iSANS The International Strategic Action Network for Security

ЗЯЛЁНАЯ БЕЛАРУСЬ

INFORSE-EUROPE International Network for Sustainable Energy

Long term strategy for Belarus

Project: ”Better Green Deal with CSO policy proposals, visions and scenarios for best mitigationpolicies for Baltic Sea Countries and Ukraine”

2024

Abbreviations

CHP – combined heat and power plant

CPP – condensing power plant

GDP – gross domestic product

GHG – greenhouse gas

Mtce – million tons of coal equivalent

NPP – nuclear power plant

PV – photovoltaic power plant

RE – renewable energy

RES – renewable energy sources

WPP – wind power plant

Introduction

Modeling the energy system in Belarus currently faces serious challenges.

Following the seizure of power in 2020 and a series of international crimes, economic sanctions were imposed on Belarus. In an attempt to circumvent them and hide possible ways to circumvent them, the government stopped publishing data on foreign trade, energy data, and a whole range of other data. As a result, reliable data on the energy balance is only available for 2020. The current state of the energy balance can only be assessed based on public data that is still available.

In this paper, an analysis of the current state of the energy system was conducted, a forecast of fuel consumption and greenhouse gas emissions was made for a scenario without changes.

An analysis of technologies that can be used in the future to improve energy efficiency and reduce greenhouse gas emissions was also conducted. A scenario for the development of the energy system was developed taking into account the use of these technologies.

State of Belarus energy system in 2020

Supply

- In 2020, only 17.1% of the country's energy demand (37 million tonnes of coal equivalent [Mtce]) was met by domestic production, making Belarus one of the least energy self-sufficient countries in the world.
- Despite the world's third-largest production of peat (1,654 kt in 2018), small amounts of crude oil (1,710 kt in 2020) and natural gas production (219 mln cubic metres in 2020), Belarus depends heavily on imports to meet its energy demand.
- Nearly all electricity generation came from natural gas in 2020 (90%, or 34.5 terawatt hours [TWh]), but this is projected to change with the commissioning of one nuclear reactor in 2021 and after commissioning of second nuclear units (1,200 megawatts [MW] each, that were put in operation in October 2020 and July 2021).
- Belarus is a large oil refiner (36th in the world, at 16.3 Mt of oil products in 2020).

Imports/exports

- Belarus depends heavily on imports of all types of fossil fuels, supplied mainly by Russia. Fuel for new nuclear power plant is planned to import from Russia too.
- The country is large importer of natural gas: according to preliminary data for 2020, Belarus imported 19 billion cubic metres [bcm] of natural gas, making it the leading gas importer among EU Eastern Partnership countries.
- Belarus imports similar amount of crude oil, but most oil is being re-exported in the form of oil products. Russia is the main supplier of crude oil, which is being refined in Belarus, and Belarus in turn is the main supplier of oil products to Ukraine.

Final consumption

The main final consumption fuel is accounted for by the consumption of heat. The key consumers are industry and the population. Also, some part is consumed in the service sector, mainly for space heating. The total consumption of heat is almost 8 Mt c.e.

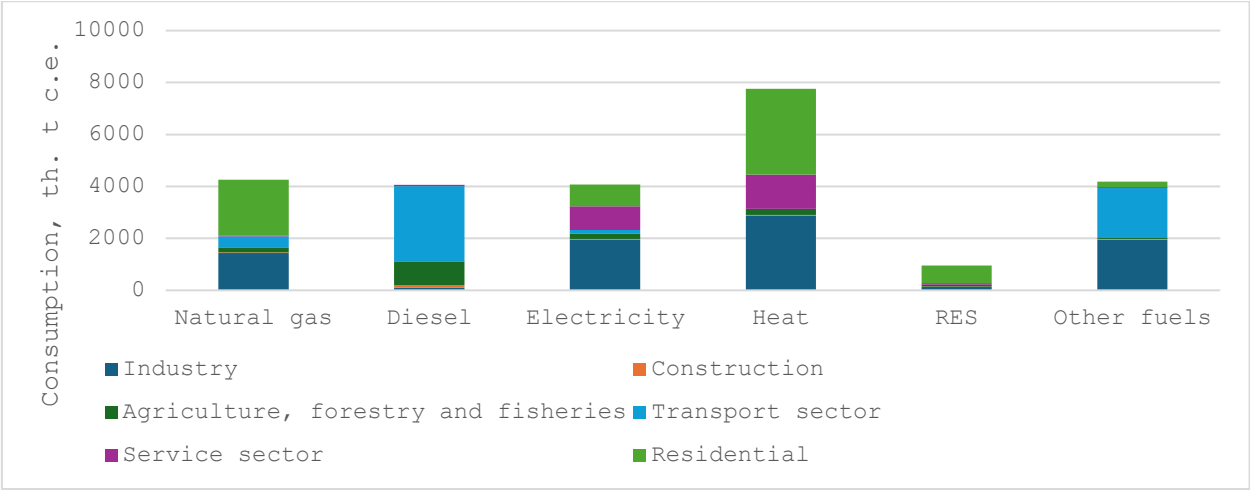


Figure 1 – Final consumption of Belarus in 2020 (Source: Belstat)

Another 4 types of fuel are distributed almost evenly among themselves, 4 million tons of fuel equivalent for each type: natural gas, diesel, electric energy and other types of energy in total.

Natural gas is mainly used by the population and industry, as well as by the transportation sector, mainly for pumping natural gas and oil.

Diesel fuel is consumed almost entirely in the transport and agricultural sectors.

The main sector of electricity consumption is industry. The share of the service sector and the population is also significant.

Among consumers of other types of fuel, the transport sector occupies a significant share, which is associated with the consumption of gasoline and liquefied gas. Industry is also a significant consumer, which consumes a significant volume of various types of fuel: peat and peat briquettes, fuel oil and other types of oil products, etc.

Additionally, approximately 1 million tons of fuel equivalent comes from renewable energy sources, the key consumer of renewable energy sources is the population. This is expressed almost entirely in the consumption of wood biomass.

Transformation

The transformation sector ensures the conversion of one type of fuel or energy into another. For example, the use of gas to produce heat and electricity or the refining of oil to produce petroleum products. The entire sector can be divided into two large blocks: oil refining (oil refining) and the production of electricity and heat (energy system).

There are also other small conversion blocks, such as peat briquette plants that process peat into peat briquettes, or the production of wood chips from wood.

However, their share is much smaller, and these blocks mainly work in the field of converting local types of fuel. Therefore, their influence and capabilities in the event of interruptions in energy supply from Russia are extremely limited.

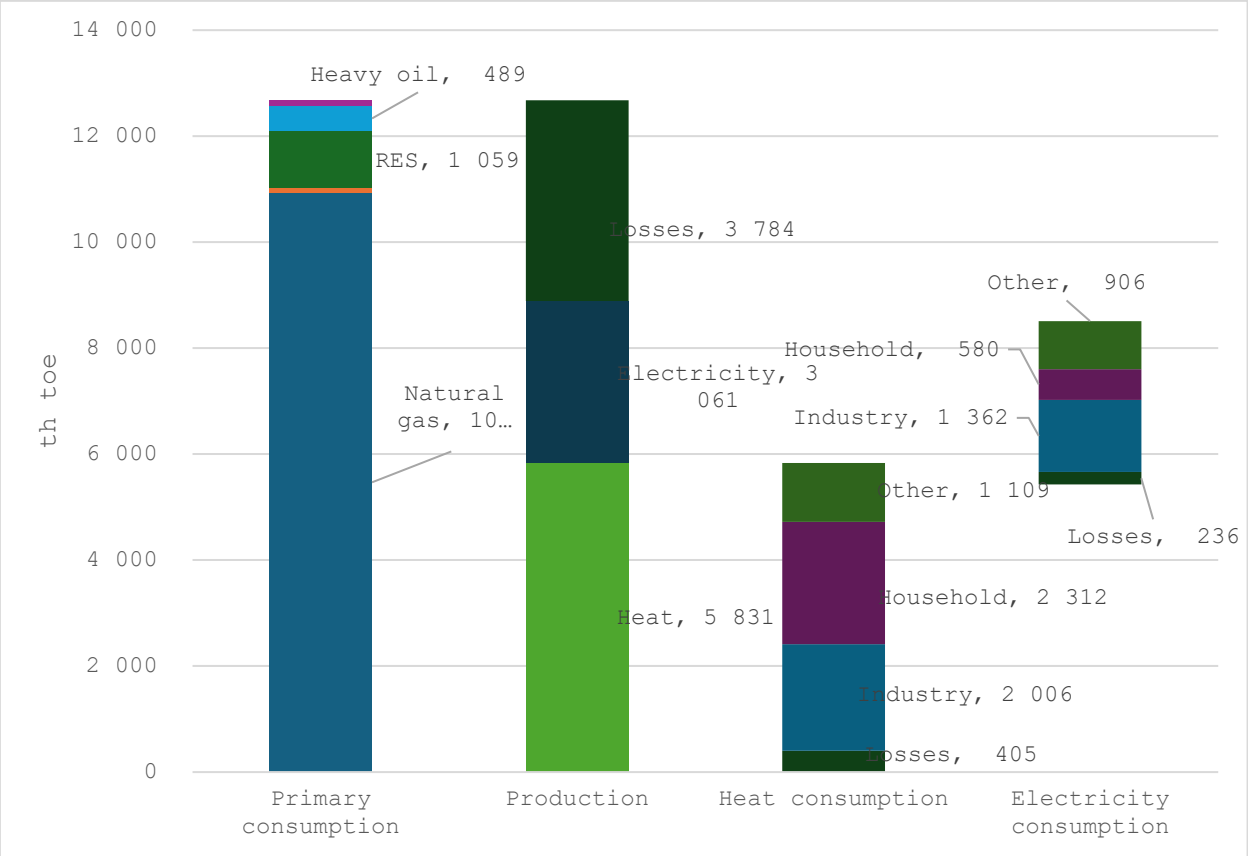
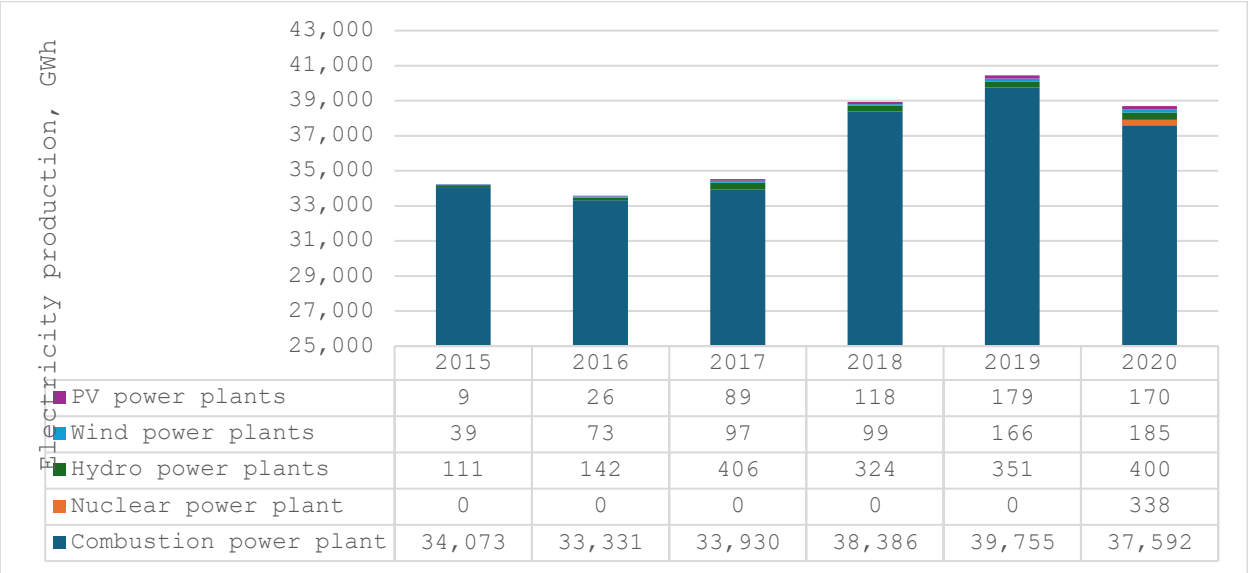


