Energy Sector Development Strategy of the Republic of Serbia up to 2040 with Projections up to 2050

- Draft –

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Introductory Considerations

The Serbian energy sector is faced with fundamental structural changes that are conditioned by both global and national circumstances, as well as economic, technological, and environmental factors and accepted development goals, both national and international. The energy system of the Republic of Serbia was the backbone of the economic and social development during the second half of the 20th century and in the first decades of the 21st century. To remain so in the future, the Serbian energy sector must be fundamentally changed and adapted to the development of the economy and society, especially in terms of sustainability.

As a response to the challenges of global warming and climate change, both in the world and EU, significant changes in the energy sector have happened last decades, most commonly described as the energy transition. More precisely, this term refers to the abandonment of fossil fuels as the main source of energy and the transition to renewable energy sources. It includes changes in the technology of energy production, but also in energy transformation, distribution, and consumption. Increasing energy efficiency in all parts of the energy chain remains a priority and assumption of this process.

In a wider look, the energy transition is the process of the overall transformation of the economy and society that aims to significantly diminish a negative anthropogenic impact of the energy sector on nature and the environment, especially related to the reduction of emission of greenhouse gases. No matter how it is considered, the process of energy transition implies the use of new technologies and materials, innovation, digitization, and smart control of processes, significant investments, but also a change of perception of all actors in the energy sector, and in society as a whole.

The Republic of Serbia has accepted the path of energy transition. By signing the Paris Climate Agreement in 2015 and ratifying it in the National Assembly in 2017[1], the Republic of Serbia agreed to actively act in the direction of reducing greenhouse gas emissions. This determination was confirmed in 2020 with the signing of the Sofia Declaration on the Green Agenda for the Western Balkans. By this document, the Republic of Serbia agreed to work jointly with the EU to make Europe a carbon-neutral continent by 2050. As a Contracting Party to the Energy Community Treaty, the Republic of Serbia has the obligation to implement the relevant EU legal framework and acquis in force in the areas of energy, environment, renewable energy, and energy efficiency, as well as certain climate aspects. With the bilateral agreement with the EU on Stabilization and Association, the Republic of Serbia confirmed the Energy Community's achievements in the field of energy and the environment.

However, the global escalation of geopolitical conflicts and war between Russia and Ukraine at the beginning of 2022 completely changed the previous international circumstances in the energy sector, particularly on the European continent. Due to sanctions and embargos on energy imports from Russia, as well as physical sabotage, the long time ago established routes for Europe's oil and gas supply are interrupted. The focus is again on energy security in the strictest meaning – providing enough amount of energy and energy sources for the functioning of the economy and society.

[1] Law on Ratification of the Paris Agreement, Official Gazette of the RS, No. 4/17

The conditions, relevant in 2015, when the Energy Sector Development Strategy of the Republic of Serbia up to 2025 with projections up to 2030 (hereinafter: The previous Strategy) was adopted, have been significantly changed. Therefore, the new Energy Sector Development Strategy of the Republic of Serbia up to 2040 with projections up to 2050 (hereinafter: The Strategy) is adopted, as the basic act for establishing the energy policy and planning the energy sector development.

The new geopolitics circumstances indicate that energy security improvement, achievement of maximally possible energy independence, and economic sustainability of energy systems remain the dominant goals in the energy policy of the Republic of Serbia. The existing, available resources will have to remain the support of the Serbian electricity sector, until the moment when the electricity generation from renewable sources, infrastructure for transmission and distribution, as well as storage capacities and the capacity for integrating renewable energy sources, are developed to the extent enabling reliable replacement of domestic lignite, in accordance with this Strategy goals. Import dependence in the oil and gas sector will inevitably increase due to a natural decline in indigenous production of these energy sources. By enhancing the energy efficiency of these resources' utilization and introducing renewable sources into the transport and heating sectors, this growth can be somewhat mitigated. Nevertheless, it is necessary to work intensively on the diversification of oil and gas supply sources and routes, as well as on the building of necessary infrastructure and increasing the level of strategic reserves.

However, this document recognized that the decarbonization of the energy sector has key importance for the energy security of the Republic of Serbia. The Strategy defines the pathway for energy sector reform and the implementation of the energy transition process. The key determinants of this pathway are the transition to renewable energy sources, more intensive implementation of energy efficiency measures, and its improvement in all energy subsectors and branches of the economy and consumption sectors. Additionally, the possibility of introducing nuclear energy in the Serbian energy sector after 2040 is being considered.

The Strategy perceives and defines goals that should be achieved, as well as activities and measures that should be realized to speed up the decarbonization of the energy sector and the national economy as a whole. Goals, measures, and activities are defined for the energy sector as a whole, but also separately, for every energy subsector, taking into consideration their integrated development, as well as the development of related economic sectors.

To ensure the achievability of the energy transition process, it is necessary to define the adequate investment framework for the promotion of the sector decarbonization. For further improvement of the investment environment, the Strategy recommends the introduction of a carbon pricing as a key financial mechanism for the speed control of the energy transition. The introduction of carbon pricing, on one side should discourage the utilization of fossil fuels and inefficient technologies, and on another side provide the part of financial sources and incentives for energy efficiency improvement, and building of capacities for RES use, as well as for aid to local communities in coal regions for overcoming negative socio-economic effects of the energy transition and providing just (energy) transition. In this process, it is important to analyze the effects of the introduction of the Carbon Border Adjustment Mechanism (CBAM) by the EU.

The process of conducting the energy transition must be gradual, but resolute, professionally, socially, and economically based, founded on good professional dialogue and acceptable solutions that will gain national consensus. The key challenge of energy transition in the Republic of Serbia is the solving problem of mining basins, i.e., the creation of a new development paradigm for the regions whose economy dominantly depends on coal production. It is very important to coordinate changes in the Serbian energy sector with strategic documents and activities in sectors such as mining, industry, transport, tourism, construction, housing, spatial planning, urban planning, agriculture, environmental protection, etc. The energy complex, climate, and economic development are only parts of an integral concept of the low-carbon economy and society of Serbia, which this Strategy advocates for.

Legal Framework for Adoption of the Strategy

The relevant legal framework for the energy sector is determined by the Energy Law[2], the Law on the Use of Renewable Energy Sources[3], Law on Energy Efficiency and Rational Use of Energy[4], the Law on Mining and Geological Exploration[5], the Law on Climate Change[6], as well as by the Treaty establishing the Energy Community[7].

The Energy Law prescribes that the energy policy of the Republic of Serbia comprises measures and activities taken for achieving long-term objectives, namely:

1) reliable, safe, and quality supply of energy and energy sources,
2) adequate level of electricity generation and the transmission system capacity,
3) creating conditions for reliable and safe operation and sustainable development of energy systems,
4) competitiveness in the electricity market based on the principles of non-discrimination, publicity, and transparency,
5) providing conditions for the improvement of energy efficiency in performing energy-related activities and energy consumption,
6) creating economic, commercial, and financial conditions for electricity generation from renewable energy sources and combined generation of electricity and heat,
7) creating regulatory, economic, and commercial conditions for the improvement of efficiency in power system operation, particularly having in mind the development of distributed electricity generation, development of distributed electricity storage capacities, the introduction of a consumption management system, and the introduction of the advanced network concept,
8) creating conditions for the use of new energy sources,
9) diversity in electricity generation,
10) improvement of environmental protection in all areas of energy-related activities,
11) creating conditions for investments in the energy sector,
12) protecting customers of energy and energy sources,
13) connecting the energy system of the Republic of Serbia with the energy systems of other countries,
14) development of the electricity and natural gas market and their connection with the regional and Pan-European markets.

[2] Official Gazette of RS, No. 145/14 and 95/18 - another law and 40/21, 35/23 - another law and 62/23
[3] Official Gazette of RS, No. 40/21 and 35/23
[4] Official Gazette of RS, No. 40/21
[5] Official Gazette of RS, No. 101/15, 95/18- another law and 40/21
[6] Official Gazette of RS, No. 26/21
[7] Official Gazette of RS", No. 62/06

The Energy Law envisages that energy policy is elaborated and implemented in more detail through the Energy Sector Development Strategy of the Republic of Serbia, the Strategy Implementation Program, and the Energy Balance of the Republic of Serbia.

