



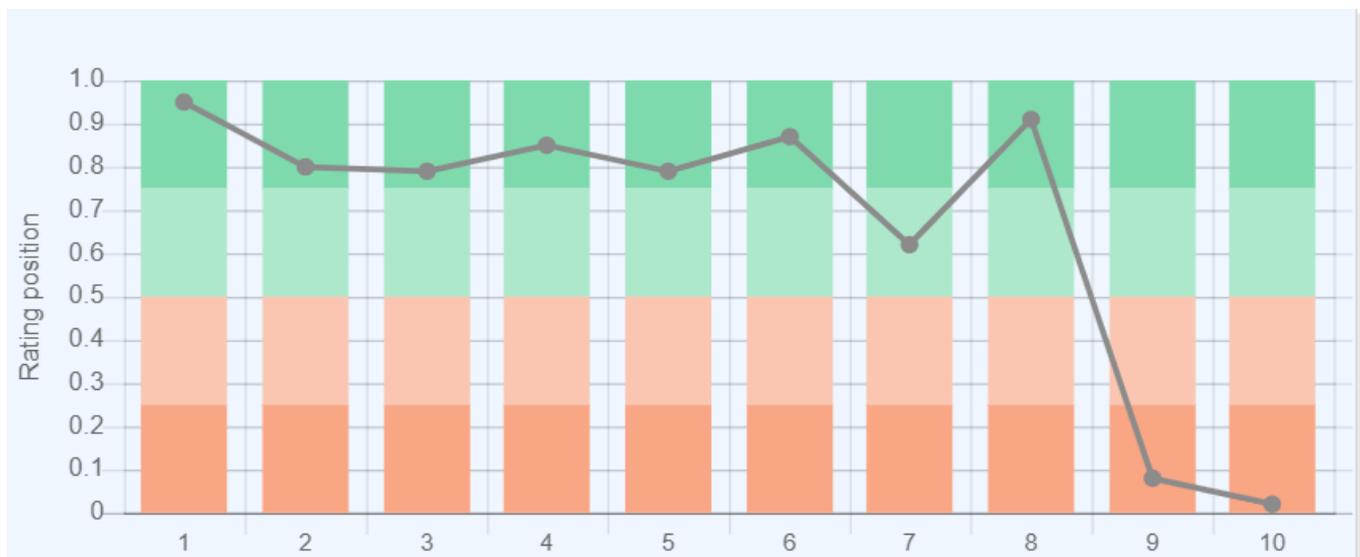
# Energy Industry in Italy



## General State of the Economy

Italy, officially the Italian Republic, is a state in Southern Europe. Its capital city is Rome. The country borders France (to the north-west), Switzerland and Austria (to

the north), Slovenia (to the north-east), and also has internal borders with the Vatican and San Marino. Italy has access to the Mediterranean Sea and its surrounding seas – Ligurian, Tyrrhenian, Ionian and Adriatic.



Sources:

1. GDP (purchasing power parity), 2020 est. / The World Factbook/Library/Central Intelligence Agency \*228
2. GDP - per capita (PPP), 2020 / The World Factbook/Library/Central Intelligence Agency \*229
3. Inflation rate (consumer prices), 2019 est. / The World Factbook/Library/Central Intelligence Agency \*228
4. Charges for the use of intellectual property, receipts (BoP, current US\$), 2020 / International Monetary Fund, Balance of Payments Statistics Yearbook, and data files. / License: CC BY-4.0 \*88
5. The Global Competitiveness Index 2019 / Rankings / Reports / World Economic Forum \*141
6. High-technology exports (current US\$) 2019-2020 / United Nations, Comtrade database through the WITS platform / License: CCBY-4.0 / Data \*134
7. 2021 Index of Economic Freedom / International Economies / The Heritage Foundation \*178
8. Reserves of foreign exchange and gold, 2017 est. / The World Factbook / Library / Central Intelligence Agency \*195
9. Annual average GDP growth in %, for the last 10 years (2011-2020) / World Bank national accounts data, and OECD National Accounts data files / License: CC BY-4.0 \*206
10. Public debt (% of GDP), 2017 est. / The World Factbook / Library / Central Intelligence Agency \*210

\* Total number of countries participating in ranking

Figure 1. Economic indices of Italy

Italy is the 71<sup>st</sup> largest country in the world, and as of 2018 is home to around 61 million people. In terms of population density, the country is 178<sup>th</sup> in the world from 258 countries considered [1,2,3]. The total length of the

country's coastline is 7,600 km [3]. Italy is a parliamentary republic, and the official language is Italian. The administrative map of the country is divided into 15 regions [3].

Italy is a member of the European Union and has a balanced and diversified market economy; the third largest in the European Union [3], reflected in Figure By almost every indicator in the presented diagram, Italy places in the top 25% of the leading countries in the world included in the rating.

From the early 1990s until 2008 the country experienced a steady growth in GDP at purchasing power parity, followed by a decrease, but since 2013 has demonstrated steady growth before reaching \$2.67 trillion (12<sup>th</sup> place in the world) in 2019 [3,4]. In 2020 Italy placed 45<sup>th</sup> in GDP per capita and has also been demonstrating positive dynamics: from \$37,200 in 2015 to \$39 000 in 2020 [3]. In 2016 inflation in Italy was in the negative zone, but this changed from -0.1% to 0.6% by 2019 [3]. Charges for the use of intellectual property was \$4.2 trillion in 2020 (13<sup>th</sup> place in the world).

According to The Global Competitiveness Report 2019, presented by the World Economic Forum, Italy placed 30<sup>th</sup> out of a total of 141 countries considered. This rating measures the effectiveness of the use of the country's own resources for sustainable development. In addition to a number of economic indicators, this index also takes into account such variables as education, health, level of innovation, etc. In the list of countries that ex-

ported high-tech products in 2019-2020, Italy was 18<sup>th</sup> out of 134 countries, ahead of the world average. According to the Index of Economic Freedom, which is based on freedom of business, freedom from government intervention, property protection, and freedom from corruption, Italy was 68<sup>th</sup> in 2021 out of the 178 countries considered. In terms of gold reserves and foreign exchange reserves in 2017 Italy was 17<sup>th</sup> in the world, along with France and the UK. According to the indicator for the average GDP growth in percentage over the last 10 years (2011-2020), the country placed 189<sup>th</sup> out of 206 countries in 2017, behind Portugal. In terms of public debt, calculated as a percentage of the country's GDP, Italy was ranked 5<sup>th</sup> out of 210 countries considered in 2017.