Figure 2 - Heat and electricity production (Source: Belstat)

The main type of fuel consumed is natural gas. The second category is the use of biomass - wood fuel and forestry and agricultural waste. In 2020, fuel oil was actively used due to its low price associated with a decrease in the price of oil and other oil products.

About a quarter of the energy consumed is lost during the conversion, and the remainder is used to produce electricity and heat. Heat accounts for about two-thirds of the output.

Renewables accounted for only 7.8% of Belarus's energy mix in 2020, mostly it is energy from biofuels and renewable waste. Renewables' share in electricity generation was even lower - 3% in 2020 (0.93 TWh).



	2015	2016	2017	2018	2019	2020
PV power plants	9	26	89	118	179	170
Wind power plants	39	73	97	99	166	185
Hydro power plants	111	142	406	324	351	400
Nuclear power plant	0	0	0	0	0	338
Combustion power plant	34,073	33,331	33,930	38,386	39,755	37,592

Figure 3 - Electricity production (Source: Belstat)

The RE capacities in the energy system are still insignificant, although recently it has begun to increase. However, in connection with NPP commission the quotas for RES commission (see Decree "About renewable energy sources" in chapter "Regulatory framework") set at zero level for the period of 2021-2023. This indicates that in the near future the commissioning of new RE capacities will at least not be accelerated and will likely to be stopped.

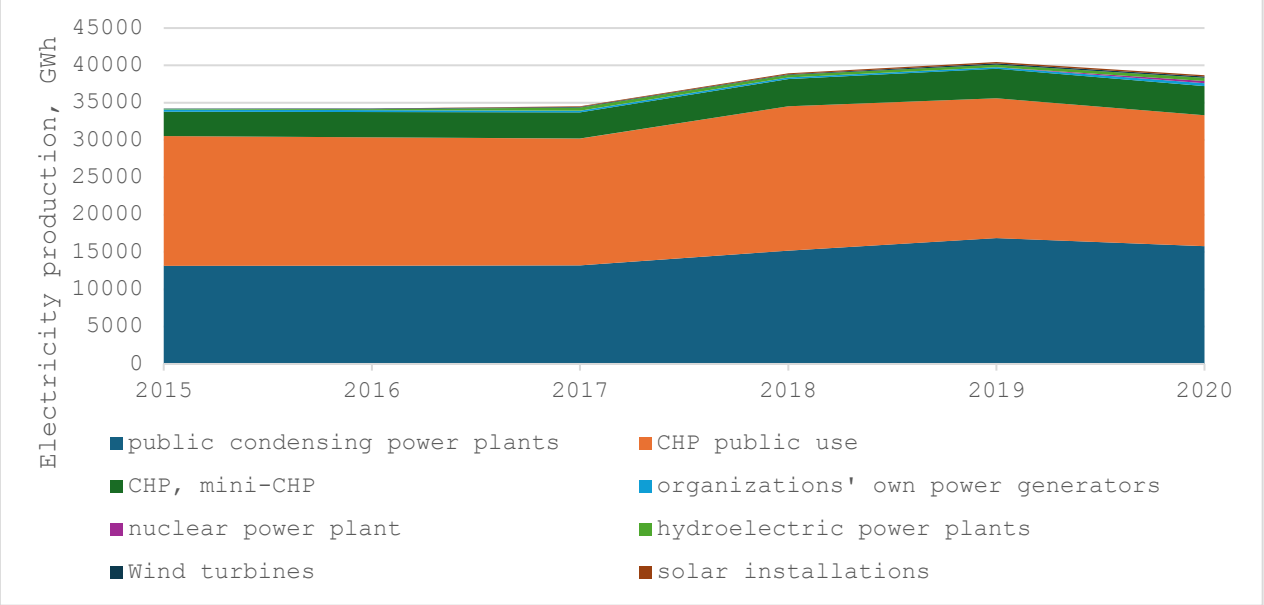


Figure 4 - Electricity production (Source: Belstat)

Electricity and heat production in Belarus is mainly based on condensing power plants and combined heat and power (CHP). These facilities operate exclusively on natural gas.

Production at mini-CHPs, which are largely owned by enterprises, is also significant. After 2020, the period of commissioning of two NPP units began, which is planned to generate about 18 TWh. At the same time, production at CHPPs cannot decrease significantly. NPPs also represent unregulated capacity. As a result, the energy system of Belarus will have very little capacity capable of regulating capacity. This complicates maintaining the power balance in the energy system even when using only natural gas and nuclear energy. The introduction of renewable energy sources in large volumes with such a structure of generating capacities will further complicate maintaining the power balance, and, consequently, the system will sooner face the maximum share of unregulated renewable energy sources, which will disrupt the reliability of operation. The transition to renewable energy sources will require not only replacing the production of electricity with new sources, but also finding opportunities to replace the generation of heat to replace CHPPs. An additional problem is the high concentration of heat generation at large power plants, which cannot be replaced by solar collectors or biomass, and the electrification of large cities will require significant changes in the network infrastructure.

Another part of the energy system is boiler houses. This is the most heterogeneous part, heat cannot be transported over long distances, and therefore the heat supply system is thousands of small-capacity installations. The types and sizes of these installations are very different, as are the types of fuel used. Not all gas boilers can switch to fuel oil.