The process of Strategy drafting was initiated and led by the Ministry of Mining and Geology as a responsible institution. The Strategy is the result of close cooperation with relevant stakeholders (state administration bodies, public and private sector, and civil society organizations) that followed the process of Strategy drafting as the Working group members.

The Baselines of the Energy Infrastructure Development Plan and Energy Efficiency Measures for the period up to 2028, with projections up to 2030, adopted by the Government of the Republic of Serbia in 2023 served as the basis for working on the Strategy. Regarding energy development scenarios and national goals, the Draft Energy Strategy and the Draft Integrated National Energy and Climate Plan of the Republic of Serbia are mutually harmonized.

Characteristics of Energy Production and Consumption in the Republic of Serbia

Domestic production of primary energy includes the exploitation/use of domestic resources such as coal, crude oil, natural gas, and renewable energy sources (hydro potential, geothermal energy, wind energy, solar energy, biogas, biomass). The production of primary energy in Serbia in 2021 amounted to 10.186 Mtoe8.

The import of primary energy (including electricity) in 2021 amounted to 7.251 Mtoe. Imports ensure the necessary additional quantities of crude oil and petroleum derivatives, natural gas, and coal. Crude oil and petroleum derivatives accounted for the largest share in imports, at 56%, followed by natural gas at 26%, coal at 9%, electricity at 8%, and biomass at less than 1%. The total available energy in 2021 amounted to 16.251 Mtoe.

The trend of changes in the use of energy sources in the Republic of Serbia from 2010 to 2021 is shown in Figure 1. There has been a slight decrease in the use of solid fossil fuels (coal) during this period. The significant decrease in coal consumption in 2014 was due to floods, while the issues in lignite production in open-pit mines in the Kolubara Basin caused problems in coal production in 2021 and increased production of electricity in HPP. The consumption of natural gas and renewable energy sources has shown a consistent trend of slight growth. As for oil and petroleum derivatives, after a decline in consumption until 2014, there has been some increase in consumption.

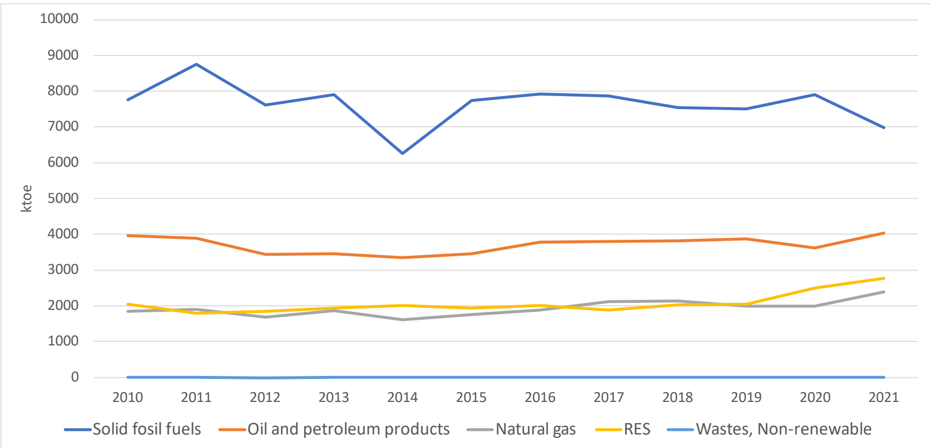

Figure 1: Gross available energy, by energy sources, 2010 – 2021

The share of fossil fuels in the gross available energy is high, and in 2021, it amounted to 82.6%. Even higher values were observed in previous periods (Figure 2).

[8] All data concerning energy consumption and production in the previous period, as well as presented energy indicators are publicly available data of the Statistical Office of the Republic of Serbia and EUROSTAT.

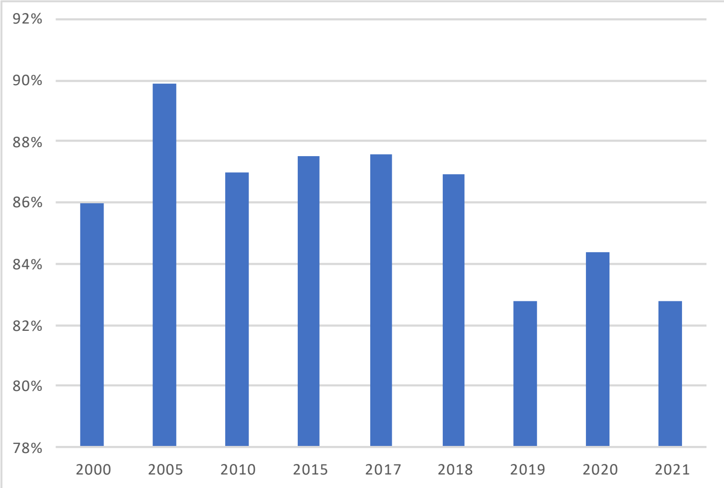

Figure 2: The share of fossil fuels in the gross available energy in the Republic of Serbia, 2010-2021

Despite some progress in the construction of new renewable energy capacities, the Republic of Serbia remains heavily reliant on fossil fuels. Coal is the most important domestic resource, particularly in electricity generation. The trend of changing energy source structures used in electricity generation from 2010 to 2021 is shown in Figure 3.

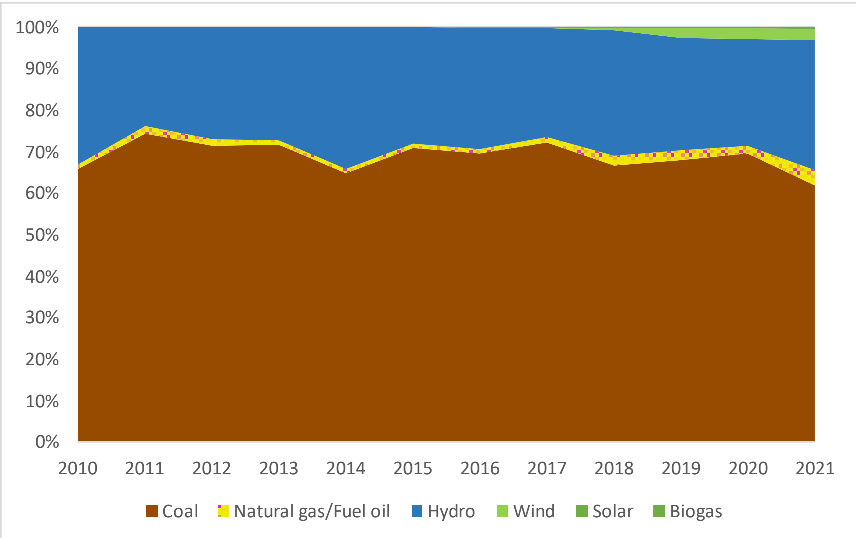

Figure 3: The structure of electricity generation in the Republic of Serbia

In addition to hydropower, a significant renewable energy source in the Republic of Serbia is wood biomass, primarily used for individual household heating (approximately 1.4 Mtoe per year). However, the heating sector is predominantly based on the use of fossil fuels. The share of renewable energy sources in district heating systems in 2021 was 0.82%, and in the rest of the sector (autoproducers and industrial heating plants) it was 4.20%, primarily in the form of solid biomass and biogas.

The total final energy consumption in the Republic of Serbia in 2021 amounted to 9.941 Mtoe. The final energy consumption for energy purposes from 2010 to 2021, by fuels and energy sources, is shown in Figure 4, while the sectoral distribution of consumption is depicted in Figure 5.

