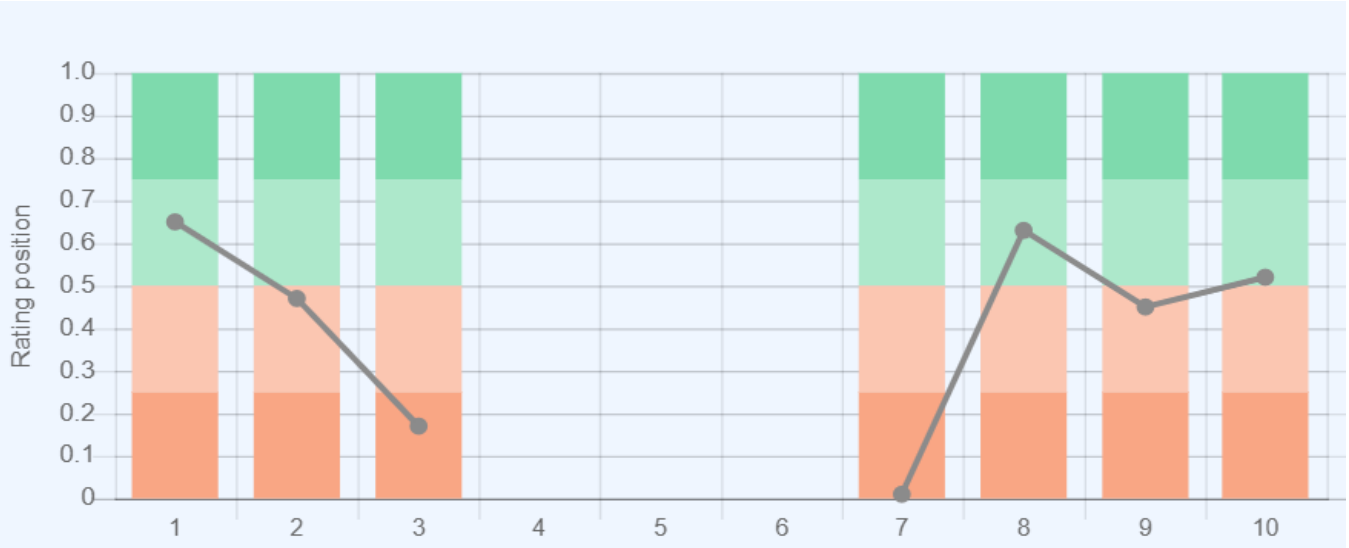
Energy Industry in **Cuba**

General State of the Economy

Cuba, the official name – the Republic of Cuba, with its capital in Havana, is located on an archipelago that forms part of the Greater Antilles in the north of the Caribbean Sea.

In terms of the size of the territory, Cuba is 104th in the world and is the largest country among the island states of the Caribbean [1]. In terms of population density, the country is ahead of most of the countries in the region, including Mexico, Brazil and Colombia and is 110th in the world, with an average density of 102 people per 1 km^2 [2]. The total length of the country's coastline is 3 735 km [3]. According to 2022 statistics, the country is home to around 11 million people [3]. The administrative map of Cuba is divided into 15 provinces, the official language is Spanish, the political form of government is a socialist republic of parliamentary type [3].

The economy of Cuba is mainly orientated towards export of agricultural products. The tourism sector also plays an important role in shaping GDP and attracting foreign investment.



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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 (from smallest to largest) *210
* Total number of countries participating in ranking

Figure 1. Economic indices of Cuba

However, the U.S. and, as a consequence, the inability to access important markets in the region, has a very negative impact on the country's economic performance. So for the majority of the selected ratings, Cuba is either not represented or is at the bottom of the diagram (Fig. 1).

Nevertheless, for such indices as the level of GDP and reserves of foreign exchange and gold (72nd place in the world), Cuba's indicators are higher than the world average, or close to them.

Between 1995 and 2014, the country experienced steady growth in GDP at purchasing power parity [4]. In 2017, this indicator was at the level of $ 137 billion (78th in the world) [3]. GDP at purchasing power parity per capita is significantly lower (122th in 2016), which has also been demonstrating positive dynamics: from $12 100 in 2014 and $12 300 in 2016 [5,3].

The inflation level in the country was 5.5% in 2017, which is somewhat higher, compared with 4.5% in 2016 [3].

According to the Index of Economic Freedom, which is based on freedom of business, freedom from government action, property protection, and freedom from corruption, Cuba was 176th in 2021, out of the 178 countries considered. According to the indicator for the average GDP growth in percentage over the last 10 years, in 2020 the country was 113th out of 206 countries. In terms of public debt, calculated as a percentage of the country's GDP, Cuba was ranked 110th out of 210 countries considered in 2017 .