For more information on the Italian economy, see the attached link library by clicking [here](#).

## Energy resources

In Italy there are practically no significant fossil resources, particularly when compared with the largest producer countries (Table 1). According to proven reserves of oil and natural gas, the country is 45<sup>th</sup> and 65<sup>th</sup> in the world, respectively [3]. In terms of tons of oil equivalent, according to 2018 data, proven oil reserves were 56.1%, gas – 34.1%, coal – 9.8% (Fig.5). The matrix of unconventional fossil resources looks somewhat different; kerogen oil accounted for 99.6%, oil sands and ext-

ra heavy oil – 0.4% (Fig.5). According to [3,6] as of the end of 2017 –2020, proven oil reserves in Italy were 487.8-600 million barrels. Oil reserves at the end of 2017, according to Italian Ministry of Economic Development [7], were estimated at 53 099 thousand tons.

**Table 1. Fossil energy resources of Italy**

Resource/explanations	Crude oil	Natural gas	Coal	Natural Bitumen*	Tight Oil*	Oil Shale **
<b>Value</b>	487.8	38.11	19	210	90	73 000
<b>Unit</b>	million barrels	Bcm	million short tonnes	million barrels	million barrels	million barrels
<b>Year</b>	2018	2018	2016	2008	2008	2008
<b>Source</b>	[3]	[3]	[8]	[10]	[10]	[10]

\*reserves

\*\*in-place resources

Proven natural gas reserves in Italy, as of 1<sup>st</sup> of January 2018 were estimated at 38.11 Bcm [3]. In 2017, the Italian Ministry of Economic Development [7] estimated natural gas reserves in the country to be at 78.244 million of standard cubic meters. According to BP, natural gas reserves were estimated at 1.5 Tcf at the end of 2020 [6]. It should be noted that the consumption of oil and gas in Italy exceeds existing production levels by many times. Total proven coal reserves, according to U.S. Energy Information Administration, was estimated at 19 million short tons in 2019 [8]. The Carbosulcis Coal Mine in Sar-

dinia has around 2.5 billion tonnes of coal and is one of the largest in Europe [9].

Italy also has significant reserves of kerogen oil – 73,000 million barrels; bituminous oil - 210 million barrels; and extra heavy oil – 90 million barrels, as of 2008 [10]. Italy, due to its geographical location, has a variety of renewable resources for energy production. A selection of basic indicators of this type of resource is presented in Table 2.

**Table 2. Renewable energy resources of Italy**

Resource/explanations	Solar Potential (DNI)*	Wind Potential (50 m)*	Hydro energy Potential**	Bio Potential Agricultural area	Bio Potential Forest Area	Geo thermal Potential	Municipal Solid Waste
<b>Value</b>	3.5-4.4	<5	47 500	41.7	32.81	2 000	499
<b>Unit</b>	kWh/m <sup>2</sup> /day	m/s	GWh/year	% of land area	% of land area	MWe	Kg per capita
<b>Year</b>	2018	2018	2013	2018	2020	2013	2018
<b>Source</b>	[11]	[12]	[13]	[14]	[15]	[16]	[17]

\*for most of the territory of the country

\*\*economically exploitable capability

The level of direct solar radiation in most of the country can reach 3.5-4.4 kWh/m<sup>2</sup>/day [11]. In the south of the country and in the region of Rome and in Sardinia, this figure can rise to 5.0 kWh/m<sup>2</sup>/day, and reach maximum values of 5.0-5.3 kWh/m<sup>2</sup>/day in south-west Sicily [11]. The distribution of wind resources is as follows: in most of the country the wind speed does not exceed 5.0 m/s; in the central regions it can reach 6.0-7.0 m/s; and in the south and north of the country it reaches a maximum of 7.0-7.5 m/s, sec at an altitude of 50 meters [12]. The economically exploitable capability of hydropower in Italy is high and in 2013 was estimated at 47500 GW/year [13]. In 2018, 41.7% of the territory of Italy was occupied by agricultural land [14], a figure that has been steadily decreasing over the last half-century. However, an increase in forest area to 32.1% can also be observed [15]. The geothermal potential of the country in 2013 was estimated at 2000 MW [16].

In 2018 the level of generation of municipal waste in Italy was 499 kg per capita, which is lower than in France – (527 kg per capita), and Germany – (615 kg per capita)

[17]. This resource is a valuable raw material for recycling or producing energy, the technologies of which have reached a very high level of development in Italy.

A detailed list of sites and special reports on Italian energy resources can be found [here](#).

## Energy Balance

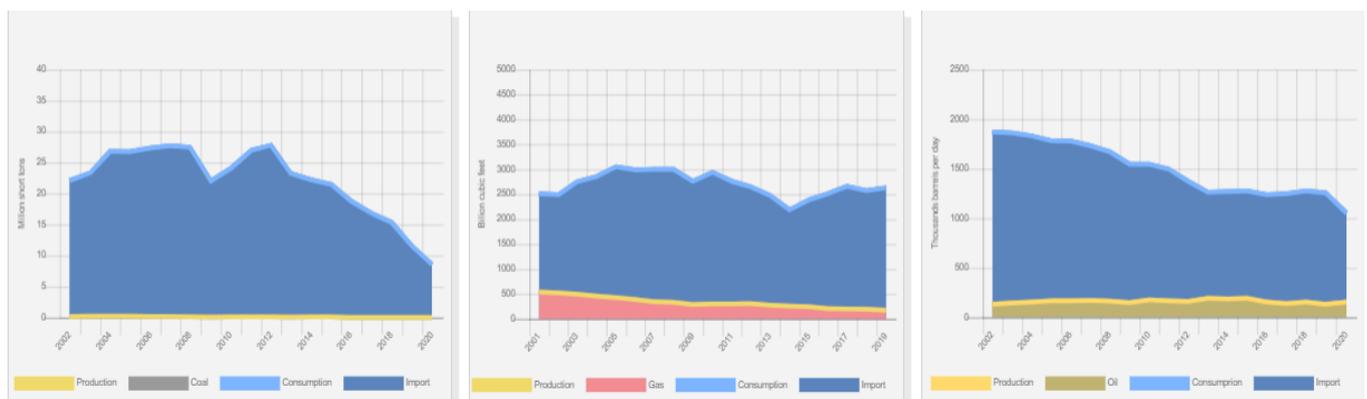
According to the BP Statistical Review of World Energy 2019, total primary energy consumption in Italy in 2020 was 5.86 Exajoules (557.1 in the world), about 36.3% of which was from oil, 41.6% from natural gas, 11.4% from renewable energy, 3.5% from coal, and 7% from hydro-power [6].