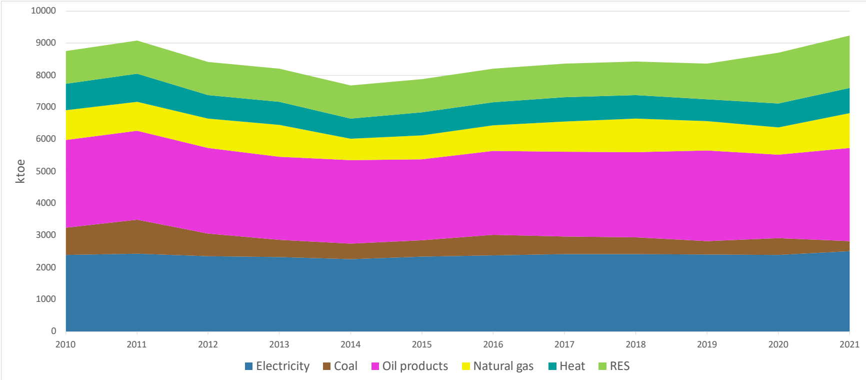

Figure 4: Final energy consumption for energy purposes by energy products in the Republic of Serbia

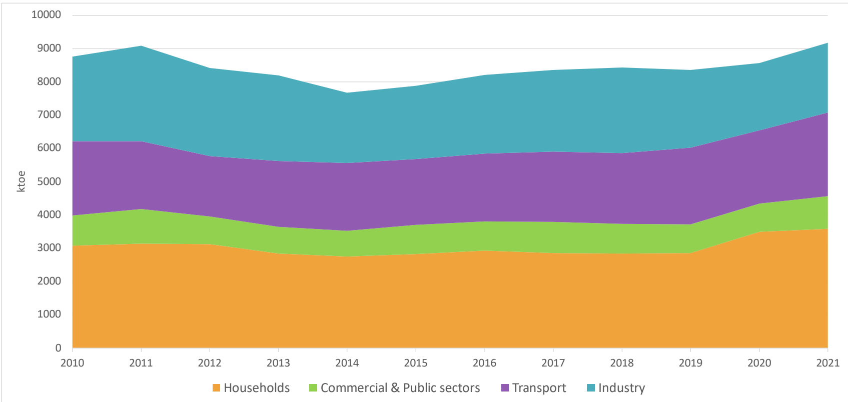

Figure 5: Final energy consumption by sectors

There has been a noticeable decline in final energy consumption during the period of 2010-2014, followed by a consistent increase thereafter. The level of final energy consumption surpassed that of 2011 only in 2021. The considered period is characterized by relatively small changes in the structure of energy sources used. There has been a decrease in the share of coal consumption. The participation of coal in final energy consumption decreased from 9.8% in 2010 to below 4% in 2021. Due to enhanced estimations concerning biomass utilization in households, the share of renewable energy sources increased to nearly 20%, while the change in the share of other energy sources during the period was less than 2%.

In the sectoral distribution of final energy consumption, the share of the household sector is the highest. The share of the household sector in final energy consumption is approximately 40%. The industrial sector accounts for 23-24%, the transportation sector for 26-27%, and the public and commercial sector contributes around 10-11% to the final energy consumption.

The Realization of the Main Strategic Objectives from the Energy Sector Development Strategy of the Republic of Serbia for the Period by 2025, with Projections by 2030

The Energy Sector Development Strategy of the Republic of Serbia for the period by 2025, with projections by 2030 (hereinafter referred to as the "previous Strategy"), was adopted by the National Assembly of the Republic of Serbia on December 4, 2015. Energy security, energy market development, and overall transition to sustainable energy were adopted as key priorities for the energy development of the Republic of Serbia, as well as the principles upon which the energy policy until 2030 needed to be developed. These priorities encompassed all long-term objectives of the energy policy defined by the then-applicable Energy Law[9].

Energy Security

During the implementation period of the previous Strategy, the supply of the domestic market with sufficient quantities of energy sources has been ensured. The overall energy import dependency of the Republic of Serbia did not significantly change during the implementation period of the previous Strategy (33.5% in 2010, 34.8% in 2021, averaging 32.8% for the period 2015-2021 - Figure 6). The total import dependency of the Serbian energy sector is lower compared to most European countries, thanks to the intensive use of domestic lignite and hydropower potential for electricity generation, as well as a significant share of biomass in the final consumption (about 40% in households). The import dependency is particularly clear in the oil sector (about 75%) and natural gas sector (about 80%), with a slight increase in the overall import dependency of these sectors during the considered period due to reduced domestic production. Serbia's energy import dependency has a significantly lower value compared to the EU average and is similar to most countries in the Southeast Europe region (Figure 7).

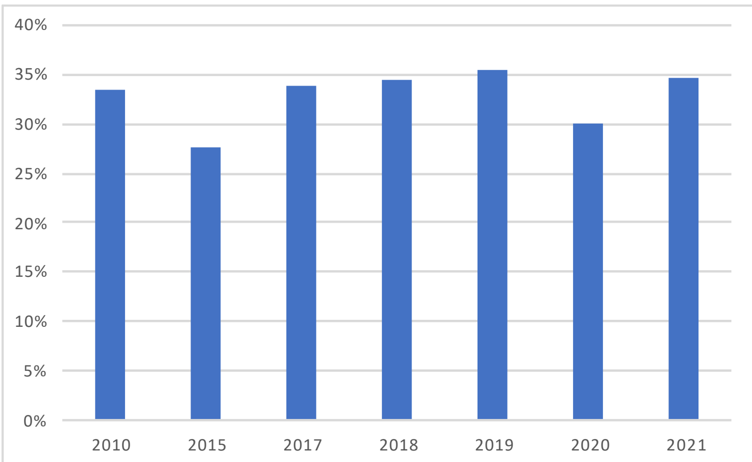

Figure 6: Energy import dependency of the Republic of Serbia for the period 2010-2021

[9] Official Gazette of the RS, No. 57/11, 80/11 correction, 93/12 and 124/12

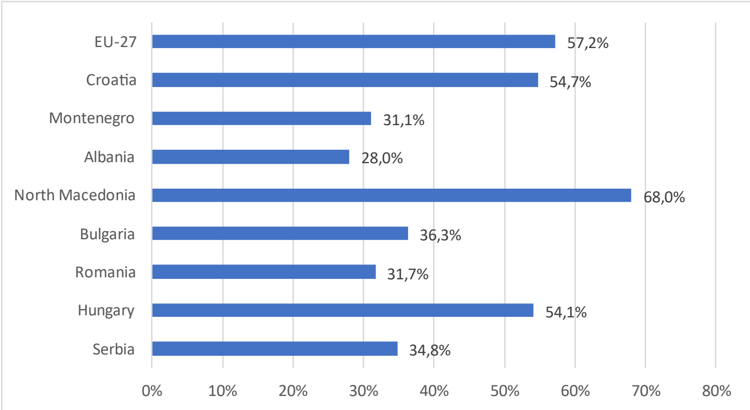

Figure 7: Energy import dependency in the Southeast Europe region and on the level of EU-27 (2021)

Significant economic and financial challenges (global recession 2009-2012, consequences of floods in 2014, fiscal consolidation 2015-2017, COVID-19 crisis 2020-2021) that the Republic of Serbia faced in the previous decade undoubtedly had an impact on the delay in implementing projects for the renewal and improvement of the electricity system. However, the reduction in final energy consumption in all sectors (except transport) has enabled the market to be predominantly supplied with electricity from domestic production. The intensive import of electricity that occurred at the end of 2021 and during 2022 is a consequence of issues with coal supply from the Kolubara basin. At the end of December 2021, two accidents in TENT B occurred, which led to the shutdown of both blocks. Most of the problems that arose were remedied by the middle of 2022, while in the months up to that period, the costs of purchasing electricity were huge.

The activities involved in ensuring mandatory oil reserves proceeded as planned, and the construction of the interconnector gas pipeline from the Bulgarian-Serbian border to the Serbian-Hungarian border established a new supply route for natural gas from Russia and increased the security of supply for consumers.