*For more information on the Cuban economy click **here.***

Energy resources

Cuba does not have significant reserves of fossil resources (Table 1), and is mainly relies on imports to meet domestic energy demand. Nevertheless, Cuban offshore oil and gas fields are very promising. However, their development is complicated by US embargoes, low oil prices, and technical difficulties associated with extraction from these fields [5].

Table 1. Fossil energy resources of Cuba

Resource/ explanations	Crude oil	Natural gas	Coal	Shale Gas	Tight Oil	Coal mine methane	Extra heavy oil
Value	124	70.79	No data	No data	No data	No data	No data
Unit	million bbl	Bcm	-	-	-	-	-
Year	2021	2021	-	-	-	-	-
Source	[3]	[3]	-	-	-	-	-

In terms of tons of oil equivalent, in 2021 proved reserves of conventional hydrocarbons in Cuba were: gas - 79%, oil - 21% (Fig.5).

Proved oil reserves in Cuba, according to [3], as of 2021, were estimated at 124 million barrels, and the proven reserves of natural gas were estimated at 70.79 billion m^3 in 2021.

Moreover, the proven reserves of oil and natural gas have declined significantly since the beginning of this century.

Cuba has high potential for the development of clean energy production. A selection of basic indicators of this type of resource is presented in Table 2.

Table 2. Renewable energy resources of Cuba

Resource/ explanations	Solar Potential (GHI)*	Wind Potential (50 м)*	Hydro energy Potential**	Bio Potential Agricultural area	Bio Potential Forest Area	Municipal Solid Waste
Value	4.9 – 5.7	5.0 - 6.0	7	61.7	31.2	0.67
Unit	kWh/m²/day	m/s	GWh/year	% of land area	% of land area	Kg/per capita/day
Year	2018	2018	2009	2020	2020	2016
Source	[7]	[8]	[11]	[9]	[10]	[13]

**for most of the territory of the country*
***gross theoretical capability*

The level of global horizontal irradiation throughout the country has a value of 4.9-5.7 kWh/m²/day [7]. The maximum level of solar radiation of 5.7-7.0 kWh/m²/day can be observed in the south, along the Caribbean Sea, as well as in the southeastern part of the country and in the province of Guantanamo. The distribution of wind resources is as follows: for the majority of the country the wind speed is 5.0-6.0 m/sec [8].
The peak of wind activity is observed in the southeastern part of the country and in the province of Guantanamo and the coast of the Caribbean Sea, where the wind speed can exceed 7.0 m/sec (at a height of 90 m) [8]. About 61.7% of Cuba is covered by agricultural land, and 31.2% is forested [9,10].

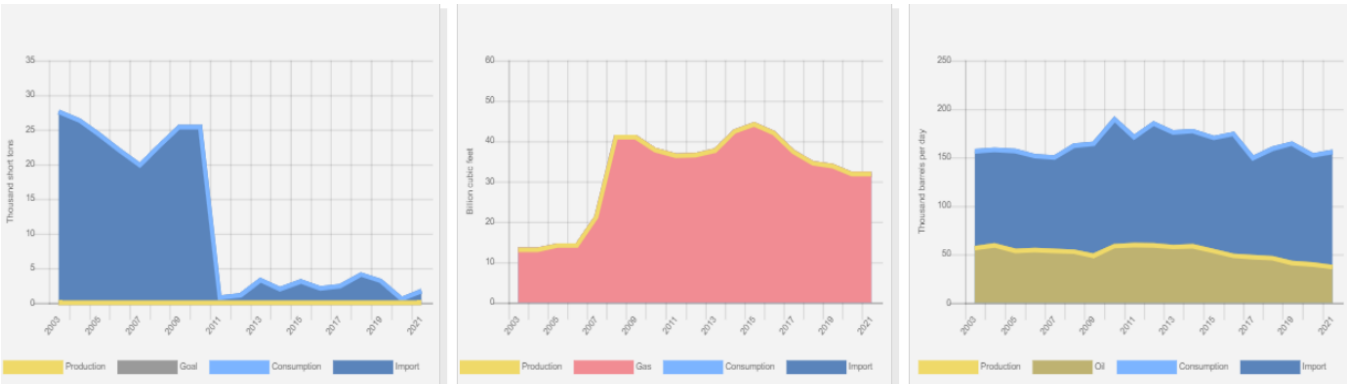
Cuba does not have a dense river network. Gross theoretical hydropower potential of the country is 7 GWh/year [11]. Potential for the use of ocean energy and sea wave energy in the south of the country can reach 15 kW/m [12].
This energy review of Cuba would not be complete without mentioning municipal waste (0.67 kg per capita per day), which on the one hand are valuable raw materials for secondary use or energy production, and on the other hand, long-term decomposing substances that substantially pollute the natural environment [13].