Oil refining

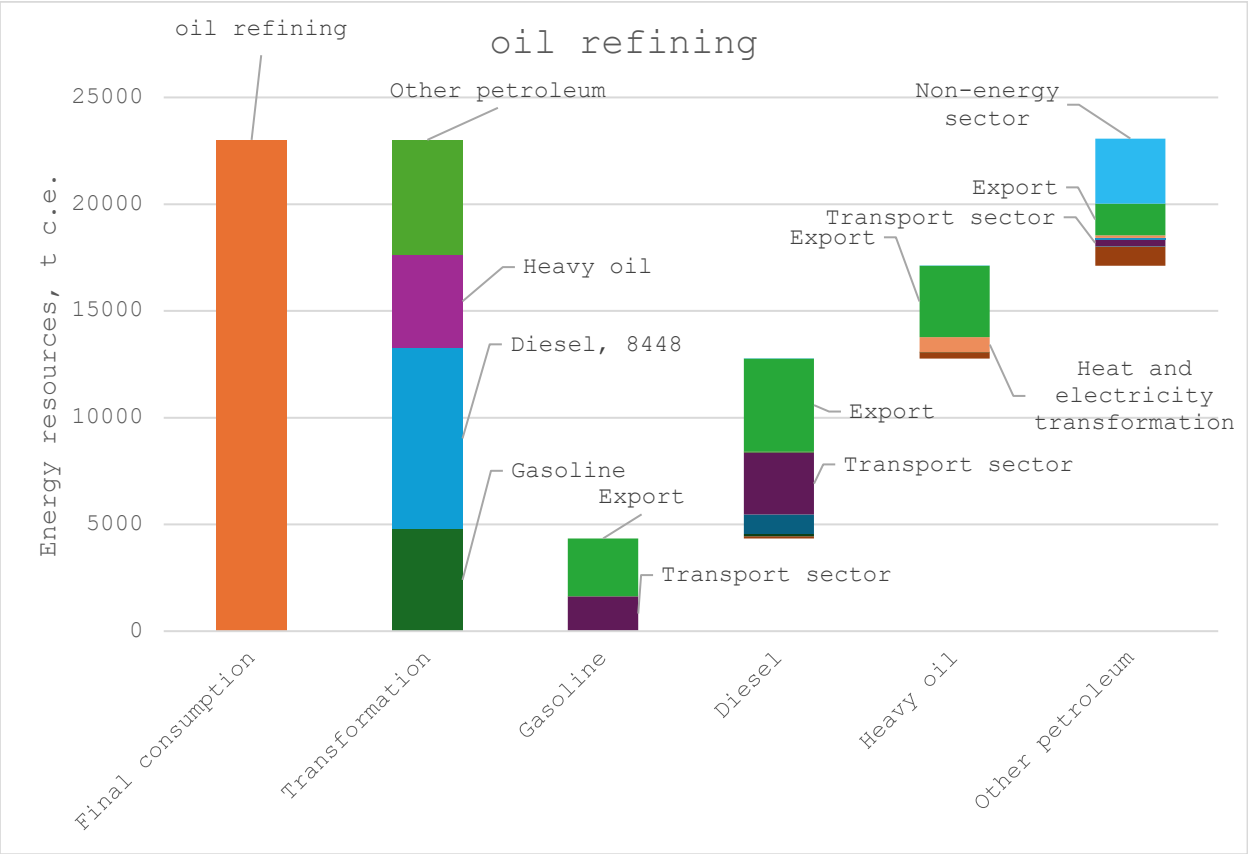


Figure 5 - Refinery

Oil refining in Belarus is carried out at two refineries with a total capacity of 24 million tons of oil (34 million tons of equivalent fuel), but in fact it rarely exceeds 20 million tons (28 million tons of equivalent fuel). In 2020, refining decreased to 23 million tons of equivalent fuel, which is due to a decrease in exports due to the pandemic.

In general, export is the key direction for the sale of manufactured petroleum products. Most of the gasoline is exported. Also, about half of the diesel fuel is exported, and until 2020, almost all fuel oil was exported. In 2020, due to low prices for oil and petroleum products on the world market, fuel oil began to be used for power plants.

Other petroleum products are mainly used as products in the non-energy sector or are exported.

Status assessment for 2022.

Several significant changes have occurred between 2020 and 2023.

The NPP was launched, which led to a reduction in electricity generation at power plants, primarily at condensing power plants, but there was probably also a reduction in energy production at CHP, since some of the heat energy began to be produced at electric boilers, installed at CHP as well.

Electric boilers with a capacity of 917 MW were installed specifically for the integration of the NPP.

Also, the export of petroleum products was reduced as a result of the imposition of sanctions. This also led to a reduction in the processing of imported oil.

In addition, there are data from public statements on changes in energy intensity, GDP, electricity consumption and gas consumption.

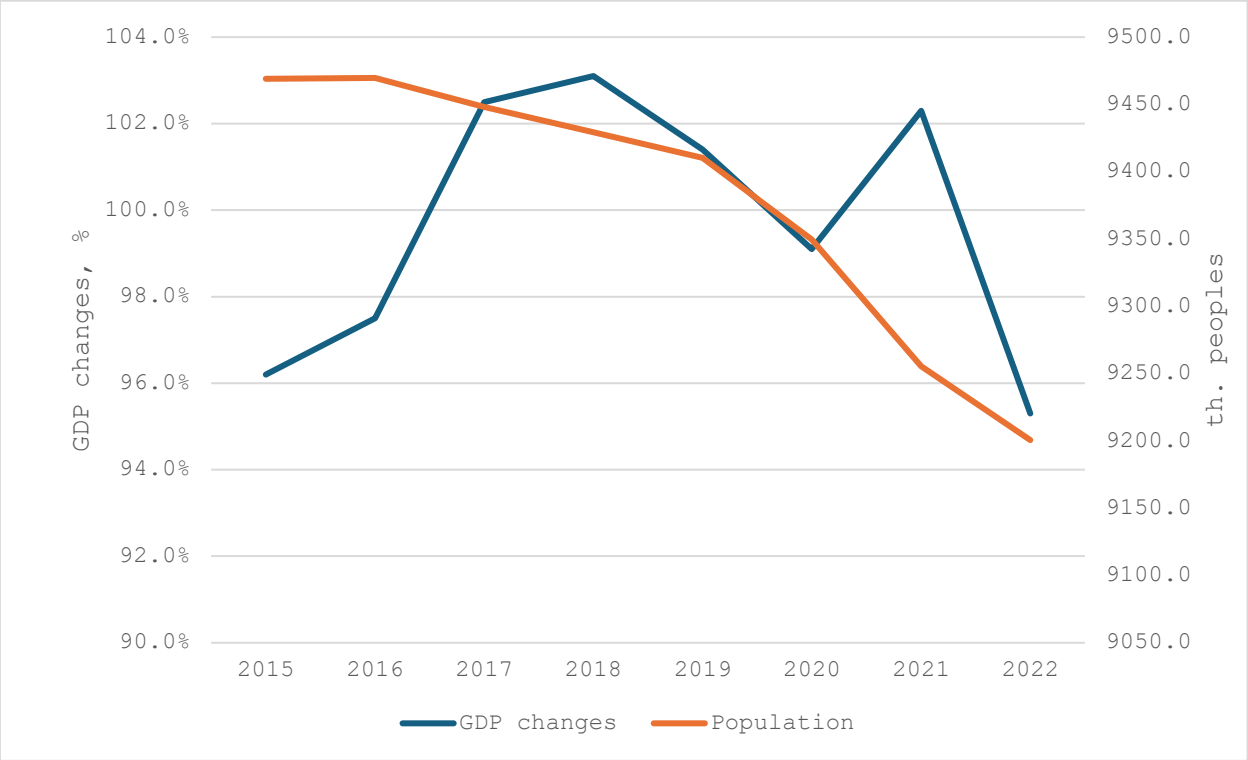


Figure 6 – Macroeconomic situation after 2020

The population has been declining since 2016, but the decline has accelerated since 2020. GDP has fluctuated significantly. In 2020, there was a certain decline due to the pandemic and a decline in exports. In 2021, the post-pandemic recovery led to GDP growth in Belarus, after which the sanctions imposed for supporting Russia in the war against Ukraine GDP fell significantly again.

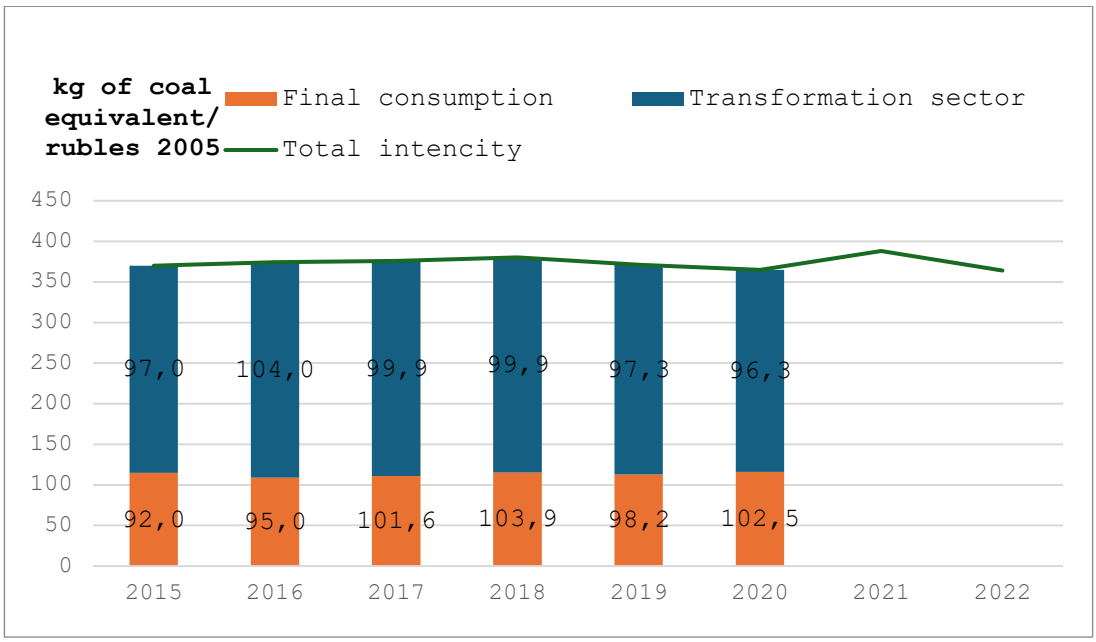


Figure 7 - Energy intensity

The energy intensity of GDP in Belarus has remained at a constant level for 5 years. In 2021, there was a certain increase in energy intensity, which is associated with the launch of the nuclear power plant and the growth of GDP, which was based on the growth of exports of industrial goods, the energy intensity of which is usually higher than the average.