However, geopolitical events in the last years have shown that relying solely on a single source for natural gas supply is highly unfavorable and considering the interdependence and interrelatedness of various energy subsectors, it can seriously jeopardize the overall energy security of the entire country.

Energy Market Development

During the implementation period of the previous Strategy, there was a formal liberalization of the domestic electricity and natural gas markets. These markets are mainly regulated, taking into account their specificities, through separate sub-legal acts. The energy market is supervised, improved and directed by the Energy Agency of the Republic of Serbia. With the Law on Amendments and Supplements to the Energy Law, the energy sector in domestic legislation has been mostly harmonized with the provisions of the Third Energy Package of the European Union and partly with the provisions of “Clean Energy for All Europeans” EU package.

In the electricity sector, the process of introducing competition in the sector has continued to increase its efficiency through market mechanisms in electricity generation and supply, while retaining economic regulation of transmission and distribution activities as natural monopolies. The Law on the Use of Renewable Energy Sources has created conditions for the accelerated development of renewable energy sources, allowing citizens and legal entities to produce electricity for their own consumption and become producers-consumers (prosumers), and introducing auctions for granting premiums for the construction of wind and solar power plants. This has been done to increase the number of market participants, enhance competition, and further develop the market.

In the wholesale electricity market in the Republic of Serbia, trading primarily occurs between suppliers as there are no significant independent producers offering electricity. Large wind parks, as privileged producers, sell electricity to JSC EPS, which, as the guaranteed supplier, has the obligation to purchase that electricity at feed-in tariffs. The activity of suppliers in the market is most pronounced in the domain of cross-border exchanges, mainly for transit purposes through Serbia, which is dominant. The organized day-ahead electricity stock market in Serbia (SEEPEX JSC Belgrade, hereinafter: SEEPEX) started its operational work in early 2016. By introducing the intraday electricity market in 2023, SEEPEX rounded off the offer on the organized electricity market. This created the conditions for bringing the Republic of Serbia closer to joining the EU market, as well as for the easier integration of renewable energy sources, which together will contribute to the acceleration of the energy transition.

The Law on Amendments and Supplements to the Energy Law further opened the natural gas market by introducing a new participant in the natural gas market and allowing foreign companies not registered in the Republic of Serbia to engage in these activities in the Serbian market. In addition, the Republic Commission on Energy Network was established as self-contained and independent body for control of electricity transmission system operators and natural gas transport system operators. Measures to fully open the natural gas market are being undertaken.

Transition to Sustainable Energy

The implementation of energy efficiency measures, increased use of renewable energy sources, environmental protection, and reduction of climate change impacts were supposed to be key elements of the sustainable transition of the energy sector in the Republic of Serbia.

In the period of implementation of the previous Strategy, the Republic of Serbia adopted two National Energy Efficiency Action Plans for the periods 2016-2018 and 2019-2021. These documents set goals for the improvement of energy efficiency and defined measures for their achievement. The last one, the Energy Efficiency Action Plan of the Republic of Serbia for the period until 2021 was made in accordance with the requirements of Directive 2012/27/EU adopted by the Ministerial Council of the Energy Community.

The Ministry of Mining and Energy is in the period 2014-2021, through the activities of the Budget Fund financed energy efficiency projects. Seven public calls for the rehabilitation of public buildings in local self-government units were implemented, within which a total of 107 projects were completed. The total investment was about 14.4 million euros (Budget fund funds about 8.9 million euros). These projects mostly included the energy rehabilitation of schools, kindergartens, health centers, and municipal buildings. At the beginning of 2022, the Directorate for Financing and Encouraging Energy Efficiency started operating. This institution implements public calls for the allocation of subsidies to households for improving energy efficiency and installing solar panels, as well as the National Program for Energy Rehabilitation of Residential Buildings and Family Homes (in cooperation with LSUs).

Energy efficiency indicators in the Republic of Serbia indicate a relatively high energy consumption per unit of gross domestic product compared to EU countries. In relation to the EU-27 average, Serbia's energy intensity is about 3.5 times higher, or about 65% higher when GDP is adjusted for purchasing power parity (PPP). A positive trend is the reduction of these indicators. Figure 8 shows the trend of change in energy intensity. During the period 2010-2021, this indicator decreased by about 20%. However, the indicator is still worse compared to countries in the region (Figure 9).

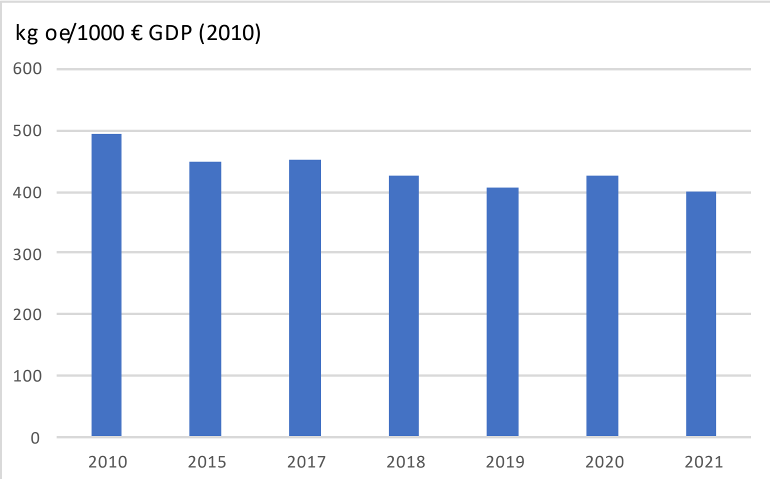

Figure 8: Energy intensity of the Republic of Serbia 2010-2021

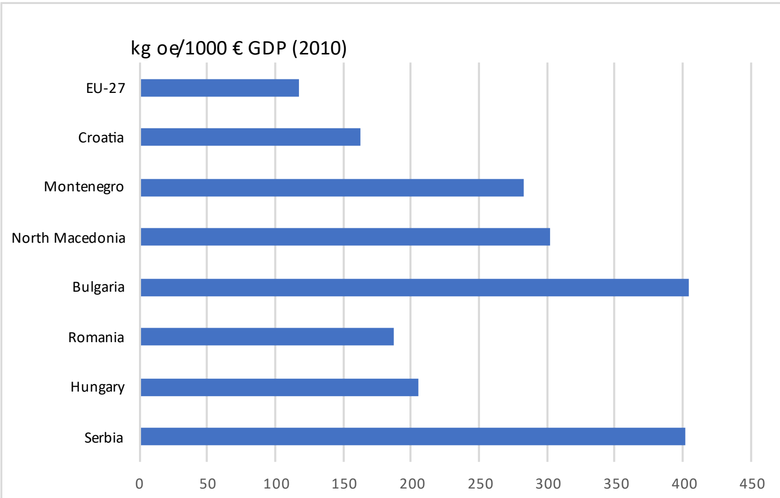

Figure 9: Energy intensity in the Southeast Europe region and on the level of EU-27 (2021)

Regarding the use of renewable energy sources, the share of biomass, hydro, and other RES is somewhat lower than the projections from the previous Strategy. In contrast to the planned 27%, the Republic of Serbia achieved a RES share in gross final energy consumption of 26.3% in 2020. The failure to meet the target is primarily due to the absence of the introduction of biofuels in the transportation sector.

When it comes to environmental protection, a number of projects have been implemented. In TENT B, a system for collecting, transporting and disposing of ash and slag was installed, which prevented ash from being scattered from the landfill, and the amount of water needed for ash transport was reduced tenfold. The new desulphurization plant started operating in TE Kostolac B and TE TENT A, so the emission of sulfur dioxide was reduced by more than ten times. These plants produce gypsum as a by-product, which is further sold. In the previous period, the reconstruction of electrofilters on units of all thermal power plants (15 units in total) was carried out, which which led to a reduction of powdery substances by up to 90%. The construction of flue-gas desulfurization systems in TENT B is underway. In summary, JSC EPS invested around 450 million euros in projects that improve the quality of air, water and soil, so now the total emissions of nitrogen oxides (NOx) and particulate matter (PM) of all facilities within JSC EPS are below the permissible limit established by the National Plan for the Reduction of the Main Pollutant Emissions from Old Large Combustion Plants (NERP) and these emissions are decreasing each year.