*For more information about energy resources in Cuba click **here.***

Energy balance

The volume of oil production between 2001 and 2017 remained fairly stable between 50-60 thousand barrels/day, falling to 37 thousand barrels/day in 2021 [14]. At the same time, consumption in 2019 was at the level of 164 thousand barrels/day compared to 189 thousand barrels/day in 2010 (Fig. 2).
In the Cuban Statistical Report (Anuario Estadistico de Cuba 2021), crude oil production in 2020 was estimated at 2 320 thousand tons, and production of petroleum products was at the level of 2 052 thousand tons.
At the same time, oil and oil products consumption in 2020 was 6 496.9 thousand tons [15].

Oil imports in 2015 according to [3] amounted to 112 400 barrels/day. Venezuela is the main exporter of oil to Cuba, and according to [6] in the first half of 2016, PDVSA supplied about 53 500 barrels / day - 40% less than in 2015.
The report [15] shows the following data: crude oil imports in 2020 amounted to 1 793.4 thousand tons, imports of petroleum products – 3 084.2 thousand tons. Production of natural gas grew annually, reaching 1 244,5 million m³ in 2015, but then showed a negative trend reaching a level of 970,1 million m³ in 2018, and falling even to 651,9 million m³ in 2021 [15].



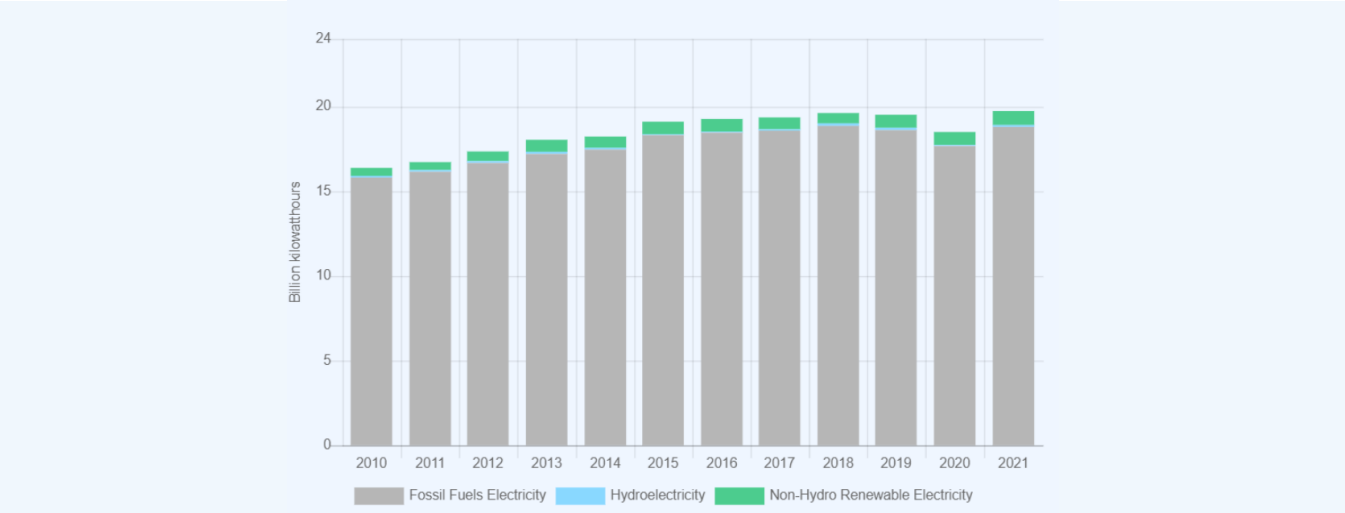
Source: U.S. Energy Information Administration (Dec 2022) / https://www.eia.gov/

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

Consumption corresponded to production up until 2010, when consumption decreased, and in 2021 amounted to 688.5 million m³ [15]. According to the U.S. Energy Information Administration, both gas production and consumption in Cuba in 2021 was 32 Bcf [14].

Coal consumption in Cuba has twice shown a sharp decline, in 2006 and in 2014. In 2016 the country practically stopped producing it [6] and the imports of this resource amounted to 2.2 thousand tons in 2020 [15].

Historically, Cuba has a high share of fossil fuels in electricity production (Fig. 3).
In 2021 Cuba produced about 19.75 TWh of electricity, of which 95.2% was by fossil fuels, 0.6%, by hydro power, 4.2% by other renewable sources (Fig.6).