Using the data from [3,6] we calculated Italian GDP per unit of primary energy use in 2020 to be \$16.6 taking into account PPP in 2011 prices per unit of energy expended (the equivalent of energy contained in one kg of oil equivalent/\$ PPP per kg of oil equivalent), which is significantly higher than the world average level of GDP energy efficiency. Oil production between 2001-2020 remained practically unchanged, not exceeding the level of 200 thousand barrels/day. In 2020 this figure was 144 thousand barrels/day [18].

Since 2001 the volume of oil consumption in the country has shown a decline (Fig.2) and in 2020 reached the level of 1050 thousand barrels/day [18]. The BP review shows lower oil production in Italy in 2020 – 112 thousand barrels/day, with consumption at a level of 1079 thousand

barrels [6]. Oil production in 2017 was estimated at 4.14 million tons, according to Rapporto Annuale 2018 [19]. The import of oil to Italy in 2017 totalled 1.341 million barrels/day according to [3], with exports at 13,790 barrels/day. The consumption of natural gas in Italy decreased from 2010 to 2019 reaching 2624 Bcf in 2019, production was also declining, and reached 170 Bcf in 2019 [18]. According to the BP Statistical Review of World Energy 2021 [6], gas consumption in the country in 2020 was 67.7 billion m<sup>3</sup>, with production at 3.9 billion m<sup>3</sup>. According to [19], gas production in 2017 was 5.56 billion standard m<sup>3</sup>. Italy is the second largest importer of gas in Europe after Germany, and the third largest consumer; the volume of imports was 2.5 Tcf in 2019, or about 92% of total consumption.

The largest exporter of gas to Italy is Russia, which accounted for 28.5% of imports in 2020. Gas is also supplied to the country via pipelines from Algeria and Libya. LNG accounts for 12.1% of total gas imports and comes mainly from Qatar [6,20]. According to [3], Italy imported 69.66 billion m<sup>3</sup> of natural gas in 2017, with exports of 271.8 million m<sup>3</sup>.



Source: U.S. Energy Information Administration (Dec 2021) / <https://www.eia.gov/>

Figure 2. The production and consumption of fossil fuels in Italy (coal – left, gas – in the center, oil – right)

Coal consumption in the country has dropped significantly in recent years and reached 8.5 million short tons in 2020 [18].

According to BP in 2020, coal consumption amounted to 0.21 [6]. Electricity production in Italy has seen a decrease in the share of fossil fuels and an increase in the share of renewable energy sources (Figure 3).

According to the U.S. Energy Information Administration 2020 Italy produced 272 TWh of electricity, where fossil fuels accounted for 56%, renewables - 26.5%, and hydro-power - 17.6% (Fig.7).

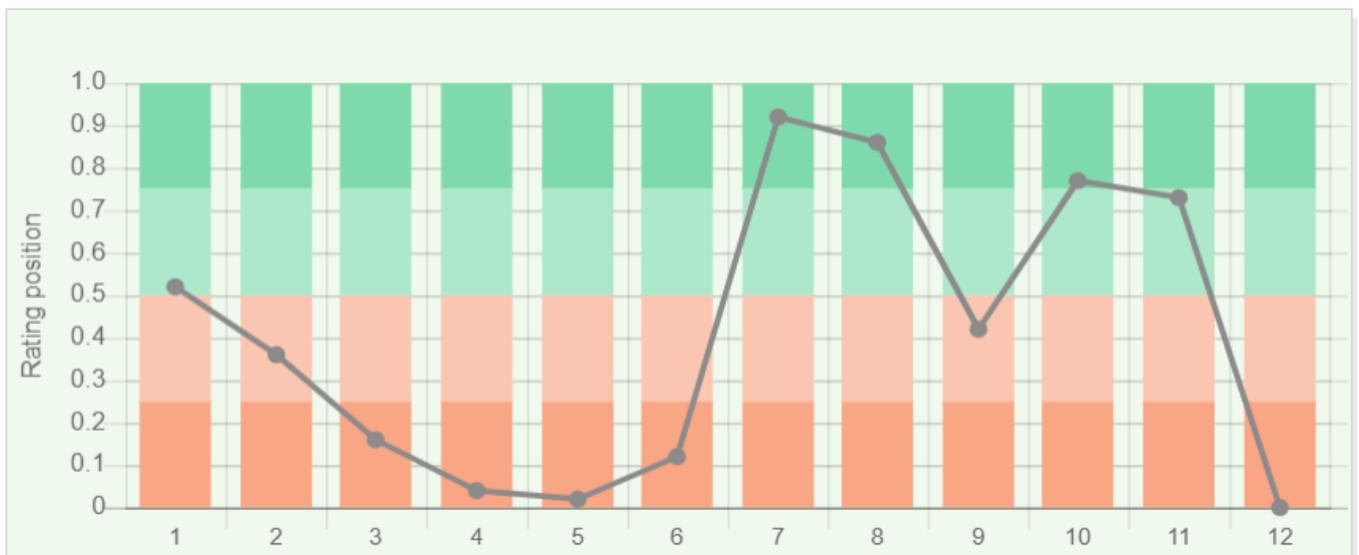


Sources:  
U.S. Energy Information Administration (Dec 2021) / <https://www.eia.gov/> ;

Figure 3. Electricity production in Italy

Italy's position in the comparative diagram of energy index is shown in Figure 4. Italy is at the bottom of the list of countries in terms of production/consumption ra-

tio of fossil fuels, ranked from high to low, for all major resource components – oil, gas and coal.