After the modernization of the oil refinery in Pančevo, the production of high-sulfur content fuel oil has ceased, and the emissions of particulate matter and nitrogen compounds from the combustion of this fuel have been significantly reduced. With the implementation of the project and the start of operations of the Deep Processing Unit in late 2020, the implementation of Directive 1999/32/EC regarding sulfur content in heating oils has been ensured.

From 2010 to 2021, there has been a reduction of approximately 3% in carbon dioxide emissions from the energy sector, resulting from fuel combustion. The dominant sources of carbon dioxide emissions are combustion of fossil fuels - coal (around 70%), petroleum derivatives (around 20%), and natural gas (around 10%). This emission source structure remained unchanged during the considered period. The reduction in emissions is a result of implementing energy efficiency measures and reducing energy consumption rather than substantial changes in the structure of primary energy use.

In the last 20 years, there have been no significant issues in energy and fuel supply impacting the functioning of the economy and society. The energy system of the Republic of Serbia has been characterized by supply stability and relatively low import dependence. However, this goal has been largely achieved by utilizing domestic lignite (70%) and large hydropower plants (30%) for electricity generation, as well as the significant use of firewood as fuel in households. Lignite consistently accounts for over 50% of the total energy sources used in primary consumption.

Although the electricity and natural gas market in the Republic of Serbia has been opened (in 2015), and significant progress has been made in the development of electricity market, the "social" aspects of energy policy, particularly in household supply, continue to have a negative impact on the energy sector and its developmental potential.

Essentially, the energy system of the Republic of Serbia, especially in the electricity sector, still relies on a concept established in the 70s and 80s of the last century. This concept implies coal as the primary fuel and hydro energy. These resources enabled to supply customers at prices that were among the lowest in Europe, but also partly below the economically necessary level, which slowed down the modernization, transformation and overall development of the system. The share of energy derived from other renewable sources (wind, solar, biogas) is only a few percentage points. Despite significant progress in the implementation of energy efficiency measures in the past decade, the energy intensity of the Republic of Serbia remains significantly higher than the same indicator for EU countries, and losses, especially in energy distribution and consumption, continue to burden the entire economic-technological system. The cost of such an "energy development model" is particularly reflected in high greenhouse gases emissions and significant contributions to local pollution from the energy sector.

Energy Resources of the Republic of Serbia and an Assessment of Their Utilization Potential

The energy resources and potentials of the Republic of Serbia consist of fossil fuels (coal, oil, natural gas, and oil shales), nuclear mineral resources, and renewable energy sources (hydropower, biomass, wind, solar, renewable hydrogen, biogas, landfill gas, gas from sewage treatment, geothermal energy sources, etc.).

Coal

Biggest energy importance among fossil fuels is within the coal basins and deposits. Geological reserves of lignite are comprising over 92% of all types of coal geological reserves in Republic of Serbia. Significant reserves of lignite are in Kosovo and Metohija basin, which are not considered in this analysis[10]. Lower Calorific Value of lignite lies in range from 4,000 kJ/kg to 10,000 kJ/kg. All basins and deposits are favoring production of the scale and utilization in thermal power plants. Reserves and resources of coal in the Republic of Serbia are presented in Table 1.

Table 1: Coal reserves and resources

Coal type	Balanced reserves (t)	Non-balanced reserves (t)	Potential resources (t)
Hard	2,798,654	1,671,580	4,470,234
Black	60,405,279	5,257,333	64,662,612
Brown	194,703,124	11,988,994	206,692,118
Lignite	2,601,271,659	1,081,067,600	3,682,339,259

on December 31st 2022

Overall balanced reserves of coal are clear indicators of its energy potential. Existing reserves in Kolubara and Kostolac (West Kostolac) basins can provide operation of thermal generation capacities until 2050, and in case of need even longer.

Oil and Natural Gas

The production of crude oil is predominantly carried out in the region of Vojvodina (97.8%) and to a lesser extent in central Serbia (2.2%). A similar situation exists for natural gas, with 95.2% being produced in the Vojvodina region and 4.8% in central Serbia. The remaining reserves of crude oil and natural gas in Serbia consist of deposits in the late stage of exploitation, necessitating the implementation of new technologies for development and production. Crude oil production reached its peak value of 1.16 million tons in 2013 and has decreased by 30% compared to that year in 2021. The beginning of the previous decade is characterized by a slight increase in natural gas production, reaching a maximum value of 572.5 million m^3 in 2015. However, thereafter, due to natural production decline, it experienced a continuous decrease ranging from 3.5% to 8.6% annually, ultimately reaching 362.1 million m^3 in 2021.

[10] Kosovo and Metohija is an autonomous province within the Republic of Serbia and based on United Nations Security Council Resolution 1244 of June 10, 1999, it is under the temporary civil and military administration of the United Nations, http://www.srbija.gov.rs/pages /article.php?id=45630

Based on the trend of domestic oil and gas production, it can be stated that unless new major deposits are discovered, their production will continue to gradually decrease in the coming period. The projected production amounts to about 240 thousand tons of crude oil and about 300 million m^3 of natural gas in 2040.

Oil Shales

Oil shales are widespread in the Republic of Serbia, with significant deposits found in the Aleksinac, Vranje, Sjenica tectonic basin, Valjevo-Mionica, Zapadno-Morava, Krusevac, Babusnica, Kosanica, Nis, and Levac basins. Within these basins, there are 23 deposits, but their level of exploration and reserve estimates is mostly hypothetical or potential reserves. Rough estimates of potential reserves amount to 8-10 billion tons.

Nuclear Mineral Resources

There are currently no active uranium mines or installed processing capacities in the Republic of Serbia. Serbia does not possess balanced uranium reserves, and the existing off-balance reserves are relatively small and do not represent a development potential in terms of the current level of exploration.

Biomass

Biomass potential is available throughout the territory of the Republic of Serbia and represents a significant renewable energy source[11]. Most of the wood biomass is located in the area of central Serbia. The current estimate of the potential of the total wood biomass that could be sustainably used for energy production amounts to about 1.668 Mtoe. The shown potential of wood biomass includes the potential of firewood, forest waste, residues from wood processing, wood biomass from trees outside forests and biomass from tree plantations. The main characteristic in the use of wood biomass for energy needs in the Republic of Serbia is its primary use as firewood in low-efficiency individual wood burners. By using it in cogeneration plants and by using more efficient individual wood burners, the utilization of biomass increases significantly. Waste thermal energy in the form of steam or hot water released in the process of electricity production can be further used for the needs of technological processes or space heating. This results in a more efficient use of primary energy.

The most important source of agricultural biomass is the harvest residues of cereals and industrial plants. It is calculated that about 30% of the total amount of harvest residues can be collected and used for energy production (1,036,828 toe). About 45% of this potential is located in AP Vojvodina. Residues produced during pruning of orchards and vineyards are another important source of agricultural biomass in the Republic of Serbia. From vines and the most common types of fruit, which have the greatest possibility of collecting biomass (in practice, about 80% of the biomass from orchards can be collected), the realistically available potential of pruning residues is estimated at about 133,602 toe. Fragmentation of land and small individual plots are currently the biggest obstacle for the economical use of biomass in energy production.

[11] Values related to the potential of biomass are taken from the Final Report Biomass-Based Heating in the Western Balkans - A Roadmap for Sustainable Development, World Bank Group, WBIF, Energy Community, 2017 and from the Book of Abstracts of the Scientific Conference - Potential and Effects of Using Biomass in the Republic of Serbia, Serbian Academy of Sciences and Arts, 2022.