Sources:
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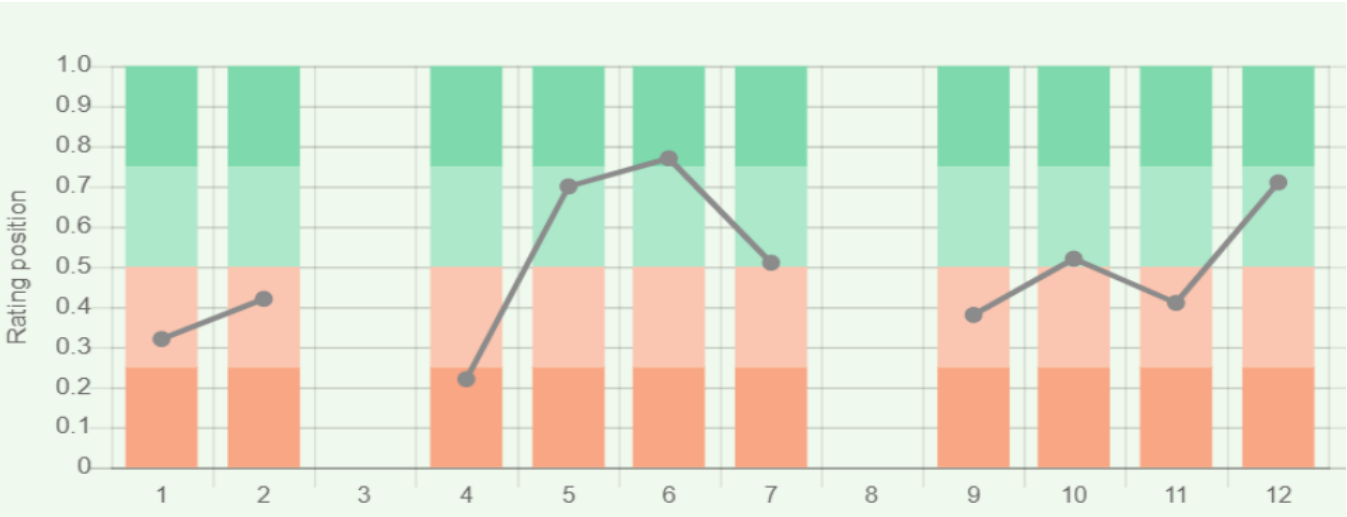
Figure 3. Electricity production in Cuba

Cuba's position in the comparative diagram of energy index is shown in Figure 4. Indices based on oil and gas reserves are at the bottom of the chart. However, in terms of production-consumption of natural gas ratio, the country demonstrates results higher than the world average.



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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 Cuba

In the Energy Architecture Performance Index 2017, which is based first on the level of economic growth, environmental safety, and energy independence of the country, including access to energy, Cuba dropped 17 ranking positions, and is 61st, behind Chile. In the list of countries for the production of electricity from renewable sources (excluding hydropower), in 2017 Cuba was 84th out of 170 countries selected for consideration.

In terms of electricity consumption per capita, the country is 129th in the world, however, for the indicator of combination of electricity production-consumption, Cuba is 62nd in the ranked list of 216 countires.

*More information about the energy resources of Cuba can be found **here.***

Energy Infrastructure

A territorial map of the distribution of the largest infrastructure projects of the fossil-fuel sector in Cuba is shown in Figure 5. As mentioned previously, gas reserves account for 79% and oil reserves account for 21% of the energy potential of fossil resources. The main oil and gas fields are concentrated in the north of the country (Fig.5). The largest oil field in Cuba is Varadero, located 125 km from Havana. According to the experts from Cupet, this field has a potential of 11.3 billion barrels [16]. The oil pipeline 230 km long connects the fields with the refineries close to Havana. The total length of the gas pipeline is 41 km [3].

Cupet operates four oil refineries with a total installed capacity of over 120 000 barrels/day (Fig. 5), the largest of which is Cienfuegos Oil Refinery (65 000 barrels/day) [17]. The most important oil storage facility, Matanzas, is located in the north, in close proximity to the fields and has a capacity of 1.8 million barrels [18] .