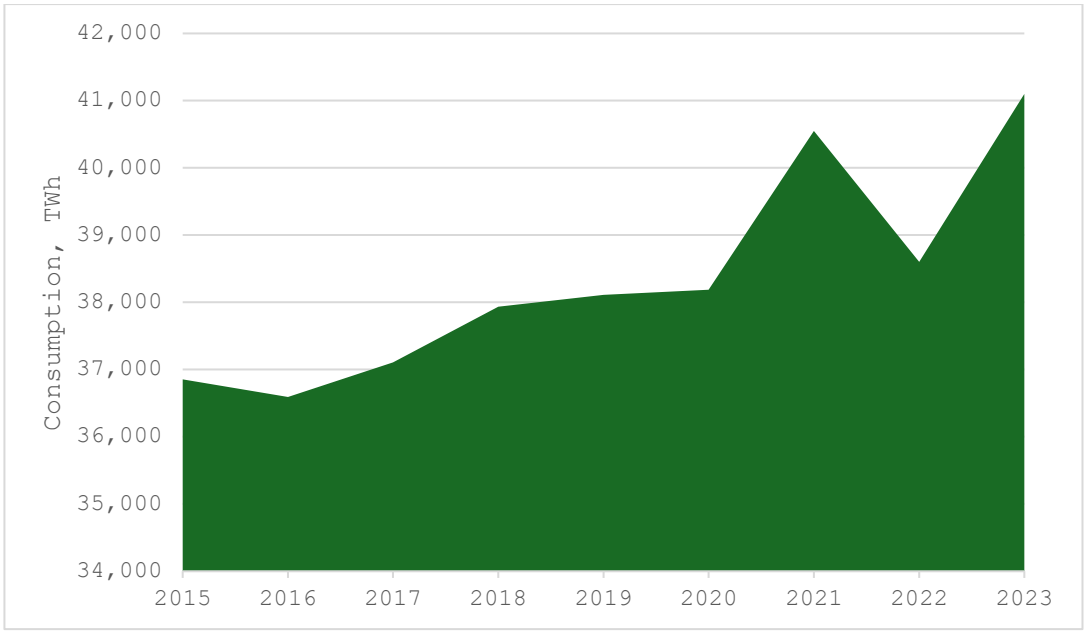


Figure 8 - Electricity consumption

Similar dynamics are also observed in electricity consumption. In addition, there are data for electricity for 2023, which shows an increase in electricity consumption. This is due to the growth in industrial exports to Russia.

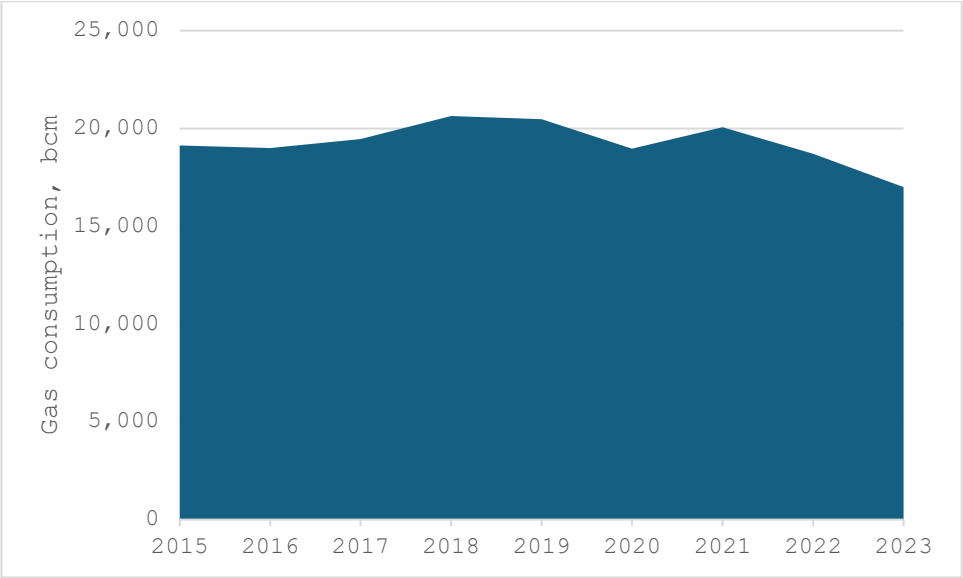


Figure 9 - Gas consumption

On the contrary, natural gas consumption is beginning to decline, which shows the effect of the launch of the nuclear power plant.

Description of the forecasting model

Balanced models

This model initially uses energy balance data. The model algorithm is based on constructing a balance of energy flows between economic sectors and the energy system. Balance methods are attractive because their results are, by definition, internally compatible. They also provide a detailed picture of economic activity, which is especially useful for energy planning. However, the procedure for constructing a matrix requires quite a lot of effort to create a matrix in the base year, but the Belarusian statistical system formed energy balances for each year until 2020.

Since energy balances are available for a long period, each balance cell for several years can be transformed into a time series. Such series allow one to represent both the value of a parameter at each moment in time and the change in the parameter over time.

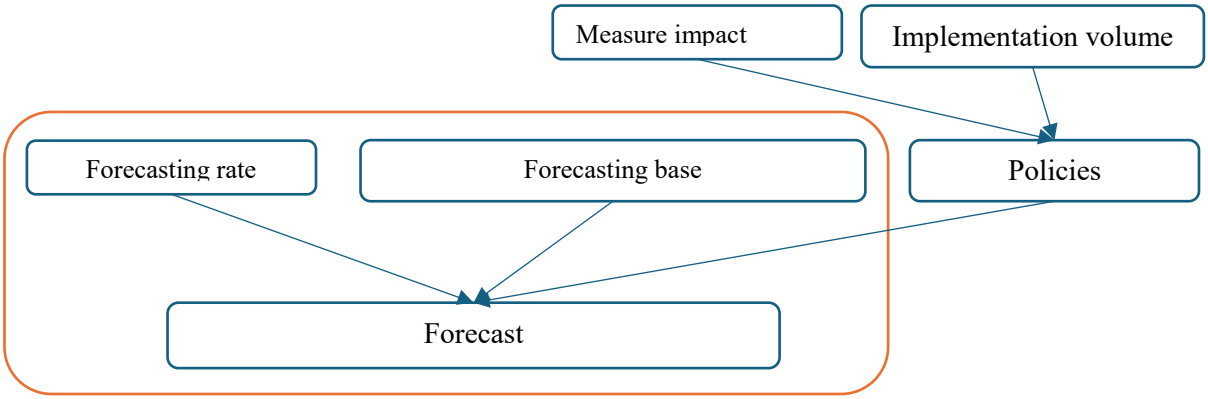
The mechanisms of moving average, trend preservation, specific indicator for various economic bases is used, and using elasticity coefficients for various indicators, forecasts of consumption of each type of fuel in each sector are formed. In this way, the baseline scenario is formed.

The target scenario is formed by changing assumptions regarding changes in the future (changes in energy intensity, economic structure, economic growth,

energy consumption per unit). However, the mechanisms of influence on the change of these indicators remain unclear.

At the same time, mechanisms for modeling policies and measures have been introduced. They include a specific unit (MW of installed capacity, MWh of replaced or saved energy), etc. The effect on the installed unit is calculated, for example, the introduction of wind power plants leads to an increase in energy production from renewable energy sources, and the replacement of gas with electricity leads to a reduction in gas consumption and an increase in electricity consumption.

Further, the low-carbon development scenario can be formed by maintaining the forecast within the framework of the baseline scenario (BAU) with the introduction of a certain volume of planned policies and measures.



10 - Structure of model

Business as usual scenarios (BAU)

The baseline scenario was modelled using data from national energy-related programs and strategies, as well as macroeconomic forecasts.

The period of 2030 is not covered by national programs, therefore for longer periods the World Bank forecasts for macroeconomic forecasts and the preservation of existing trends for energy parameters were used. This concerns the energy intensity of GDP, changes in the structure of heat consumption

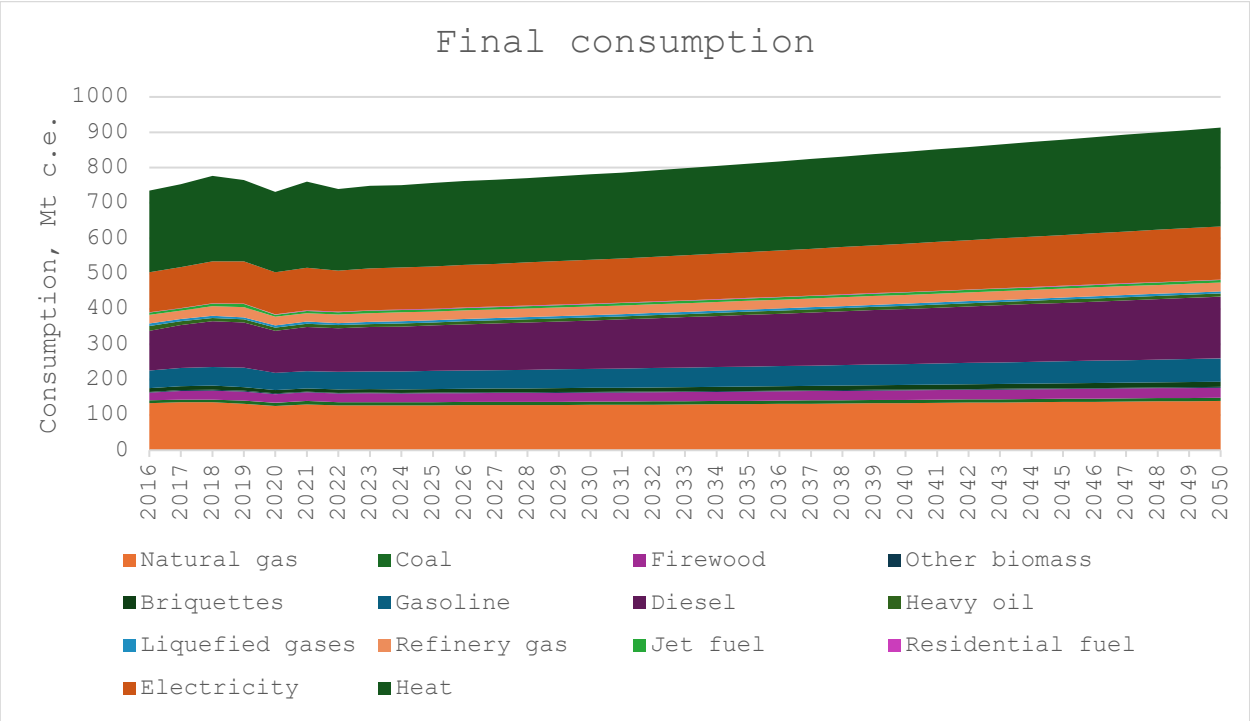


Figure 11 - Final consumption (BAU scenario)

Consumption of natural gas and gasoline is relatively stable.

