waste
Nitrogen and phosphorus balances	Gross nitrogen balance Gross phosphorus balance
Energy management	Primary energy productivity Final energy intensity of the economy
Renewable energy	Share of renewable energy in gross final energy consumption
Greenhouse gas emissions	Greenhouse gas emissions (base year=100) Greenhouse gas emissions by emission sources Greenhouse gas emissions in non-ETS sectors

A further element that is observed to get an insight into green economy is the **environmental quality of life**, which is connected with regulatory, living space, and cultural services that environment provides for the people. This function also refers to the general condition of environment and is an example of the relations that exist between environment and society. The environmental quality is a key factor directly affecting general well-being of humans and other living creatures. The pollution level directly affects the quality of life of the society by the impact it has on its health. The environmental quality of life indicators refer to the human exposure to various pollutants and to health conditions resulting from them as well as to access of population to basic services in the scope of water and sewage management that simultaneously protect the environment. These objective measurement indices are complemented with the subjective ones that determine people's feeling about the quality of environment they inhabit. The suggested array of indicators of the population's environmental quality of life is compiled in table 4.

Table 4. Indicators of environmental quality of life

Objective scope	Variable/indicator
Gaseous air pollutants	Average number of days with exceeded value of 120 µg/m^3 by 8-hour ozone concentration Urban population exposure to air pollution by ozone (SOMO35) Premature deaths attributable to ozone exposure
Particulate air pollutants	Emissions of PM_{10} and $PM_{2.5}$ per capita Urban population exposure to air pollution by PM_{10} National $PM_{2.5}$ average exposure indicator Premature deaths attributable to $PM_{2.5}$ exposure
Noise	Percentage of population exposed to road traffic/railway/industrial noise in agglomerations over 100 thousand inhabitants Percentage of population exposed to aviation noise in agglomerations with an airport located within their boundaries Share of entities exceeding industrial noise limits in total number of inspected companies Percentage of households exposed to excessive noise from neighbours or from the street
Access to drinking water	Percentage of population using water supply network Percentage of population supplied with water meeting requirements
Municipal sewage treatment	Percentage of population using sewage network Wastewater treatment facilities per 1000 population not using sewage network
Green areas	Green areas in cities per capita Green areas in cities in % of total area of cities

Transition from a traditional economy to a green one demands from public sector (government and self-government one) many various instruments within different **economic policies**. There are diverse tools within public government reach that force entities to certain actions aimed at making the economy greener, i.a. legal regulations, taxes or subsidies. They can support actions to increase efficiency (e.g. the use of environment elements) and to provide stimuli for the development of eco-friendly production and consumption patterns. Monitoring of such tools and actions as well as their results should become a focal point of the decision makers. Simultaneously, these instruments create new economic opportunities that lead to the development of certain kinds of activities generating job places and stimulating economic growth. Activities within various policies that aim at promoting green economy should both be based on a deep insight into factors affecting green growth and properly reflect relations between green economy components. To make it possible, decision taking representatives of different public authorities must have access to information on the results of implemented actions. A set of indicators of economic opportunities and policy responses is presented in table 5.

Table 5. Indicators of economic opportunities and policy responses

Objective scope	Variable/indicator
Organic farms	Organic agricultural area in % of total agricultural area Percentage of payments for farms carrying out organic farming
Outlays on environmental protection	Outlays on fixed assets for environmental protection in relation to GDP Share of outlays on fixed assets for environmental protection in investment outlays of national economy Household expenditures on environmental protection per capita
Environmental taxes	Share of environmental tax revenues in GDP Share of environmental tax revenues in total revenues from taxes and social contributions
Research and development (R&D) activity	Research and development (R&D) intensity Research and development (R&D) expenditure per capita
Inventions and patents	Patent applications in environment-related technologies in % of total patent applications filed in the European Patent Office Patents in environment-related technologies granted in % of total patents granted by the European Patent Office Patent applications in environmental technologies in % of total patent applications filed in the Patent Office of the Republic of Poland Patents in environmental technologies granted in % of total patents granted by the Patent Office of the Republic of Poland
Eco-innovation	Eco-innovation index
Green technology	Participants/laureates of GreenEvo Technology Accelerator
Eco-Management and Audit Scheme (EMAS)	Organisations with Eco-Management and Audit Scheme (EMAS) registration Sites of organisations with Eco-Management and Audit Scheme (EMAS) registration
Green public procurement	Share of green public procurement in total public procurement Share of green public procurement value in total public procurement value

The given set of indicators to monitor green economy does not illustrate the analysed subject to the full and will be further assessed due to, among others, new data sources including the ones coming from public statistics surveys and introducing new instruments that are to make economy greener.

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