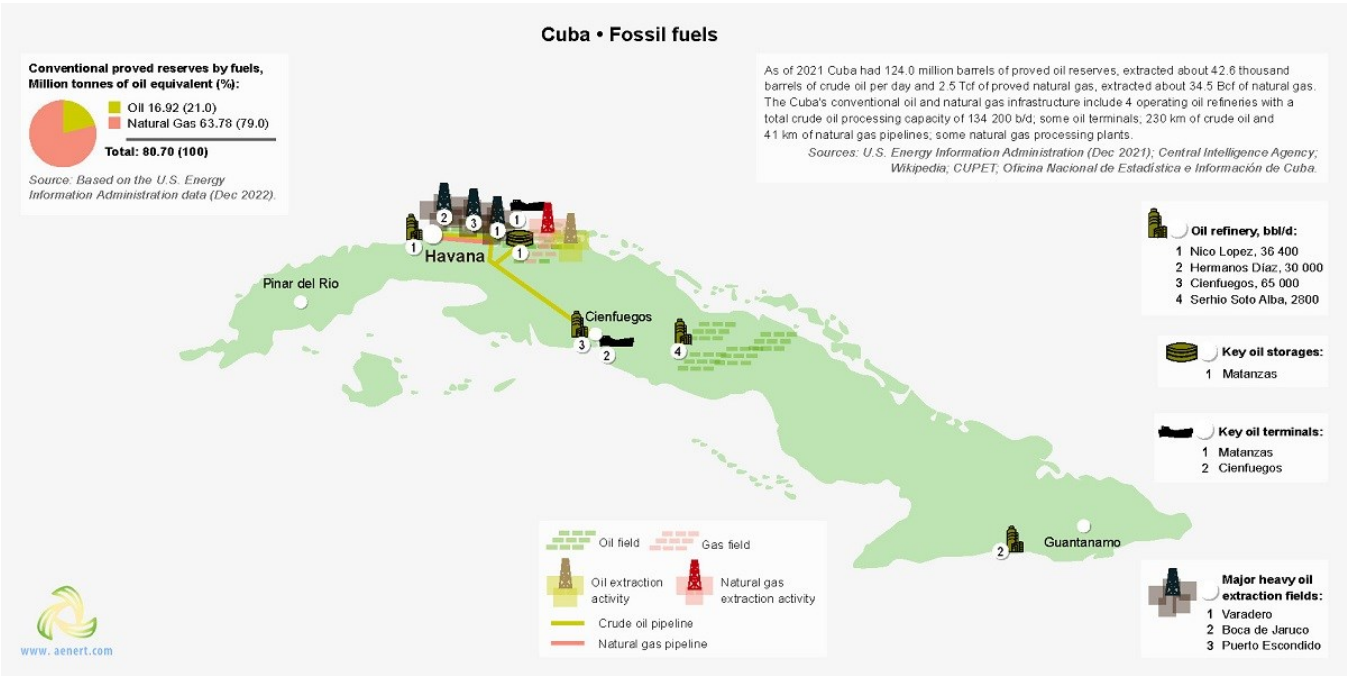


Figure 5. Basic infrastrucural facilities of the fossil fuel sector in Cuba

The main oil terminals are located in the area of the capital and Cienfuegos.

The map of the territorial distribution of the largest infrastructure objects of electricity production is shown in Fig. 6. According to [15], the total installed capacity of the Cuban energy complex in 2018 was about 6.661 GW.

The share of fossil fuels in electricity production in the country prevails, and in 2021 amounted to about 95.2%, with about 0.6% of hydropower, 4.2% of other renewable energy sources (Fig. 6).