Sources:  
 1. Crude oil proved reserves, 2021 / International Energy Statistic/Geography / U.S. Energy Information Administration (Nov 2021)\*98  
 2. Natural gas proved reserves 2021 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*99  
 3. Total recoverable coal reserves 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*81  
 4. Combination production-consumption for Crude oil 2018 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*219  
 5. Combination production-consumption for Natural gas 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*123  
 6. Combination production-consumption for Coal 2019 / International Energy Statistic / Geography / U.S. Energy Information Administration (Nov 2021) \*128  
 7. Electricity – from other renewable sources (% of total installed capacity), 2017 est. / The World Factbook / Library / Central Intelligence Agency \*170  
 8. GDP per unit of energy use (PPP per unit of oil equivalent), 2020 \*66  
 Primary energy consumption - BP Statistical Review of World Energy 2021/BP;GDP (purchasing power parity) - The World Factbook/Library/Central Intelligence Agency  
 9. Energy use (primary energy use of oil equivalent per capita) 2020 \*127  
 Primary energy consumption – BP Statistical Review of World Energy 2021; Population - United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021\*66  
 10. The Global Energy Architecture Performance Index Report (EAPI) 2017 / Rankings / Reports / World Economic Forum  
 11. Electric power consumption (kWh per capita), 2016 \*217  
 Electricity Consumption - The World Factbook / Library / Central Intelligence Agency; Population - United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, custom data acquired via website. Retrieved 15 November 2021  
 12. Combination of electricity production-consumption (kWh)/The World Factbook/Library/Central Intelligence Agency \*216  
 \* Total number of countries participating in ranking

Figure 4. Energy indices of Italy

However, in terms of oil reserves, the country's positioning looks quite promising.

In a rating from 2017 listing countries by their level of production of electricity from renewable sources (excluding hydropower) Italy was 13<sup>th</sup>, behind Belgium, but ahead of Spain, among the 170 countries selected for consideration. In the Energy Architecture Performance Index 2017, which is based principally on the level of economic growth, environmental safety, and energy independence of the country, including access to energy, Italy ranks 29<sup>th</sup>; it should be noted that during the last 8 years the country has lost 4 ranking positions. For such indicators as GDP per unit of energy expended in 2017, Italy is in the top quarter of the diagram – 10<sup>th</sup>, in terms

of energy use per capita the country is 9<sup>th</sup> out of 127 countries considered. In terms of electricity consumption per capita, the country is 59<sup>th</sup> in the world. However, for the indicator of combination of electricity production-consumption, Italy is at the bottom of the list of 216 countries considered.

*More information about the energy balance of Italy can be found in the documents from our reference library [here](#).*

## Energy Infrastructure

A territorial map showing the distribution of the largest infrastructure projects of the fossil-fuel sector in Italy is shown in Figure 5. In the total potential of fossil energy resources, oil plays a predominant role – 56.1%. Natural gas accounts for 34.1%, while coal accounts for 9.8%, although the total amount of fossil resources is small (Fig. 5). Italy's gas fields are predominantly offshore fields. One of the leading gas fields is Corsini Mare Est, which produced 161 mln cfd in 2010 [21]. The Italian gas infrastructure is represented by 12 gas processing plants, and 12 gas storage facilities. Gas is transported within the country via a network of pipelines with a total length of 20,223 km (Fig. 5).

Gas imports are carried through three LNG terminals, the largest of which is Adriatic LNG (Porto Levante), with an installed capacity of 8 bcm/year, which provides about 10% of national consumption [22]. In 2001, the Sannazzaro Pilot GTL Plant was erected by ENI with an installed capacity of 20 barrels/day, enabling the production of liquefied natural gas [23].

In the north of the country, and in the southern Palermo region, natural gas hydrates have been discovered during the course of scientific research (Fig. 5).

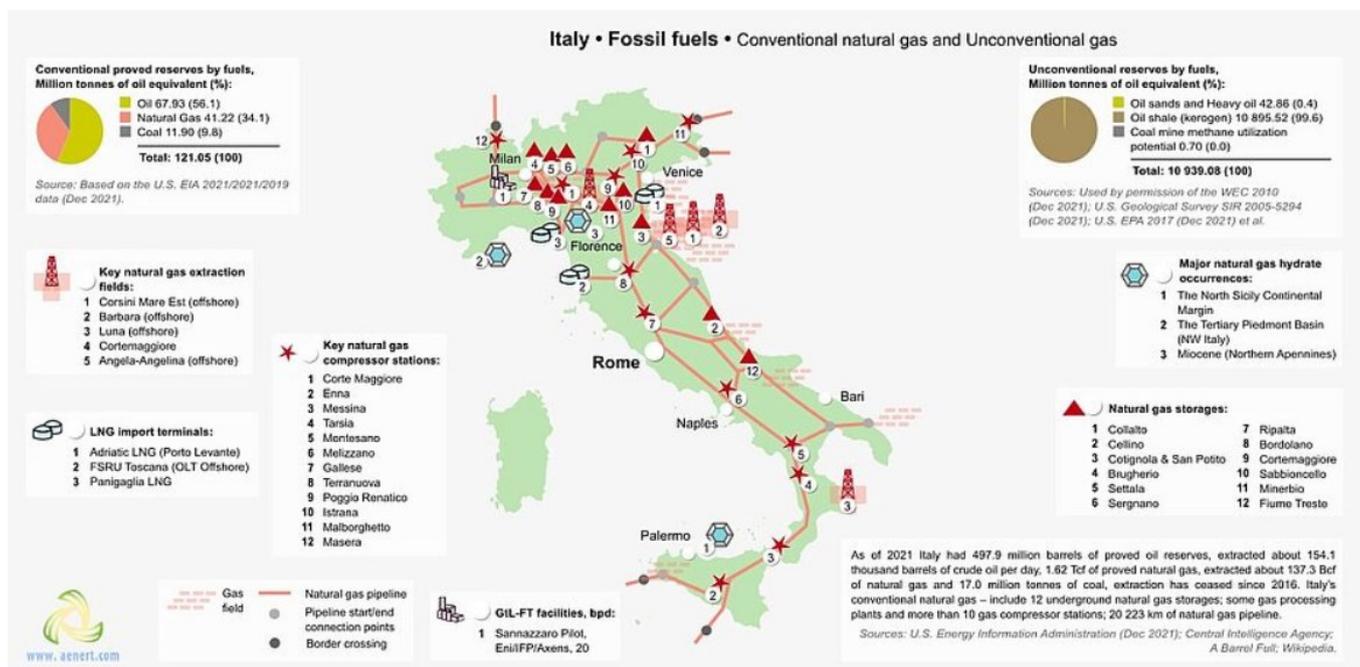


Figure 5. Basic infrastructure facilities of conventional and unconventional natural gas in Italy