Animal husbandry in the Republic of Serbia mostly includes the breeding of cattle, pigs, sheep, goats and poultry. An important resource for energy production is biogas produced from manure. Manure is a suitable material for the production of biogas, because in addition to containing organic matter, it also contains anaerobic bacteria that can be used to start the process of anaerobic digestion. Estimates are that about 60% of the total potential of manure is the real energy potential for biogas production. Biogas is used for the production of electricity and/or heat energy, and high-purity biogas (methane) in compressed or liquefied form is used as motor fuel.

In addition to manure, the potential for biogas production is also found in the dairy industry and the slaughterhouse industry. The Republic of Serbia has significant processing capacities, especially in livestock production. Residues from meat processing are the ideal raw material for biogas production, as they contain high concentrations of organic matter (proteins, fats and carbohydrates). It is estimated that the total potential for biogas production from manure, dairy and meat processing industry and biodegradable municipal waste is about 0.115 Mtoe per year.

Republic of Serbia exports large quantities of agricultural products that can be used as raw materials for the production of first-generation biofuels. However, in light of the RED II directive[12], the consumption of first-generation biofuels in the Republic of Serbia is limited to 2% of energy consumption in transport.

The raw material base for lignocellulosic biorefineries for the production of second-generation bioethanol consists of agricultural biomass, biomass on marginal land, as well as sawdust, residues from the bakery industry, the juice, beer and alcoholic beverage industry. Waste edible oil from restaurants and the food industry and waste animal fat from the slaughterhouse industry are raw materials for the production of second-generation biodiesel. The estimated potential for second-generation bioethanol production from agricultural biomass in the Republic of Serbia is 83,200 toe/year, from biomass on marginal land 59,000 toe/year, while the potential from wood biomass from forest farms is 20,000 toe/year. The estimated potential for the production of second-generation biodiesel from waste oil in Serbia is 8,600 toe/year, while from animal fat it is 12,900 toe/year.

It should be noted that the limiting factor in the use of biofuels is the technical possibility of mixing them with conventional fuels, as well as various restrictions on the type of biofuels that can be used according to the RED II directive.

Regardless of the type of biomass, considering its importance for the energy sector of the Republic of Serbia and its quantitative variability over time, in order to properly plan its use, it is necessary to periodically conduct analyzes that determine the biomass potential available for sustainable use.

Hydropower

The theoretical potential of hydropower in the Republic of Serbia is about 27 TWh per year. Due to restrictions related to environmental protection, occupancy and reservation of space and other conditions, a large part of the remaining potential cannot be used, so that the technically usable

[12] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)

potential is estimated at 18 TWh (with an installed plant power of 4,736 MW). The average annual production in the last five years is about 10.7 TWh.

Research studies and projects in this sector indicate the possibility to additionally use the potential of large watercourses. Table 2 shows the total investigated hydro potentials of large watercourses in the Republic of Serbia. The remaining technically usable potential is located on rivers Danube, Sava, South and West Morava.

Table 2: A summary of the technical potential of major rivers in the Republic of Serbia

River	Prospective installed capacity (MW)	Prospective yearly production (GWh)
Drina[13]	343.2	1,392.8
Ibar	120	455
Morava (Velika Morava)	147.7	645.5
Lim	56	224
In total	**666.9**	**2,717.3***

* estimated prospective annual production for the operation of hydropower plants 4,000 hours a year

Pump-storage hydropower plants (PHPP) are a very important link in the use of renewable energy sources for the production of electricity (regardless of the fact that their net energy balance is negative), because they represent energy stores and play a major role in balancing the power system. In the vicinity of the existing HPP Bistrica, a project for the construction of a new hydropower facility, PHPP Bistrica (628 MW) is being prepared. Also, there is a possibility of building a pump-storage hydropower plant on the Danube. The total estimated installed capacity of PHPP Đerdap 3 is 1,800 MW. It should be noted that these are projects based on the locations studied so far from the aspect of the potential for PHPP construction.

Table 3: Summary of prospective PHPP in the Republic of Serbia

PHPP	Prospective installed capacity (MW)
Đerdap 3	1,800
Bistrica	628
In total	**2,428**

In the territory of the Republic of Serbia, there are 856 potential locations for the construction of small hydropower plants. About 120-130 locations are economically profitable, where they have either already been built or are in construction, so there is no respective potential for the construction of new small HPPs. It should also be taken into account that on several rivers in the Republic of Serbia, the hydro potential will only be able to be partially used, due to the priority of water management, i.e. some rivers are planned as sources of regional water supply systems (Toplica, Crni Timok, Rasina, Studenica, Veliki Rzav, Mlava, Lepenac, etc.). Also, there is a large number of small rivers in protected

[13] In order for the realization of potential projects to be possible, and to utilize the hydro potential of the Drina River in certain parts of the watercourse, it is necessary to first of all resolve the question of jurisdiction between the entities in Bosnia and Herzegovina.

areas, where construction is not allowed. Due to all of the above, hydro potential from small HPPs cannot have a significant impact on the development of energy in the Republic of Serbia.

Wind Power

In order to assess the capacity for the construction of wind power plants, it is necessary to consider the wind energy potential of the region, topographical elements including transport conditions, environmental impact and the possibility of evacuation of the produced electricity.

The potential of wind energy was determined based on the base of available measurement data from dedicated measuring poles and data for the mean level of the atmosphere from virtual poles located in 20 points in identified windy regions in Serbia. Virtual measurement data cover a one-year period with an hourly resolution of records at measurement heights of 100, 120 and 140 m. The data is based on the ERA5 global meteorological database, which has proven to be the best in terms of assessing wind energy potential.

Based on the given background and data on the potential of wind energy, analyzes were carried out on the basis of which it is concluded that the technically available potential for the construction of wind power plants in Serbia is about 10.75 GW, which could collectively produce about 30 TWh of electricity per year. The greatest wind energy potential is located in the regions of Banat (about 10.7 TWh of electricity per year) and Bačka (about 6.5 TWh of electricity per year), but there are also significant potentials in the eastern part of Serbia (about 2 TWh of electricity per year).

Technological progress in terms of increasing the efficiency of wind power plants, convenience of installation on different terrains, etc. stipulate that the determination of the power of wind power plants is a permanent activity and in the future it is necessary to innovate the aforementioned estimates.

Solar Power - PV

The Republic of Serbia has good predispositions in terms of annual insolation, so the expected annual production of fixedly installed south-facing photovoltaic panels in open space amounts to 1,200-1,400 kWh/kWp, while on roof surfaces it is 1,000-1,200 kWh/kWp.

The advantage of building solar power plants compared to all other renewable sources of electricity is that this resource is available at every location and that its spatial variability is significantly less than is the case with wind power.

The main limiting factor regarding the installation of photovoltaic systems is the relatively low specific power per area unit, which requires the occupation of large areas. There are two main directions for planning the construction of photovoltaic panels - installations on the roof surfaces of industrial, commercial, residential and other buildings and installations on dedicated structures placed on the ground. In addition to these surfaces, water surfaces in calm artificial lakes and reservoirs can also be used for the installation of photovoltaic systems.

The construction of photovoltaic power plants on the ground is limited primarily by the utility value of the land. In terms of technology, systems with solar trackers and systems with fixed structures are being developed today. Systems with solar trackers require relatively flat land with a slope of less than 10°, while fixed structures can be placed on terrain with more complex topography. In world practice, the construction of photovoltaic power plants on arable land, where the so-called agrivoltaic power plants whose structures enable simultaneous agricultural production. Such possibilities should be carefully considered on land with cadastral class 6, 7 or 8.

A significant opportunity for the construction of photovoltaic power plants is provided by the devastated land in the surface coal mines in the Kolubara region and the Drmno coal mine region. The possibility of the combined application of reclamation measures and the construction of photovoltaic power plants on ash pits and other land currently used by thermal power plants should be considered. Apart from the devastated land, there is a good electric power infrastructure in the target regions that has been developed for the needs of energy evacuation from thermal power plants.

Taking into account the given assumptions and limitations, the technical potential of photovoltaic panels installed on structures on the ground in the Republic of Serbia amounts to 8,750 MWp with an expected annual electricity production of 12,579 GWh.