The transformation sector is undergoing significant changes after the launch of the NPP. However, no further changes are expected, since the current policy regarding the development of renewable energy sources is aimed at creating barriers to their development.

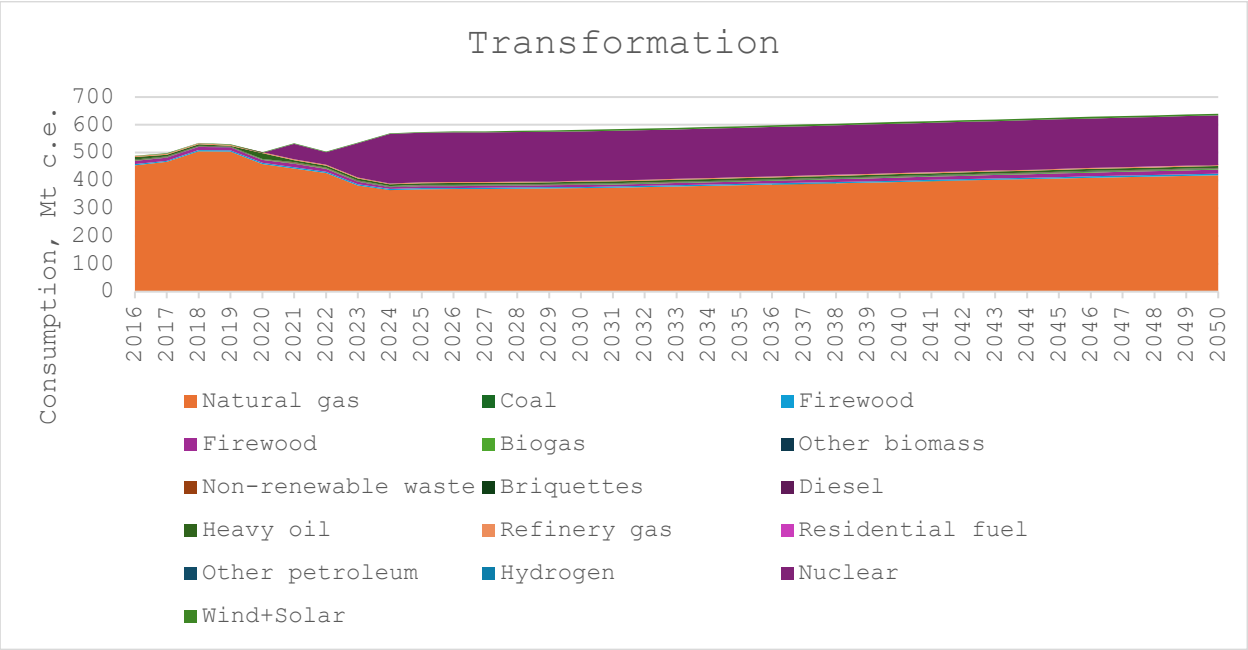


Figure 12 - Transformation (BAU scenario)

Since electricity and heat consumption increases slightly in this scenario, natural gas consumption also increases.

Taking these trends into account, electricity consumption is growing. The growth is mainly concentrated due to the increase in the use of diesel fuel, heat and electricity.

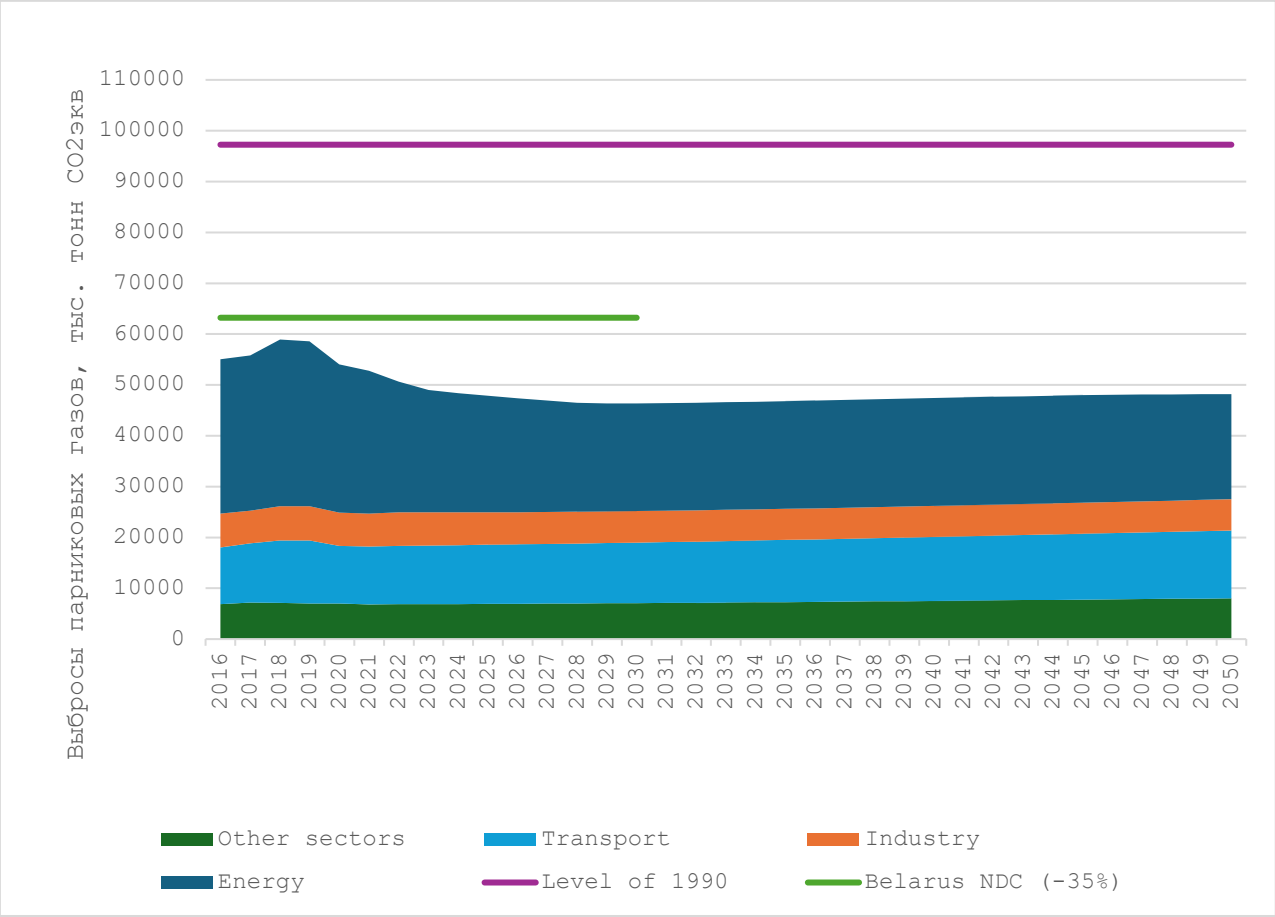


Figure 13 – GHG emission (BAU scenario)

In this scenario, greenhouse gas emissions are reduced after the launch of the nuclear power plant, but emissions then begin to grow again due to economic growth and increased natural gas consumption. By 2050, total emissions in the energy sector will return to the 2019 peak level, completely offsetting the reduction in greenhouse gas emissions after the launch of the nuclear power plant. However, even under these conditions, the level of emissions will not exceed the NDC by 2050, which indicates that the goals set are very low in ambition.

Technologies used

To change the basic trend in Belarus, it will be necessary to implement a number of policies and measures, both general (planned for implementation in many different countries) and specific ones, necessary for implementation in Belarus due to the specifics of the energy system.

By policies and measures to reduce greenhouse gas emissions we mean various activities that lead to a reduction in greenhouse gas emissions both through the implementation of organizational measures and through the introduction of new equipment.

We will divide all policies and measures into:

- Policies and measures in final energy consumption;
- Policies and measures in energy extraction and production;
- Policies and measures in energy transformation and transportation;

Final consumption

Improving the energy efficiency of technological processes - Improving the efficiency of technological processes is possible without changing the types of fuel used. Replacing equipment with more modern ones allows reducing energy consumption both due to more efficient equipment and due to more energy-efficient technologies**.**

Improving the efficiency of heat and electricity consumption in the service sector - the service sector mainly consumes electricity and heat, which means that measures to reduce greenhouse gas emissions should be aimed at reducing the consumption of heat and electricity**.**

Substitution of natural gas for electricity - Natural gas is used in many technological processes. Its substitution will lead to a decrease in greenhouse gas emissions in the final consumption sector**.**

Use of biogas instead of natural gas - where **natural gas** cannot be replaced to electricity**.**

Substitution of heat energy with electricity - substitution of heat energy with electricity is possible both in technological processes and in the processes of heating buildings and structures.

Improving the efficiency of energy consumption by the population - the total consumption by the population can be divided into two large parts:

- consumption by the urban population;

- consumption by the rural population.

The urban population mainly consumes heat and electricity. Reduction of heat consumption is mainly achieved by insulating enclosing structures, replacing windows and improving the quality of insulation regulation.