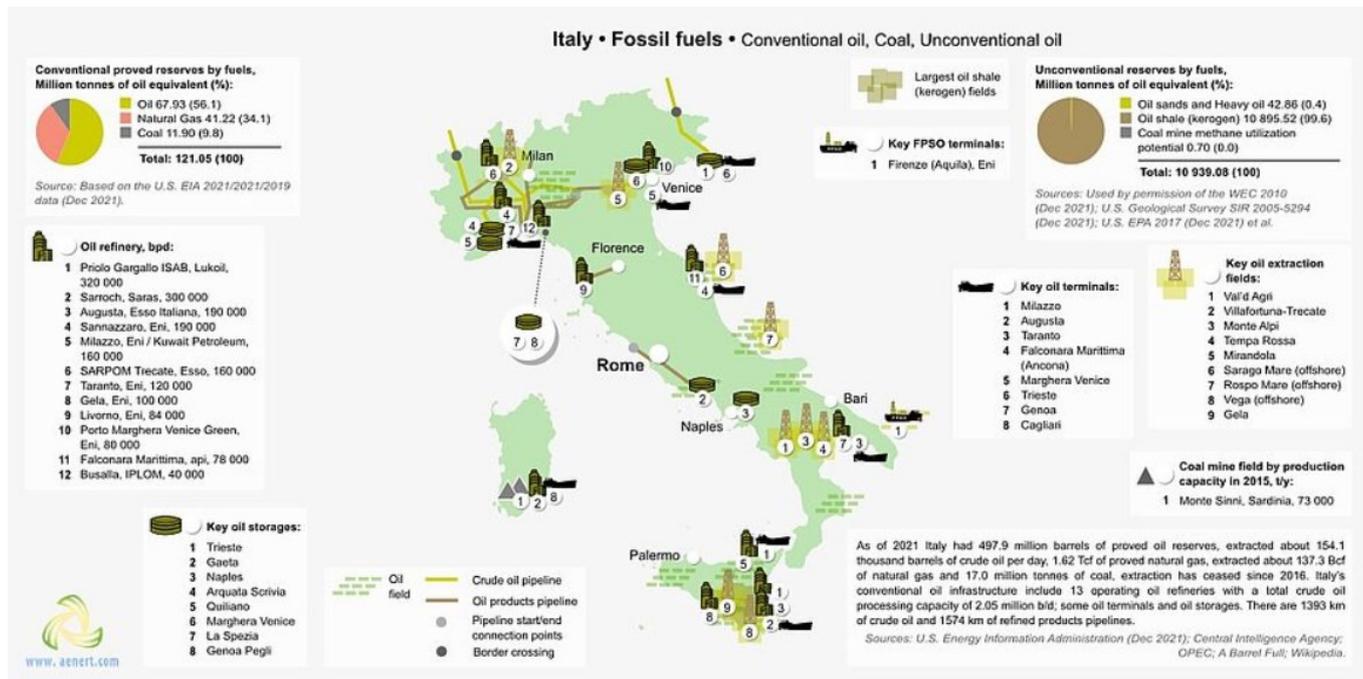


Figure 6. Basic infrastructure facilities of conventional oil, coal and unconventional oil in Italy

The Val'd Agri is one of the leading oil fields with extraction at the level of 85,000 bbl/d in 2014 [24].

In 2016 the installed capacity of oil refineries in Italy was 2.05 mln barrels/day, second only to Germany in Europe [20,25]. The largest refinery, Española Priolo Gargallo ISAB, has an installed capacity of 320,000 bbl/d [25] (Fig.6). Import of oil and oil products is carried out through 8 oil terminals; the largest storage of petroleum products is at Trieste TAL SIOT (2 030 000 m<sup>3</sup>) [26]. Transportation of crude oil and petroleum products is carried out via pipeline networks with a total length of 1,393 km and 1,574 km, respectively (Fig. 6). In the south of the country, oil field development is carried out through FPSO with a production capacity of 12,000 barrels/day and a tank capacity of 700,000 barrels [27].

Italy is among the top ten countries in the world in terms of reserves of kerogen oil, but the development of this resource in the country is not progressing, due to the lack of competitive technologies.

The main coalfield is located at Monte Sinni, on the island of Sardinia. In 2015 extraction here was 73,000 tons, but by 2018 had decreased to 30,000 tons [28]. The map of the territorial distribution of the largest infrastructure objects of electricity generation in Italy is shown in Figure 7.

The share of fossil fuels in electricity generation in Italy in 2017 was 56% (Fig.7).

The country has a significant number of stations for the production of electricity from hydrocarbons, including power plants with an installed capacity of more than 100 MW; among them five oil, eleven gas, eleven oil, and three combined type power plants (Fig.7). The largest Italian power plants are: Turbigio gas power plant, with a total installed capacity of 1,755 MW [29]; Porto Tolle oil power plant, with a capacity of 2,640 MW[30]; the coal powered Brindisi Sud (Federico II) with a capacity of 2,640 MW; and Alessandro Volta (Montalto di Castro) combined power plant with an installed capacity of 3 600 MW [31,32]. Hydropower in Italy accounts for 17.3% of electricity generation and is represented by both pumped storage plants and large and small hydropower plants (Fig.7). The largest pumping station is Entracque (Rovina/Chiotas/Luigi Einaudi) with an installed capacity of 1318 MW [33]; the main hydroelectric power plant is San Giacomo with an installed capacity of 448 MW [34].