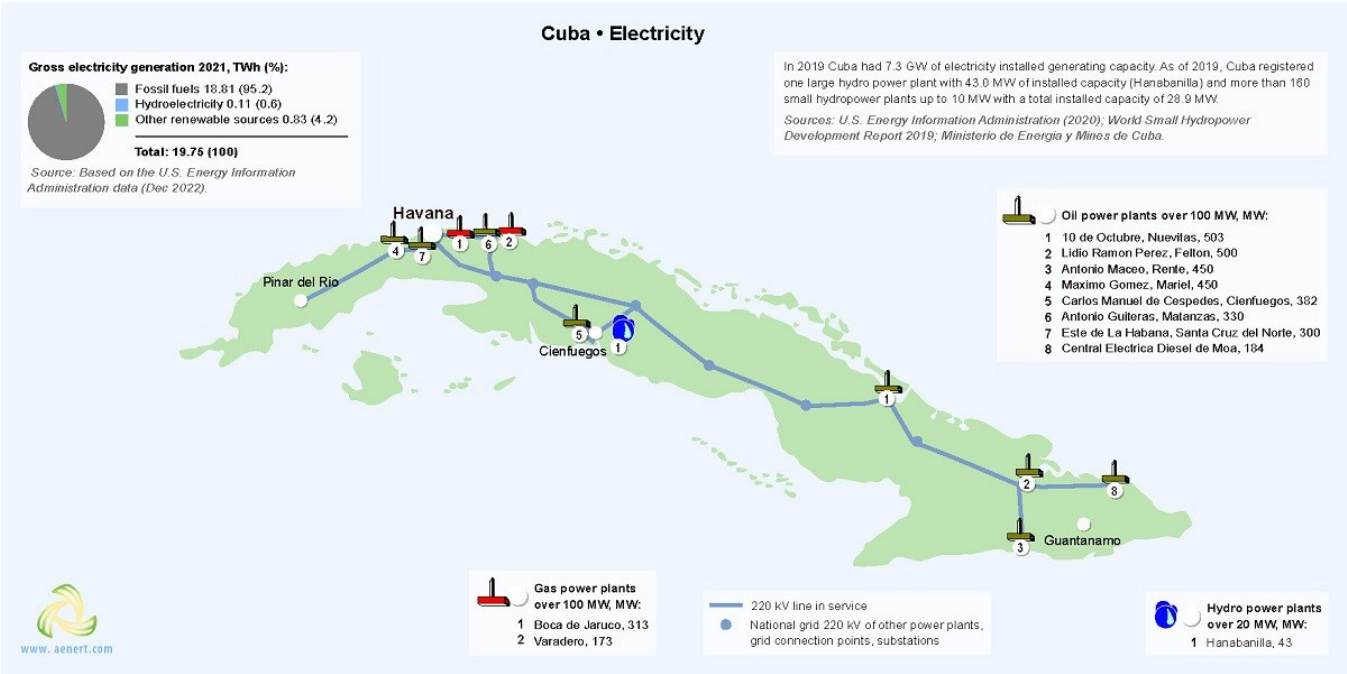


Figure 6. Electricity production in Cuba

In the first case, electricity is produced mainly from hydrocarbon raw materials. There are 8 large oil power plants with a capacity of more than 100 MW, 2 large gas power plants with a capacity of more than 100 MW (Fig. 6).The leading oil power plant is 10 de Octubre, with a capacity of 503 MW, and the largest gas plant is Boca de Jaruco, with a capacity of 238 MW [19,20]. In 2021, around 119.7 GWh of electricity was generated by means of hydropower, the total installed capacity of hydropower in the county amounted to 64.6 MW [15]. The largest hydropower plant is Hanabanilla Hydro power plant, with a capacity of 43 MW [21]. In Figure 7, you can see the main facilities of the Cuban infrastructure for the production of energy from renewable sources. As noted above, renewable energy in Cuba, excluding hydropower, does not have a decisive influence on electricity generation. Thus, the total electricity production from renewable sources in 2020, excluding hydropower, was 0.74 TWh (see sources in Fig. 7).

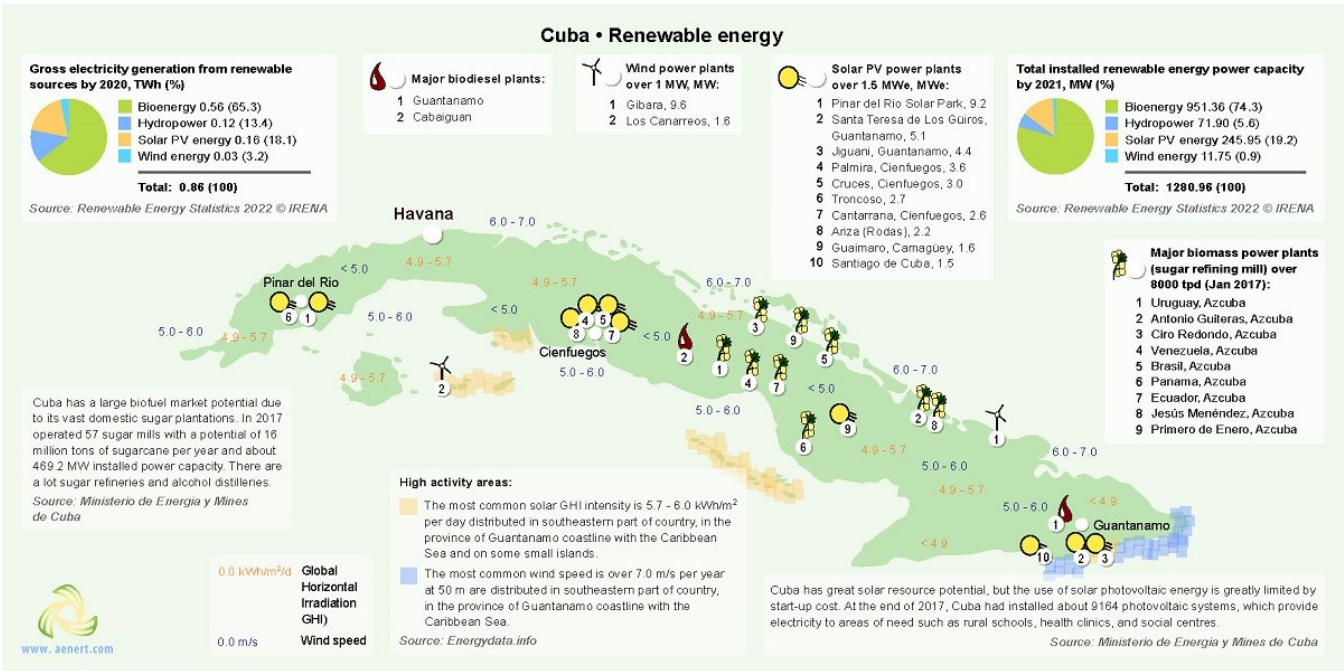


Figure 7. Renewable energy in Cuba

According to IRENA in the field of electricity generation in 2020, the leader was bioenergy – 65.3%, solar energy – 18.1%, hydropower was 13.4%, wind energy – 3.2% (see sources in Fig. 7).