Increasing the thermal resistance in privately built houses in rural areas will lead to an effect similar to the insulation of houses in urban areas, with the only difference being that the consumption of natural gas will be reduced.

Electrification of residential buildings – this measure is being implemented to transition to the use of exclusively electric energy in residential buildings for all needs, on the assumption that electric energy will be produced from carbon-free energy sources.

Substitution of peat with firewood - in Belarus, the population partially uses peat briquettes and its replacement with wood fuel does not require funding. Solid fuel boilers can operate on both wood and peat. In this case, greenhouse gas emissions cease.

Substitution of gas with firewood - substitution of natural gas with firewood is more difficult to implement than substitution of peat. This change of technology requires replacement of boiler equipment. At the same time, using a solid fuel boiler is less convenient. Therefore, in order to switch to the use of wood today, it is necessary to create an economic incentive.

Street lighting - street lighting involves replacing existing electric lamps with energy-efficient ones. The replacement of street lighting was singled out as a separate measure due to the significant economic feasibility of carrying out these works.

Transformation and transportation

Using biomass to produce electricity - not only fossil fuels but also biomass in the form of wood chips can be used to produce electricity in steam turbines.

Use of biomass for heat production - these activities are already being carried out quite actively. Work is underway to replace old boiler houses using natural gas with new solid fuel boilers using wood biomass. This activity has already confirmed its economic feasibility, and given the sustainable forest management regime, greenhouse gas emissions from wood burning can be considered zero.

Increasing the efficiency of power plants - increasing the efficiency of power plants is possible in several directions. Partial replacement of equipment with more efficient equipment is possible, including replacement of boiler units or steam turbine units. Such work is carried out at power plants in Belarus.

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Hydrogen use - one of the options for regulating the power in the power system and using excess electricity, especially with a large share of base load and unregulated production on renewable energy sources, is the possibility of producing hydrogen by electrolysis of water. It is assumed that hydrogen can be used as a motor fuel in transport, especially in terms of use in freight transport and air transport. The second option for using hydrogen is mixing it with natural gas and using it as a fuel in industry and in households.

Reduction of losses in electrical networks - reduction of losses in electrical networks leads to a reduction in the volume of electricity production and, consequently, to a reduction in the use of fossil fuels in power plants. The main equipment, the replacement of which can reduce electricity losses in networks is power lines and transformer substations.

Reducing losses in heating networks - leads to a significant reduction in the production of heat, while reducing the consumption of fossil fuels.

Minning and production

Wind energy - the development of wind energy involves the construction of wind power plants (hereinafter referred to as WPP). This allows for a significant reduction in greenhouse gas emissions by reducing the use of other fossil fuels in the production of electricity.

Solar energy for electricity production - this event involves the introduction of solar energy for the production of electricity. Solar power plants (hereinafter referred to as SPP) allow electricity to be produced without greenhouse gas emissions, and, therefore, can replace the use of fossil fuels using other technologies.

Solar energy for heat production - the use of solar energy for heat production also allows the use of solar energy, but it is used to produce heat rather than electricity. In this case, the carrier of heat in such technologies is usually hot water.

Biogas energy - biogas stations are capable of processing livestock waste by fermenting it and turning it into methane, which is used to produce heat and electricity. In this case, heat energy is used on site (usually for heating and hot water supply of agricultural buildings), and electricity is supplied to the network.

Использование тепловых насосов - heat pumps allow the use of low-temperature energy sources to obtain hot water for heating and hot water supply.

Low-temperature sources can be wastewater from enterprises, heat from exhaust ventilation, or simply the heat of the surrounding air, soil, or underground water.

Low Carbon Development Scenario (LCD)

The implementation of the proposed measures allows changing the general trend in final energy consumption. Measures in the field of reducing gas consumption and electrification of gas supply led to a stable reduction in natural gas consumption.

Also, significant effects are provided using electric vehicles, which significantly reduces the consumption of motor fuels. However, both the electrification of natural gas consumption and the use of electric vehicles lead to an increase in electricity consumption.

An even greater increase in electricity consumption is created by the electrification of heat consumption. This is because heat occupies the largest share in the structure of final consumption and, in addition, technologically, the transition to electric heating is one of the cheapest and technologically simplest procedures.

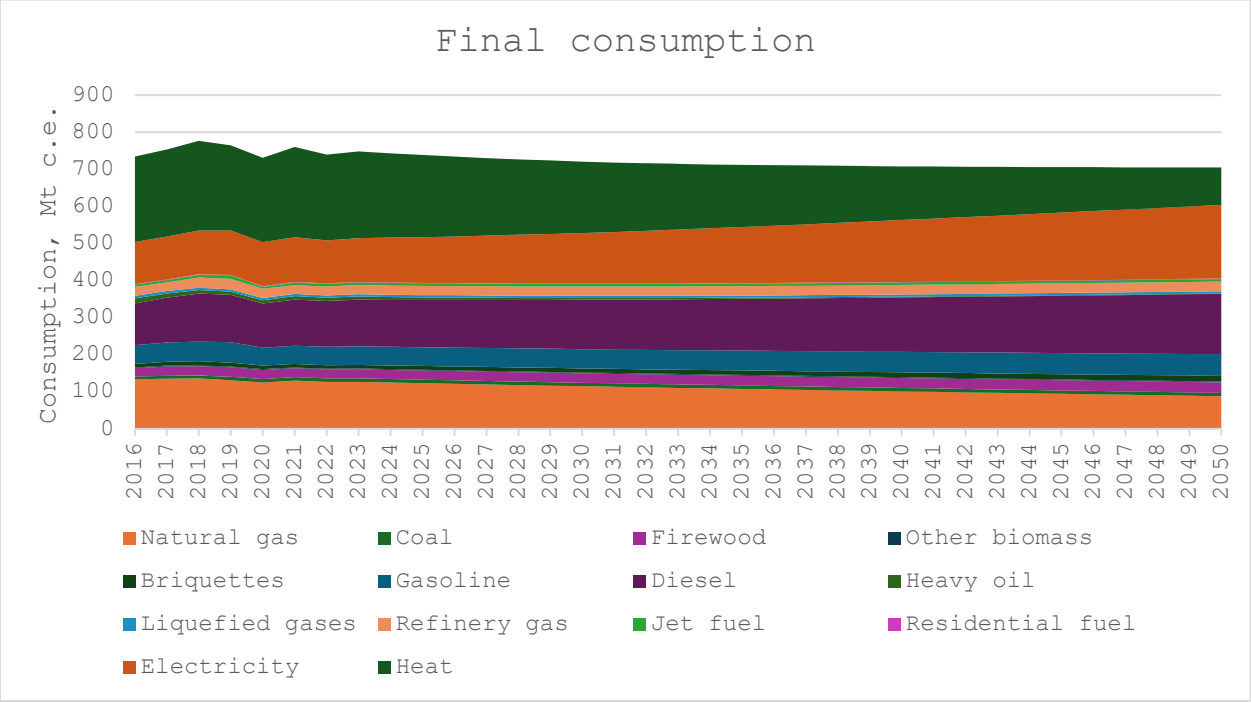


Figure 14 - Final consumption (LCD scenario)

As a result, by 2050, electricity will become the main type of energy and will account for more than a third of total consumption. The second type of fuel is diesel fuel, which is much more difficult to replace, since it is mainly used for freight transportation and for the operation of construction and agricultural machinery. In

these areas, the technologies for using electricity instead of fossil fuels are less developed.

Reduction of heat consumption occurs not only as a result of its replacement with electricity. Measures to improve energy efficiency give the greatest effect precisely when saving heat. This applies to both low-efficiency housing stock and inefficient technological processes based on the use of steam.