As noted above, renewable energy in Italy accounts for 26.7% of electricity generation (Fig.7). Thus, the total production of electricity from renewable sources excluding hydropower in 2020 was 72.45 TWh (Fig.8). According to IRENA (Fig.8), in 2019 the share of hydropower in the total balance of electricity production from renewable sources prevailed and amounted to 40%. Solar stations accounted for 20.5%, bioenergy for 16.9%, wind energy for 17.4%, and share of geothermal energy for 5.2% [35] (Fig.8). In zones of high wind activity, there are over a dozen wind parks, each with a capacity of more than 85 megawatts. In 2020 there were about 2 000 wind turbines with a total installed capacity of 10 800 MW [6,36]. The largest is the Troia Wind Park with an installed capacity of 181.9 MW [37]. The three largest producers of wind turbines in Italy are Vestas Italia, Moncada Energy Group and Leitwind (Fig.8). As noted above, the level of direct solar radiation in some parts of the country can reach 5.3 kWh/m<sup>2</sup>, which is a suitable resource for energy production [11]. Consequently, a large number of solar energy facilities, both photovoltaic and thermal with solar energy concentrators, are located on this territory. Notable facilities include: one parabolic type CSP station – Archimede (5 MW) [38]; Rende CSP Linear Fresnel type plant (1 MW); and CPV Solar Plant –

Santa Lucia with a capacity of 1.2 MW [39,40]. About 9% of the electricity in Italy is produced by photovoltaic stations. The largest station of this type is Montalto di Castro with an installed capacity of 84.2 MW [41]. Solar energy is also used for space heating, an example being a solar installation in a Metro Cash & Carry store in Rome with a capacity of 2.1 MWth [42]. It should be noted that Italy has one of the highest indicators in the world for the ratio of electricity production through photovoltaics to the total amount of electricity produced. Calculations, according to data from [43] show that this share certainly exceeds 8%, which is several times larger than the world average of just over 1%.

Italy is actively developing hydrogen as an energy source for vehicles. As of November 2017, there are 2 hydrogen filling stations in operation in the country (Fig.8). There are also several plants producing hydrogen in the country, including the largest one managed by Milazzo, with an installed capacity of 54,166 Nm<sup>3</sup>/hr [44], and two hydrogen fuel cell power plants; Fusina, owned by Enel, has the largest capacity – 16 MW [45].

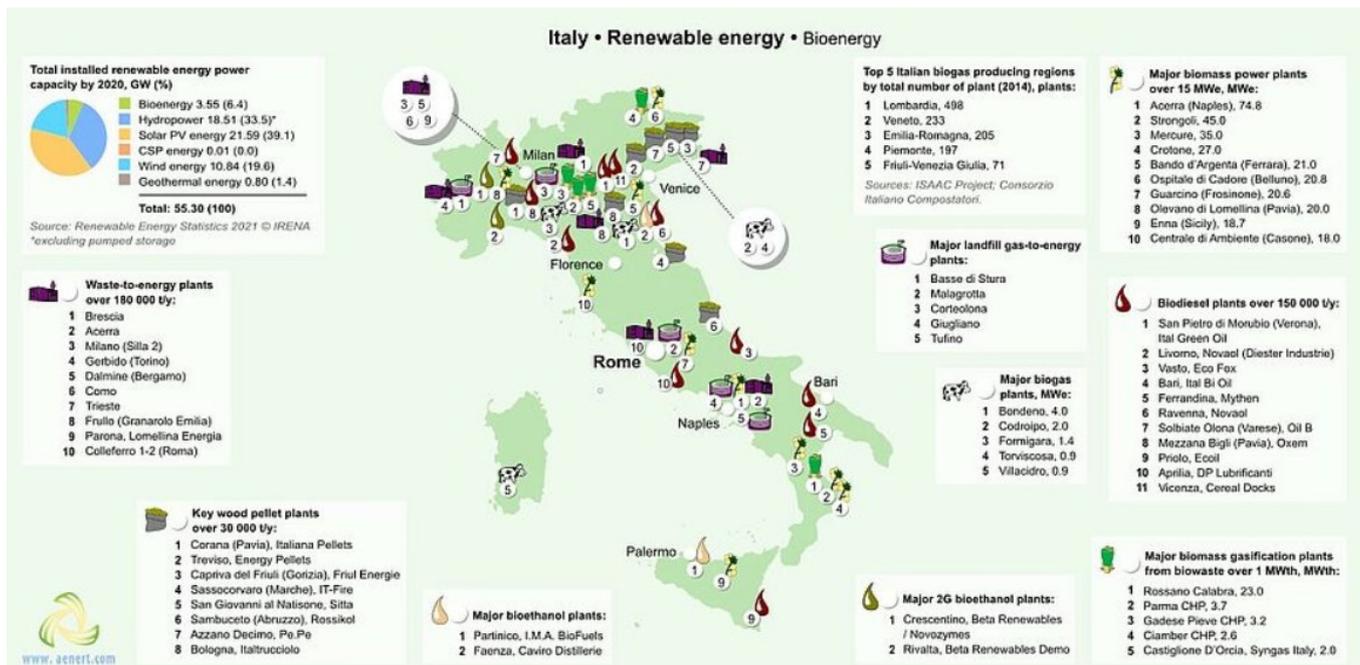


Figure 9. Renewable energy in Italy: Bioenergy

As previously mentioned, the geothermal potential in Italy was estimated at 2,000 MW [16]. In the central regions of the country there are a number of Dry Steam

type geothermal power plants (the largest being Valle Secolo (120 MW)) and Single flash type geothermal power plants (the largest being the complex of stations

Bagnore 3 and 4 (60 MW) [46,47]. They are found in Tuscany, where in 1913 the generation of electricity from geothermal energy was born. Today in Italy, more than 6% of electricity from renewables is generated using this technology.

Figure 9 shows the main bioenergy facilities in Italy for energy production.

Bioenergy is actively developing in Italy and in 2020 the installed capacity was around 3.5 GW (6.4%) and in 2019 about 19.5 TWh (17%) of electricity from renewables was generated from biomass (Fig. 8,9). The country has biomass and municipal waste processing plants; biogas, biodiesel, bioethanol, pellet and landfill gas production (Fig.9).