The total area of the roofs of buildings in Serbia is about 600 km^2. With flat roof surfaces, the entire surface can technically be used for installing photovoltaic panels. With sloping roofs, parts of the roof surfaces that are oriented to the south can be economically justified for the installation of photovoltaic panels. Due to the existence of shadows, the complexity of the roof geometry and other roof installations (windows, chimneys, etc.), it can be assumed that the actual surface of photovoltaic panels that can be placed on roof surfaces is about 15% of the total surface of roofs.

With these assumptions, the technical potential for the construction of photovoltaic power plants on roof surfaces is about 11,096 MWp, with an expected annual production of 13,242 GWh of electricity. The greatest potential of photovoltaic power plants is in the Belgrade region (about 1,699 MWp), and in other regions it ranges from 147 MWp in the Toplica district to 970 MWp in the Južna Bačka district.

Floating PV plants can be planned on artificial lakes, while their construction can be conditionally acceptable on natural lakes if the coverage does not exceed 5% of the lake surface. The natural potential for the construction of floating solar power plants on the territory of the Republic of Serbia, which takes into account only the surface of the lake and the mentioned limitations, amounts to about 4,249 MWp, with an annual electricity production of 4,678 GWh.

The total potential for the construction of PV plants and the production of electricity through the photovoltaic conversion is many times greater (10 times) than the above, however, it is considered to be sufficient at the moment and will not represent a limitation for integration and implementation of projects. Considering the technological progress regarding this RES, the data on the solar energy potential in the Republic of Serbia needs to be regularly updated.

Geothermal Energy Sources

The Republic of Serbia is located in an area with favorable geothermal potentials and resources. The utilization of geothermal energy for heating and other energy purposes in the Republic of Serbia is in its initial phase and is very modest compared to its potential and resources.

Within the Pannonian Basin, there are 83 hydrothermal wells with a total average flow rate of approximately 700 l/s, and the water temperature ranges from 21°C to 82°C. Outside the Pannonian Basin, there are 159 natural thermal water springs with temperatures above 15°C. The total flow rate of all natural springs is around 4000 l/s.

Considering that almost all the geothermal potential is at temperatures below 90°C, the potential for electricity generation is quite limited. However, the potential for utilizing geothermal energy for heating purposes is significantly greater. If approximately 25% of the theoretically estimated total thermal power from all geothermal sources, which amounts to about 800 MW, were to be utilized, it would enable an annual use of around 330 ktoe of thermal energy.

Additional potential for the use of geothermal energy lies in the installation of geothermal heat pumps that use geothermal energy at depths of up to 200 m as a heat source. As a heat source, heat pumps can also use waste and ambient heat, internal energy of surface water, etc. Practically the entire territory of the Republic of Serbia is suitable for heat pump use. It is estimated that heat pumps with a total power of about 7 GW could be installed in individual heating systems, with an annual heat energy production of about 1.4 million tons.

The estimation of the total available technical potential of renewable energy sources in the Republic of Serbia is shown in Table 4.

Table 4: ***Overview of total available technical potential of renewable energy sources in the Republic of Serbia****

Renewable energy source	*Unit*	***Total available technical potential***
BIOMASS	*Million toe/ year*	***3.196***
Agricultural biomass	*Million toe/ year*	***1.037***
Parts in fruit growing, vine growing and fruit processing	*Million toe/ year*	***0.134***
Processing industry	*Million toe/ year*	***0.030***
Liquid manure	*Million toe/ year*	***0.074***
Wood (forest) biomass	*Million toe/ year*	***1.668***
Biodegradable municipal waste	*Million toe/ year*	***0.026***
Biodegradable waste (except municipal waste)	*Million toe/ year*	***0.043***
Biofuels	*Million toe/ year*	***0.043***
HYDROPOWER	*Million toe/ year (GWh/year)*	***1.547 (18,000)***
WIND POWER	*Million toe/ year (GWh/year)*	***2.593 (30,152)***
SOLAR POWER - PV	*Million toe/ year (GWh/year)*	***2.622 (30,499)***

Renewable energy source		*Unit*	*Total available technical potential*
GEOTHERMAL ENERGY	***For electricity generation***	*toe /year (GWh/year)*	***309 (3.6)***
	For heat generation	*Million toe/ year*	***0.33***
TOTAL		*Million toe/ year*	***10.288***

* The presented RES potentials represent a dynamic category, and the presented data are not limiting their use, except for the sustainable use of biomass, taking into account its annual increase. During the realization of the projects, the economic, environmental, spatial, and other aspects of RES use must be additionally considered.

Development of the Energy Sector of the Republic of Serbia up to 2040

The energy sector is the mainstay and support for the Republic of Serbia's overall economic and social development. Energy security, reliable and secure supply of adequate quantities and high-quality energy, and energy sources are the basic postulates of energy sector development.

The development of the economy of the Republic of Serbia in the further decades should be based on structural changes, dynamic technological innovations, and dynamic internal entrepreneurial initiatives and investments, along with institutionally designed, sustainable reforms, which guarantee such development. Such development means sustainable economic growth based on innovation and knowledge, with a clear direction toward sustainable resource utilization, environmental protection, and systematic activities aimed at mitigation of and adaptation to climate change.

All proposed scenarios of energy sector development should be fitted and should support to such sustainable development of the economy and society. The energy transition, gradual abandonment of fossil fuels, and transition towards cleaner and more efficient technologies based on RES, is a precondition, but also an accelerator of dynamic and high-quality economic development. The energy transition is the basis of the climate economy, as a new and desirable development paradigm that implies an integrated system of economy and economic reflections, based on the prioritization of activities that contribute to a reduction of the negative impact on climate and linking of all economic activities with climate goals.

The development of the energy sector of the Republic of Serbia and the speed of the energy transition are also influenced by the obligations that the Republic of Serbia undertakes on a global level and within the framework of the EU integration process. Bearing in mind that the Paris Agreement implies the principle of joint but differentiated responsibility for climate change and emission reduction while respecting individual national circumstances, the Republic of Serbia expects significant financial and other support from the EU, to the extent that it follows its climate ambitions and goals. The Republic of Serbia also expects the integration into the EU's technological and research initiatives that follow the energy transition, in order to support and participate in the development of new industries and the creation of new jobs.

Vision and Goals of Development

The vision proposed by this Strategy is for the Republic of Serbia until 2050 to remain energy secure and achieve to the greatest possible extent carbon neutrality. This vision entails a cleaner, more efficient, marketable, and socially grounded energy sector that develops propulsive and serves as the driving force behind technological, economic, and overall social development. It envisions an energy sector that insists on energy efficiency and RES use, provides a secure supply of all energy sources, provides affordable energy for the economy and population, fosters the creation of new "green" jobs related to research, technological development, entrepreneurship, and innovation, supports the development of innovative energy services, improves the competitiveness of the economy and provides conditions for intensive energy poverty reduction.

The achievement of the proposed vision is not simple. It requires knowledge and the willingness to engage in deep structural reforms, transform the public sector, change the understanding and behaviors of the population, and adopt sustainable economic practices. The investments necessary for project realization are extremely high and require multidecade commitments and a systematic approach to planning and implementation. The extent to which the vision can be achieved will largely depend on the integration of the Republic of Serbia's energy market into international and EU energy, technology, service, and research markets, as well as accessibility to EU funds allocated for the energy transition.

Energy security, decarbonization and economic competitiveness of the energy sector are the general priorities of energy development and the principles on which it is necessary to develop the energy policy of the Republic of Serbia. Intensive application of energy efficiency measures in all areas of energy consumption and all energy sectors, research and innovation in energy are necessary prerequisites for the sustainability of energy policy. The listed priorities contain all the long-term goals of the energy policy defined by the Law on Energy, which together should ensure the achievement of the general goal of the Strategy, which is a safe and affordable supply of energy and energy products for the population and the economy, with a progressive reduction of the emission of gases with the greenhouse effect and other negative impact on the environment and human health.