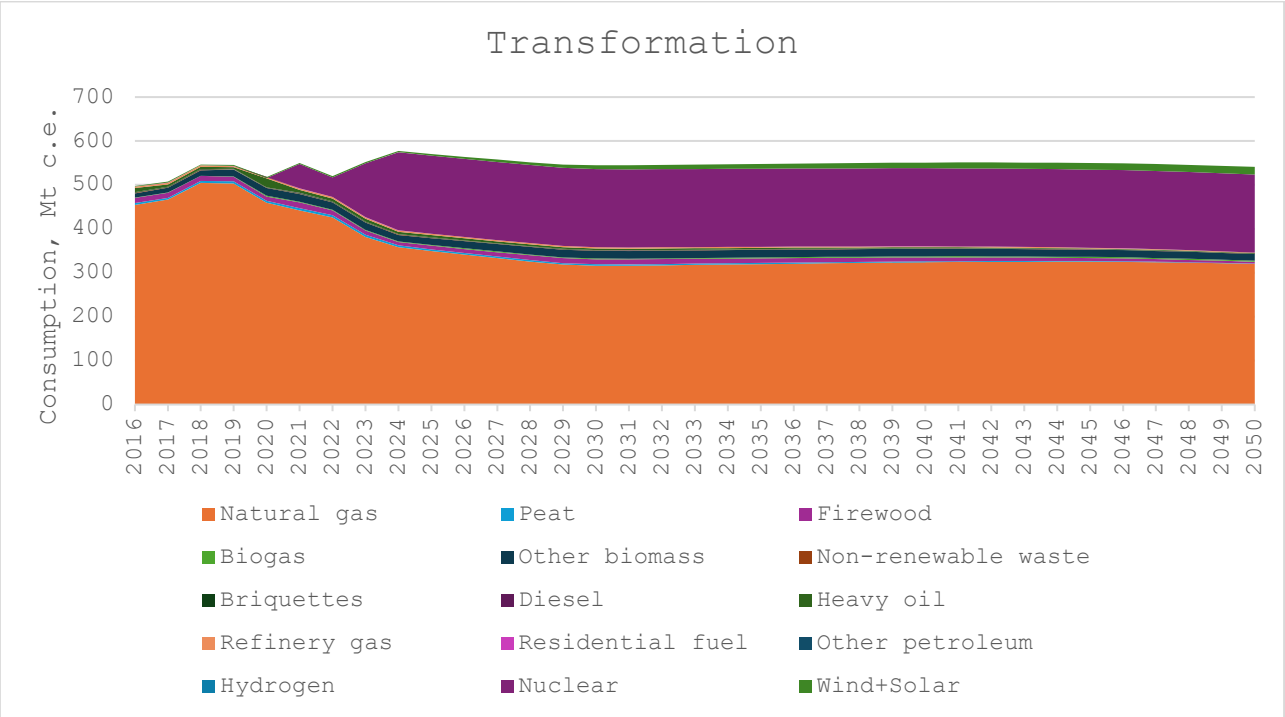


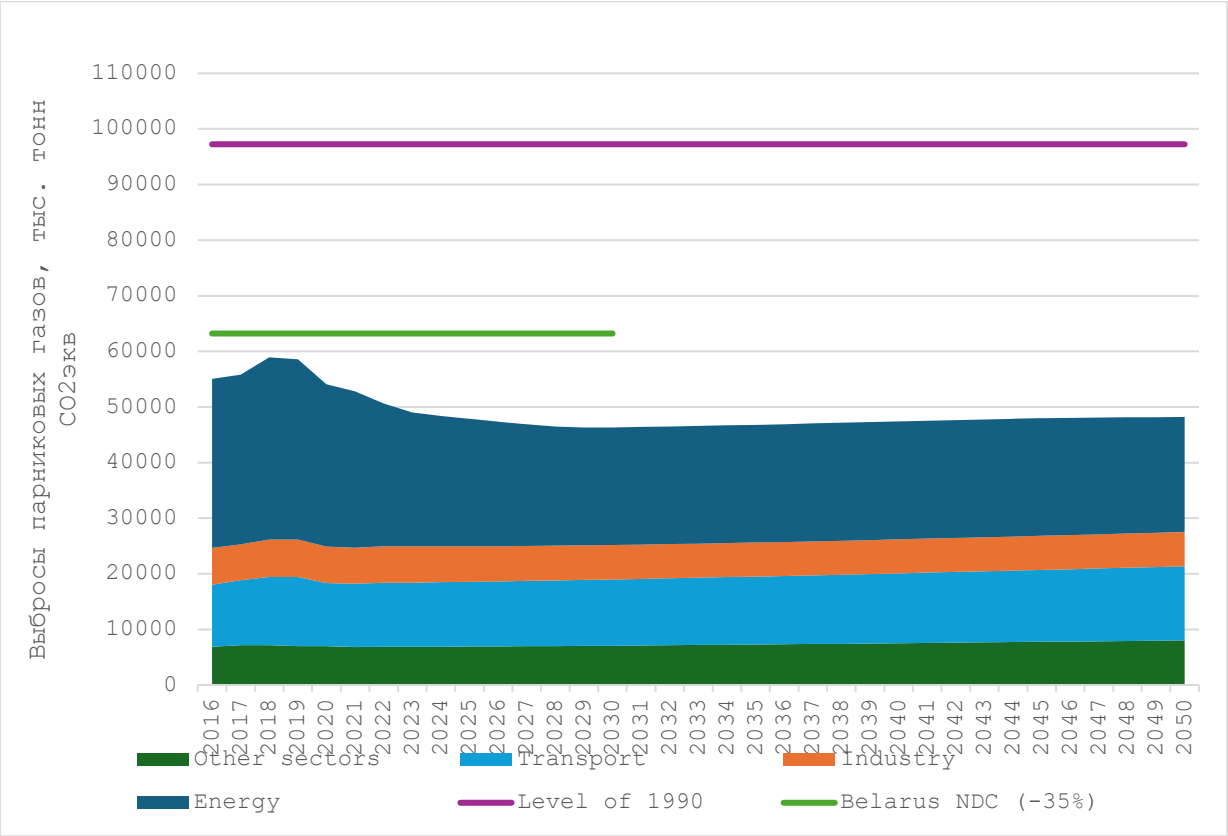
Figure 15 - Transformation (LCD scenario)

As a result, in this scenario, consumption for heat production is reduced first of all. In addition, the use of electricity instead of heat is much more economical. This is due to both higher losses of heat energy in networks and the fact that electric heating allows for more precise regulation of energy consumption. In addition, a mass transition to electric heating using heat pumps can significantly reduce the total amount of energy consumed.

As a result of the implementation of the proposed measures and the additional introduction of renewable sources, both for the production of heat and for the production of electricity, the total fuel consumption is reduced.

At the same time, rapid growth of solar and wind energy was not predicted, as there are legal and technical restrictions on this.

This scenario will reduce greenhouse gas emissions relative to today's level and ensure a stable reduction on the horizon until 2050. The level of emissions in 2050 will reach 48% of the 1990 level.



16 - GHG emission (LCD scenario)

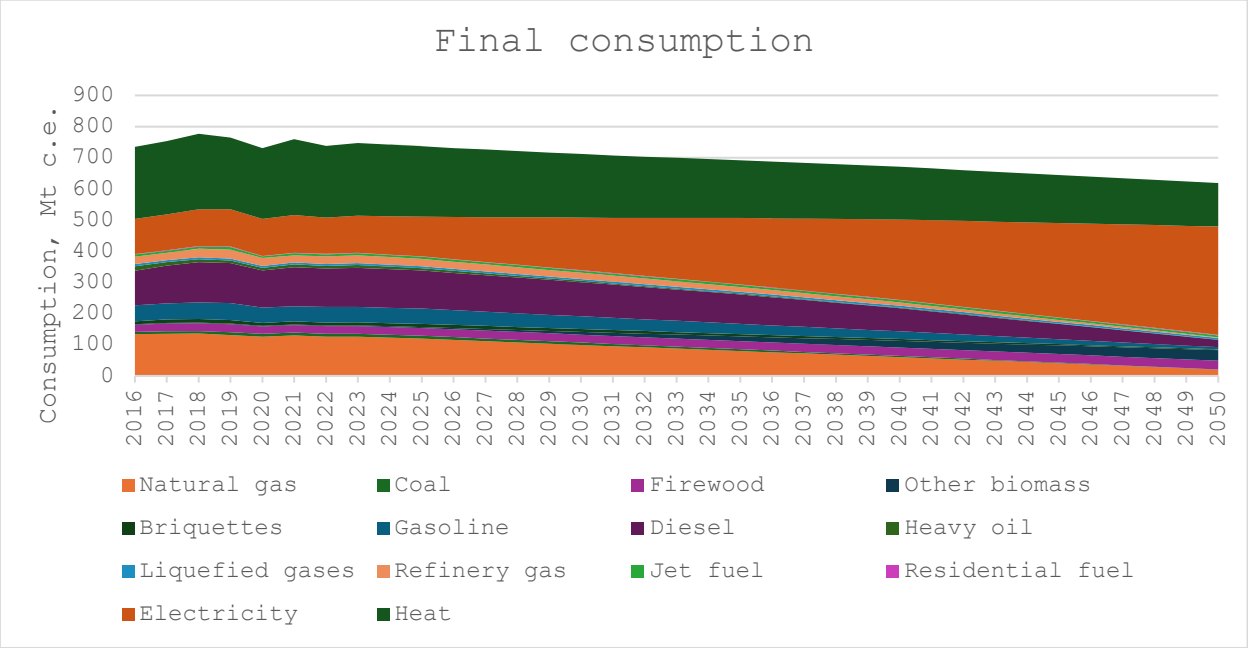
This work did not include detailed modelling of the power system to analyze the possibility of maintaining the power balance. Therefore, significant introduction of renewable energy sources was not predicted. For a greater reduction in emissions, more detailed modelling of the power system and several other special measures, such as reduction of emissions in agriculture or construction, are necessary.

Climate neutrality scenario

In the climate neutrality scenario, the scope of implementation of these measures increases significantly. First, efforts to save energy must be increased several times. Significant efforts will also need to be made to electrify end-use consumption.

The most extensive area in terms of final consumption is the electrification of heat consumption, but in terms of investment and technologies the most complex is the electrification of transport.