Bioenergy is actively developing in Cuba, mainly because of the abundance of sugar plantations. In 2017, 16 million tons of cane were produced by 57 sugar processing enterprises (see sources in Fig. 7). Arzuba owns the largest enterprises of this type – Uruguay Sugar Refining Mill, with an installed capacity of 13 800 tons/day [22]. Cuban bio-engineers successfully apply modern technologies for the production of biodiesel at Guantanamo biodiesel plant that produces about 100 tons of fuel annually [23].

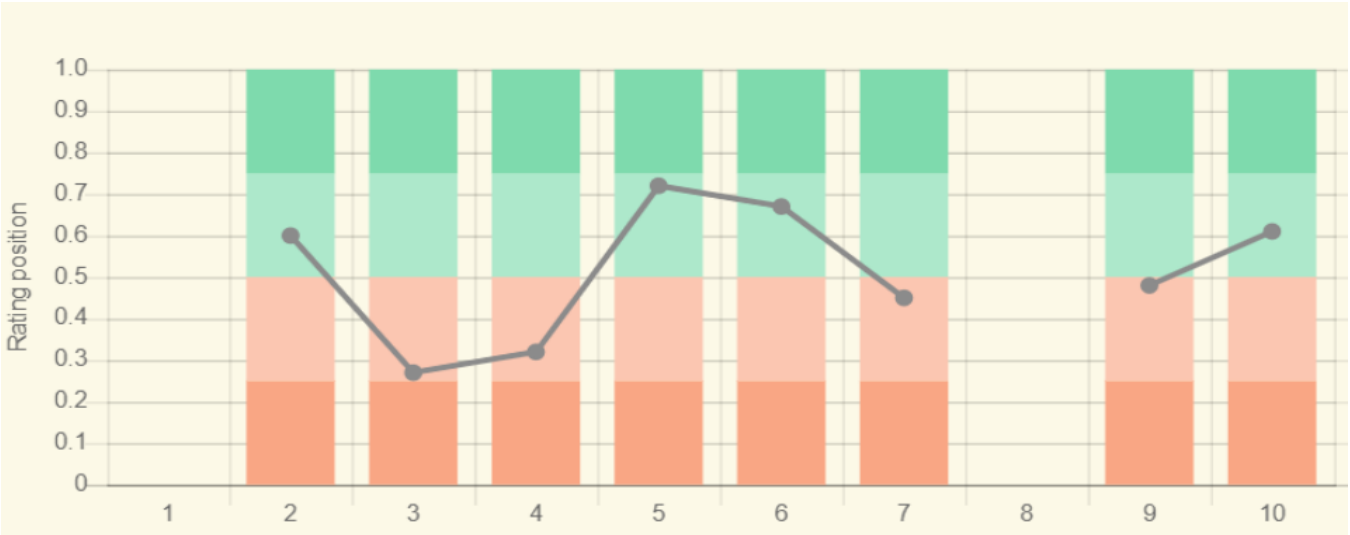
The maximum level of solar radiation can reach 6.0 kWh/m2 per day, and the level of wind activity is 7.0 m/s, which is the richest resource for energy production [7,8]. Due to this, there are about 9 164 photovoltaic systems in Cuba that provide energy for schools and hospitals. However, the high cost of installing photovoltaic panels at the initial stage hinders the development of this type of power in Cuba (Fig. 7). The largest solar power plant is Cantarrana with an installed capacity of 2.6 MW, and the largest Wind Farm is Gibara, with a capacity of 9.6 MW [24,25].

One of the main aims of the energy program until 2030 is to increase the share of renewable energy to 24%, at the moment it does not exceed 4.3%. To achieve this goal, the country will need an investment of about $ 600 million. To this end the Raul Castro government has opened this energy sector for foreign capital [26]. Within the framework of this program, construction of seven wind parks with a total capacity of 750 MW, together with the Spanish company Gamesa, as well as equipping residential buildings and municipal facilities with 133 000 solar water heaters is envisaged [27].