The country has biomass and municipal waste processing plants; biogas, biodiesel, bioethanol, pellet and landfill gas production (Fig.9). Fri-El Green Power S.p.A operates the largest biomass power plant, Acerra (Naples), with an installed capacity of 74.8 MW [48]. The main Italian production enterprise in the field of biomass fuels is San Pietro di Morubio, with an annual production capacity of 360,000 tons of biodiesel [49]. Italy is actively engaged in the production of bioethanol; Partinico, managed by I.M.A. BioFuels produces 172,000 t/year [50]. Second generation bioethanol from cellulose is produced at the largest plant, Crescentino, which has an installed capacity of 75 million litres [51]. In Lombardy alone there are about 500 biogas plants, the largest being Bondeno with an installed capacity of 4 MW [52] (Fig.9). Other notable enterprises include: Rossano Calabria biomass gasification plant, with a capacity of 23 MWe [53]; and Corana

(Pavia), which is producing about 60,000 tons of pellets per year in [54]. The leader in the generation of electricity from municipal waste is the plant in Brescia, which can process 800,000 tons per year [55]. Basse di Stura landfill gas-to-energy plant generates about 8.4 MW of electricity from landfill gas [56]. Italy's National Energy Strategy 2017 aims to reduce the final energy consumption by 10 million tons of oil equivalent by 2030; achieving a 28% share of renewable energy in total energy consumption, and a 55% of the share of renewable energy in electricity generation by 2030. Another important area is the development and introduction of environmentally-friendly fuels and the phasing out of the use of coal in the production of electricity by 2025 [57]. In the past few years, the German manufacturer of wind turbines, Senvion, has been very active in the Italian market, and in 2016 the company received a contract for the installation of 30 turbines with a total capacity of 60 megawatts, and in 2017 managed the construction of the first offshore wind farm in the Mediterranean, with a capacity of 30 MW [58,59].

In July 2017, Montello completed the construction of the first municipal waste to biomethane processing plant [60]. In 2017, the Tuscany region set a record in the generation of electricity using geothermal energy – 51 GWh more than in 2016 [61].

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*For current information on the development of energy in the country see [here](#). More information about Italian energy infrastructure is also available [here](#).*

## Education and Innovation

The set of indices reflecting the position of Italy in relation to other countries in the field of education and innovation can be seen in Figure 10. Italy is 29<sup>th</sup> out of 132 countries considered in the ranking of countries of the Global Innovation Index 2021 (see diagram). According to the number of patents granted to Italian nationals, both domestically and abroad, the country ranks 10<sup>th</sup> in the world, and 6<sup>th</sup> in Europe. Similarly, by the number of patents in force, the country is 8<sup>th</sup> in the world, indicating the country's favorable conditions for innovation.

In terms of government expenditure on education as a percentage of the country's GDP, the country demonstrates a result close to the world average – 94<sup>th</sup> out of 177 countries selected for consideration. Nevertheless, 30 Italian universities are included in the rating of the world leading universities – “QS University Rating”. It is also worth noting that the country's GDP is

high, therefore, in absolute terms, the level of government expenditure on education is considerable. In terms of public expenditure on research and development as a percentage of GDP, Italy is 27<sup>th</sup>, behind a number of European countries, but ahead of Spain, Poland, Greece. Italy is very well positioned when considering the number of publications of specialists in scientific and technological journals and patent activities. The country is 8<sup>th</sup> out of 240 participating countries in the Scimago ranking, and in Scientific and Journal Activities is ranked 8<sup>th</sup> out of 197 countries. The country is also among the leaders in the region in terms of the number of Internet users.

Italian Universities, such as the University of Trento, Scuola Normale Superiore di Pisa, the University of Rome “La Sapienza”, Politecnico di Milano, and Università degli Studi di Bologna train specialists in various fields of energy, including Energy Engineering, Environmental and Land Engineering, etc.

In the field of synthetic fuel production, leaders in patenting among Italian companies are Eni S.p.A., Agip Petroli S.p.A., Enitecnologie S.p.A. Research and development in this field is carried out by the Politecnico di Milano, Università degli Studi di Milano, Università degli Studi di Messina, CNR-ITAE “Nicola Giordano”. Istituto Nazionale di Oceanografie e di Geofisica Sperimentale, the University of Rome “La Sapienza”, and

Istituto Nazionale di Geofisica e Vulcanologia (INGV) publish scientific papers in the field of gas hydrates. In the field of hydrocarbon production from reservoirs with low permeability, the absolute leader in terms of patenting is Eni S.p.A.; research in this field is being carried out by Eni S.p.A. and Politecnico di Torino.



Sources:

1. The Global Innovation Index 2021, Rankings / Knowledge / World Intellectual Property Organization / Cornell University, INSEAD, and WIPO (2021): Energizing the World with Innovation. Ithaca, Fontainebleau, and Geneva \*132
2. Patent Grants 2011-2020, resident & abroad / Statistical country profiles / World Intellectual Property Organization \*185
3. Patents in Force 2020 / Statistical country profiles / World Intellectual Property Organization \*109
4. QS World University Rankings 2022 \*97
5. SCImago Country Rankings (1996-2020) / Country rankings / SCImago, (n.d.). SIR-SCImago Journal & Country Rank [Portal]. Retrieved 17 Nov 2021 \*240
6. Internet users in 2018 / The World Factbook / Central Intelligence Agency \*229
7. Internet users in 2018 (% Population) / The World Factbook / Central Intelligence Agency \*229
8. Government expenditure on education, total (% of GDP), 2019 / United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics. License: CCBY-4.0 / Data as of September 2021 \*177
9. Research and development expenditure (% of GDP), 2018 / UNESCO Institute for Statistics. License: CCBY-4.0 / Data \*119
10. Scientific and technical journal articles, 2018 / National Science Foundation, Science and Engineering Indicators. License: CCBY-4.0 / Data \*197

\* Total number of countries participating in ranking

Figure 10. The indices of education and innovation in Italy

The leading patent holders in the field of unconventional oil are Eni S.p.A., Enitecnologie S.p.A., Snamprogetti S.p.A., Agip Petroli S.p.A. Eni S.p.A.. Politecnico di Milano are conducting research in this area. In the field of associated gas – Eni S.p.A., Enitecnologie S.p.A. Politecnico di Milano is actively engaged in research in this field. The leading patent holders in the field of bioenergy are Eni S.p.A. and Agt Srl. Università degli Studi di Perugia, Università di Padova, Università degli Studi di Bologna, and Università degli Studi di Milano are conducting research in this area.