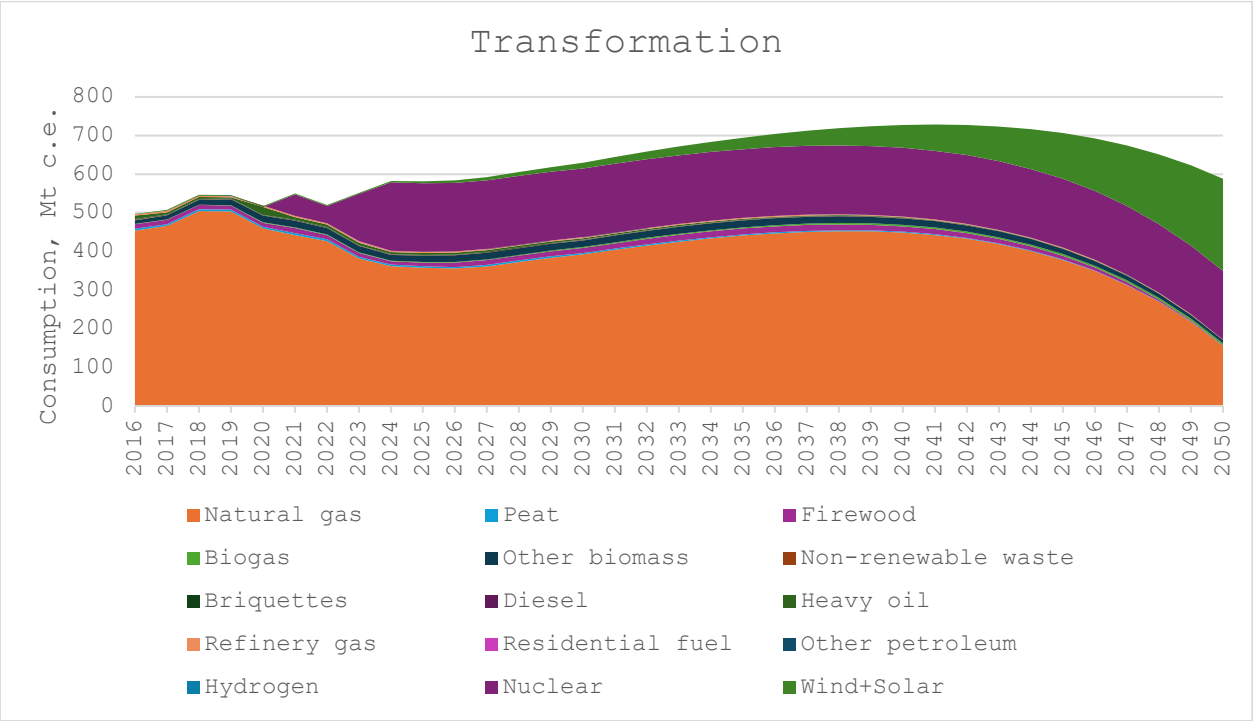
The graph shows forecasts of the impact of such efforts on the structure of final consumption.



17 - Final consumption (CN scenario)

It is evident that the dynamics of overall consumption have changed. **Instead of growth, the trend has changed to reduction.** At the same time, there is a tendency to reduce the consumption of natural gas and motor fuels (gasoline and diesel). Only electricity consumption is increasing.

In the transformation sector, the key is the development of renewable energy sources, primarily wind and solar. The growth of electricity generation from renewable energy sources not only replaces electricity generation from gas, but also reduces the overall energy consumption for conversion. This is because the calculated wind energy is converted into electricity without losses with an efficiency of 100%, i.e. replacing a significantly larger volume of energy consumed at gas stations, the efficiency of which is significantly lower than 100%.



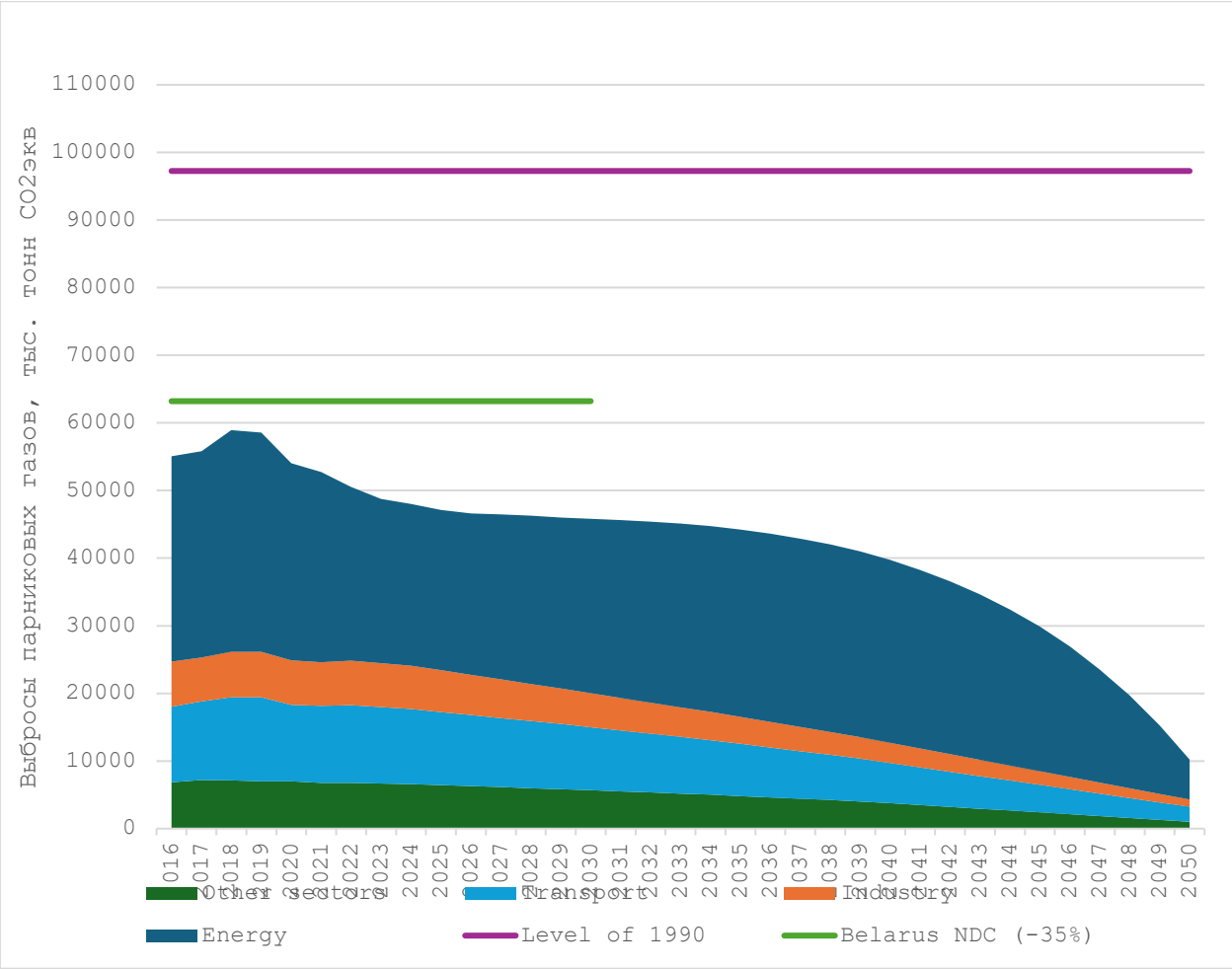
18 - Transformation (LCD scenario)

The nuclear power plant remains in the balance of electricity after its launch, the consumption of fuel oil and other petroleum products is reduced, as they are used mainly in small boiler houses or power plants, and their replacement is not a serious problem. And the reduction in natural gas consumption is replaced by electricity produced by wind and solar power plants. The reduction in thermal energy production at the thermal power plant is replaced by solar collectors.

Greenhouse gas emissions under this scenario initially decline slowly, and in the first period remain at a constant level. This is due to two competing trends: energy conservation and electrification.

While energy conservation immediately leads to a reduction in emissions, the opposite trend may be seen for electrification, which is associated with an increase in emissions at power plants with a relatively low share of renewable energy sources in the energy balance.

However, in the future, greenhouse gas emissions will begin to decline very rapidly, primarily because final consumption is already largely electrified and the effect of substituting natural gas in the conversion sector is very significant.



19 - GHG emission (CN scenario)

Achieving such results will require truly colossal efforts. The model assumes an annual increase in the volume of renewable energy input and reaches annual inputs of more than 7 GW of solar and wind by 2050. Other measures also require huge volumes of input and implementation.

This scenario allows greenhouse gas emissions to be reduced to 10% of 1990 levels and to 18% of 2020 levels.

Conclusions

Current status:

The main final consumption fuel is accounted for by the consumption of heat.

Another 4 types of fuel are distributed almost evenly among themselves, 4 million tons of fuel equivalent for each type: natural gas, diesel, electric energy and other types of energy in total.

Electricity and heat production in Belarus is mainly based on condensing power plants and combined heat and power (CHP). These facilities operate exclusively on natural gas.

Oil refining in Belarus is carried out at two refineries with a total capacity of 24 million tons of oil (34 million tons of equivalent fuel), but in fact it rarely exceeds 20 million tons (28 million tons of equivalent fuel). In 2020, refining decreased to 23 million tons of equivalent fuel, which is due to a decrease in exports due to the pandemic.

BAU scenario:

The transformation sector is undergoing significant changes after the launch of the NPP. However, no further changes are expected, since the current policy regarding the development of renewable energy sources is aimed at creating barriers to their development.

Since electricity and heat consumption increases slightly in this scenario, natural gas consumption also increases.

Taking these trends into account, electricity consumption is growing. The growth is mainly concentrated due to the increase in the use of diesel fuel, heat and electricity.

Low carbon development scenario:

As a result of the implementation of the proposed measures and the additional introduction of renewable sources, both for the production of heat and for the production of electricity, the total consumption of fuels is reduced.

This scenario will reduce greenhouse gas emissions relative to today's level and ensure a stable reduction on the horizon until 2050. The level of emissions in 2050 will reach 48% of the 1990 level.

To further reduce emissions, it is necessary to model the operation of the electric power system in more detail and several other special measures, such as reducing emissions in agriculture or construction.

Climate neutral scenario

Instead of growth, the trend has changed to reduction.

In the transformation sector, the key is the development of renewable energy sources, primarily wind and solar.

Greenhouse gas emissions under this scenario initially decline slowly, and in the first period remain at a constant level. This is due to two competing trends: energy conservation and electrification.

Achieving such results will require truly colossal efforts. The model assumes an annual increase in the volume of renewable energy input and reaches annual inputs of more than 7 GW of solar and wind by 2050. Other measures also require huge volumes of input and implementation.

This scenario allows greenhouse gas emissions to be reduced to 10% of 1990 levels and to 18% of 2020 levels. It is enough for climate neutrality taking into account deposing possibility of Belarus.