*Detailed information about energy infrastructure of Cuba can be found **here.***

Education and Innovation

The set of indices reflecting the position of Cuba among other countries in the field of education and innovation can be seen in Figure 8. Figure 8 presents indices that are not directly related to the energy sector, but largely predetermine its future, both in Cuba and throughout the world.



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* Total number of countries participating in ranking

Figure 8. The indices of education and innovation in Cuba

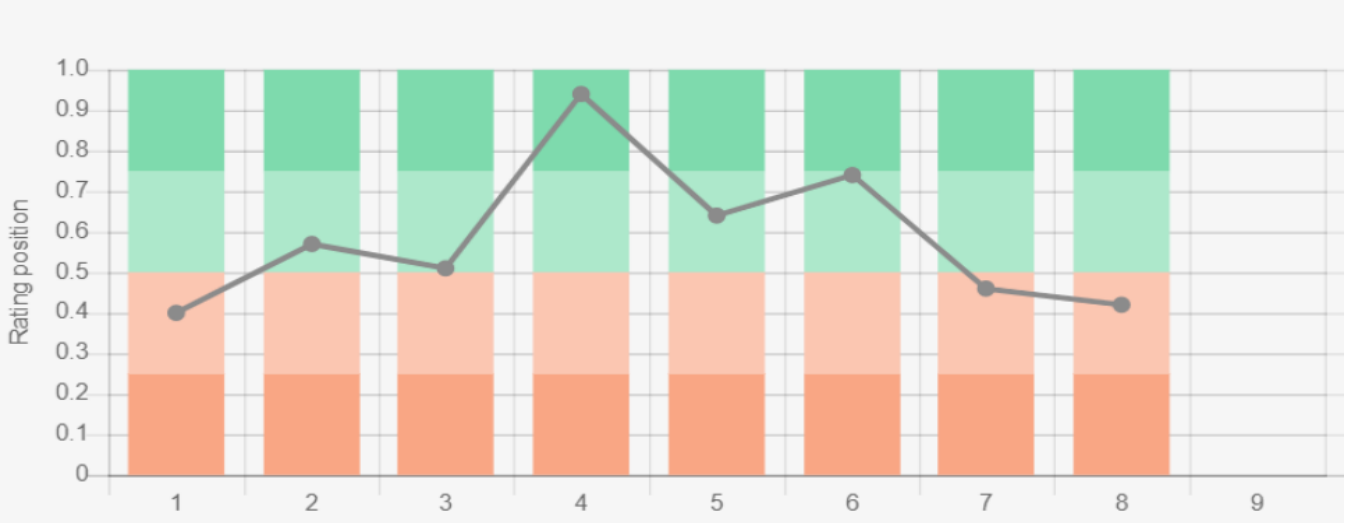
According to the number of patents granted to Cuban residents, both inside the country and abroad, the country ranks 74th in the world. Similarly, by the number of patents in force, the country 80th in the world, which largely characterizes the country's patent attractiveness. Three Cuban universities are included in the QS University Rating. The country occupies 62nd place in the world in terms of government expenditure on research and development.
However, Cuba is well positioned when considering the number of publications of specialists in scientific and technological journals. It is also regarded highly by the Scimago Journal and Country Rank where Cuba is 67th out of 240 countries considered.
A large number of universities conduct research in the field of bioenergy, such as Universidad Central de Las Villas and Instituto Superior Politecnico "Jose Antonio Echeverria" (CUJAE).

For more information on Cuba's education and innovations, as well as on the country's research institutes, please click ***here.***

Ecology and Environment Protection

A diagram of environmental indices is shown in Figure 9.

Figure 9 shows the indices that have an indirect effect on the energy sector, but in many respects predetermine its future. First of all, the country demonstrates a relatively high level of CO_2 emissions in general, however, per capita this level is much smaller.



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* Total number of countries participating in ranking

Figure 9. Environmental indices of Cuba

According to forest area as a percentage of land area, Cuba is not among the world leaders, however, the trend associated with its change looks very positive. In this rating, the country is at 14th place out of 234 countries surveyed, conceding only Chile in the region, which indicates the rational use of this resource.

Cuba also has a relatively high valuation of the Environmental Performance Index rankings (EPI), which focuses primarily on assessing the environmental performance of national governments. In this rating in 2020 Cuba is 64th out of 180 countries and demonstrates a positive trend.
According to the Environmental Vulnerability Index, which is based on years of observations and 50 indica-

tors, which include for example, changing climatic characteristics or the quality of water resources, waste volumes, oil spills and other hazardous substances, etc. Cuba is 157th, and is characterized as "highly vulnerable". Cuba also belongs to a group of countries with very high levels of methane emissions. According to the Ecological Footprint Atlas rating, Cuba is among the environmental debtors.

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*Additional information about the Cuban energy industry can be found in the attached link library **here.***

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