A large number of Italian companies patent technical solutions in the field of energy production from renewable sources. In the field of solar energy Magaldi Industrie, S.R.L., ENEA-Italian National Agency for New Technolo-

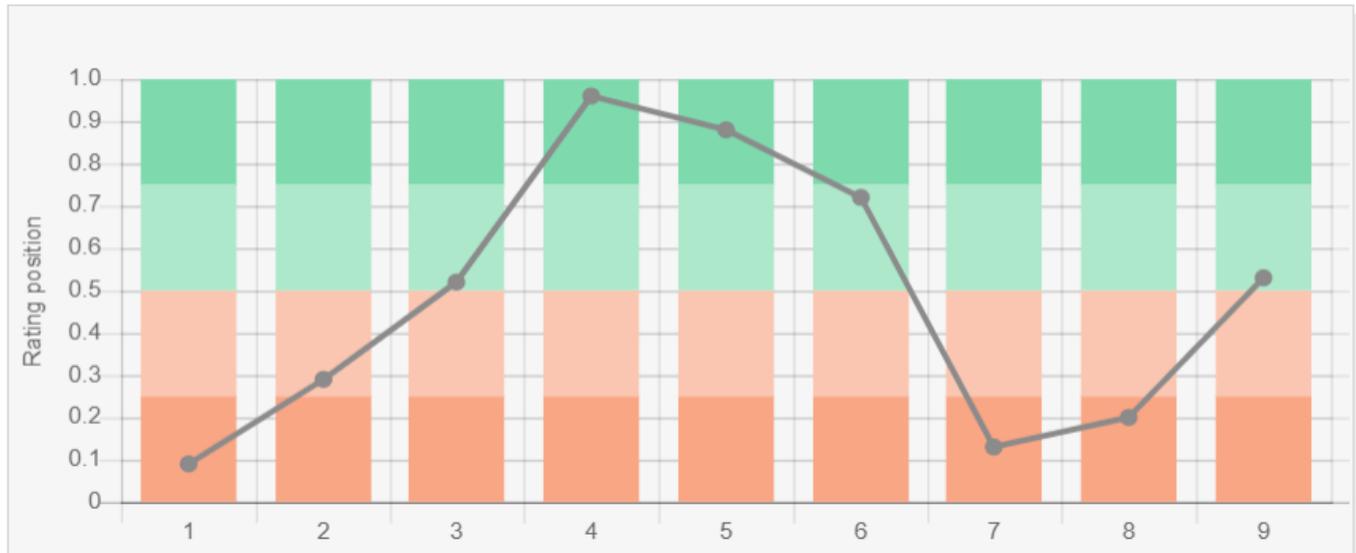
gies, Energy and Sustainable Economic Development, Eni S.p.A., Nuovo Pignone S.p.A. can be noted. Leading research organizations in this field are ENEA-Italian National Agency for New Technologies, Politecnico di Milano, University of Rome “La Sapienza”. Enel Green Power S.P.A, S.I.Sv.EL.S.p.a. top the list in the number of patents in the field of wind power; research in this field is being conducted by Politecnico di Milano, Università degli Studi di Bologna.

Additional information about education in the country can be obtained [here](#), and the list of research institutes [here](#).

## Ecology and Environment Protection

The environmental indices presented in Figure 11 reflect to some extent the ecological situation in the country, which in the case of Italy is quite negative. Firstly, the country demonstrates a relatively high level of CO<sub>2</sub> emissions both in general, and per capita. In 2020, the level

of CO<sub>2</sub> emissions from the process of coal mining and processing was 297 Mton [63]. On average, the cost of eliminating the consequences of this kind of emission costs Italy more than 528 million euros (health costs, pollution costs) [62].



Sources:

1. CO<sub>2</sub> total emission by countries 2020 / European Commission / Joint Research Centre (JRC) / Emission Database for Global Atmospheric Research (EDGAR)\*208
  2. CO<sub>2</sub> per capita emission 2020/European Commission/Joint Research Centre (JRC) / Emission Database for Global Atmospheric Research (EDGAR) \*208
  3. Forest area 2020 (% of land area) / The Global Forest Resources Assessment 2020 / Food and Agriculture Organization of the United Nations \*234
  4. Forest area change 2010-2020 (1000 ha/year) / The Global Forest Resources Assessment 2020 / Food and Agriculture Organization of the United Nations \*234
  5. The Environmental Performance Index (EPI) 2020 / Rankings / Yale Center for Environmental Law & Policy / Yale University \*180
  6. Annual freshwater withdrawals (m<sup>3</sup> per capita), 2017 \*179  
Annual freshwater withdrawals, total (billion m<sup>3</sup>), 2017 – Food and Agriculture Organization, AQUASTAT data. /License: CC BY-4.0; Population – United Nations, Department of Economic and Social Affairs, Population Division (2019).  
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  9. The Climate Change Performance Index (CCPI) 2022 / Overall Results / Jan Burck, Thea Uhlich, Christoph Bals, Niklas Höhne, Leonardo Nascimento / Germanwatch, NewClimate Institute & Climate Action Network \*60
- \* Total number of countries participating in ranking

Figure 11. Environmental indices of Italy

It should also be noted that there is a relatively high level of methane emissions in Italy. The situation is further clouded by the fact that Italy, which ranks 25<sup>th</sup> of the 64 countries responsible for more than 90% of global CO<sub>2</sub> emissions related to energy in the Climate Change Performance Index (CCPI) 2022, has emissions that are categorized as “medium”. In terms of forest area as a percentage of the country, Italy was 112<sup>nd</sup> in the world in 2020; however, the trend associated with its change from 2010 -2020 looks very positive; by this indicator the country is 9<sup>th</sup> in the world.

The situation is brightened by a very high valuation of Italy in the Environmental Performance Index rankings

(EPI) 2020, which focuses primarily on assessing the environmental performance of national governments. Here, the country is 20<sup>th</sup> out of 180 countries, behind a number of European countries, but ahead of the USA. The overall negative picture is aggravated by the Ecological Footprint Atlas rating, according to which Italy is among a number of ecological debtors.

For more information on the energy industry of Italy, see the attached link library by clicking [here](#).

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The sources of charts and curves are specified under the images.