Energy Sector Development Strategy of the Republic of Serbia		
Energy Security - Security of supply - Reduction of import dependance	**Competitiveness** - Energy market - Affordability of energy - New jobs	**Decarbonization** - Reduction of GHG emissions and impact on the environment - Greater use of RES
Energy Efficiency		
Research and Innovation		

Figure 10: Priorities of energy development

The listed priorities are closely related and interdependent and permeate all areas of energy. Energy security of the Republic of Serbia and relatively low import dependence, in the conditions of gradual abandonment of coal as the dominant energy source, is impossible to achieve and maintain without strong development of energy production from renewable energy sources, intensive application of energy efficiency measures, research and innovation in energy. The prerequisite for all this is the development of the energy market, i.e. the creation of a market environment that promotes precisely such investments and projects in the energy sector.

The proposed priorities of the Energy Strategy are interwoven with the five dimensions of the Integrated National Energy and Climate Plan of the Republic of Serbia for the period up to 2030 with a vision up to 2050.

To accomplish the energy policy goals in the coming period, significant changes are required across all segments of the energy chain and subsectors. The key changes include:

- Intensive implementation of energy efficiency measures and decreasing specific energy consumption in all sectors of final consumption.
- The intensive application of energy efficiency measures and reduction of losses in production, transport/transmission, and distribution of all forms of energy.
- Reducing the use of coal for electricity generation.
- The construction of natural gas fueled TPP/CHP.
- A significant increase in electricity generation using solar and wind energy.
- The introduction of capacity for storage of electricity and heat produced by RES (reversible hydropower plants, batteries, electrolyzers for hydrogen production, etc.).
- A significant increase in the share of electricity in the final energy consumption (industry, transportation, households, public and commercial sector).
- The intensive introduction of RESs and heat pumps for heat generation in district heating systems and in the final consumption.

Additionally, in the case of a decision to start using nuclear energy for electricity generation, during the implementation period of this Strategy it is necessary to start the process of creating social, legal, institutional, regulatory, infrastructural, educational, personnel, and all other necessary conditions in the Republic of Serbia for the introduction of nuclear energy into energy mix after 2040.

Some of the preconditions for the energy transition and achievement of development vision and goals include the measures:
- Defining energy and climate objectives and developing and implementing national energy and climate plans with clear measures for reducing greenhouse gas emissions.
- Introducing a mechanism for greenhouse gas emissions pricing.
- Analyzing and revising all regulations to support progressive decarbonization of the energy sector and ensuring their full implementation.
- Prioritizing energy efficiency and enhancing it across all sectors.
- Increasing the share of renewable energy sources and creating the necessary investment conditions for investments in RES and integration in the energy system.
- Striving to decrease and gradually phase out of coal subsidies, strictly respecting state aid rules.
- Actively working on a just transition for coal regions.
- Developing programs for addressing energy poverty.

The great challenge for the achievement of the proposed vision and stated goals lies in the social sphere. Changes in the energy sector will significantly affect the whole of society and will have multiplicative social consequences. An important change involves moving away from using energy policy as a tool of social policy. The consistent application of market principles in determining energy prices and sources poses a major challenge. Another aspect concerns employment, wages, and standards, as well as the way of life of people, especially those employed in energy companies associated with the production and use of coal, as well as their families. Therefore, issues of energy poverty and just transition need to be considered comprehensively alongside the expected changes in key energy sectors. The burden of the energy transition, to a significant extent, will be paid by all citizens of the Republic of Serbia, but it is necessary to ensure that it is fairly distributed and that the most vulnerable parts of society are protected and taken care of. This means that the transition process must prioritize humanitarian and social sustainability.

Essentially, the transformation of the energy sector of the Republic of Serbia, in the context of the proposed vision and development goals, should be treated as a chance for development and changes across the entire economy:

- Structural changes in the industry, shifting from energy-more intensive to energy-less-intensive industrial programs and industrial branches; Gradually increasing energy prices will result in higher costs for energy-intensive industries, thereby incentivizing the implementation of energy efficiency measures and a shift in production programs and technologies.
- Further growth in the service sector; The energy transition in the service sector encourages smart technical solutions, generates savings in consumption and more efficient use of energy, reduces material costs, and thus contributes to decoupling the trends of economic growth and energy consumption growth.
- Investments in renewable energy; Incentives from the EU funds and other domestic and foreign funding sources will contribute to the creation of new "green" jobs in the energy sector and related systems.

Besides these general incentives, during the process of energy transition in the Republic of Serbia, the following process and impulses will have positive impacts on economic growth:

- The modernization of technological systems in energy companies, especially in the EPS, along with the restructuring process, will contribute to the change of employment structure and volume - primarily from jobs related to coal exploitation and utilization for electricity production towards jobs related to energy production by RES use and improvement of energy efficiency.
- The implementation of carbon pricing will lead to an increase in the price of energy-intensive products, but at the same time will provide resources for the more intensive implementation of energy efficiency programs and measures at national and local levels in all sectors of consumption (industry, households, transport, public and commercial sectors), greater use of RES and financial resources for overcoming the socio-economic consequences of the energy transition.
- The application of incentive programs and the establishment of a sustainable financing mechanism for energy efficiency projects and measures in buildings present opportunities for significant engagement of domestic industry.
- The expansion of the new, less material and energy-intensive industry will be driven by increased energy efficiency, the implementation of smart energy systems, and the adoption of clean production and recycling processes and measures.
- Research and development in the field of renewable energy sources, new energy technologies, innovative energy planning, and energy efficiency models, as well as scientific networking, and new and improved education in the field of energy, provide an opportunity for new forms of employment in energy transition-related jobs.

Development Scenarios

For sectoral elaboration and conduction of established strategic goals, two scenarios of possible energy development of the Republic of Serbia, up to 2040. In the annex of the Strategy, projections of energy balances for both analyzed scenarios are presented.

Scenario BAU (from "Business as Usual - BAU") is related to continuation of current practice, both in energy consumption and energy production. As such it **does not represent a preferred scenario of energy development,** but it is commonly used in the strategic planning process as a reference, for monitoring of the progress in conducting of some activities, or implementation of various measures, by monitoring intensity and structure of consumption, or utilization of specified energy sources.

Scenario S refers to **energy development promoted by the Strategy.** Changes of the intensity and the structure of energy production according to the pathways defined by Scenario S, fully ensure fulfilling goals of energy development of the Republic of Serbia up to 2040. All the measures and activities proposed in the Strategy, has a transformation of the energy sector, based on this scenario, as an essential goal.

Main Assumptions of the Development

Energy development is a follower and a driver of overall economic and social development. Thus, projections of energy development are based on historical trends and projections of changes in macroeconomic and demographic indicators.

Serbia's GDP growth for the first two decades of the 21st century averaged 2.9%, which was slightly higher than the world growth rate of 2.8%. In the first decade of the 21st century, growth rate of GDP was 4.5%, and in the second decade, 1.3%. In the second decade, the growth rate in Serbia was lower than the world rate, which was 2.1%. The negative growth rate of Serbia's GDP in 2020, due to the Covid-crisis (-0.9%), influenced Serbia's lover statistical growth rate in the second decade of the 21st century.

Based on trends in previous period and relatively optimistic assumptions of development, for formulation inputs for scenario of energy development, for the period until 2040, with a vision until 2050, slightly higher annual growth rates than those achieved in the period 2001-2020 was adopted, i.e. a growth rate of 3% on average per year. In a considered period, a more intense growth is assumed in the period until 2035, while after that GDP would grow with slightly lower intensity.

The number of inhabitants, the age structure and the level of education of population, affect the structure of the economy, and have influence on its future development. Also, number of inhabitants and the average number of inhabitants per household, as well as the growth of the housing stock space, are some of the main factors that determine energy consumption in households. Demographic projections needed to make projections of future consumption are based on the results of the 2022 Census and projections of population change. A projection of population change with average fertility rate was adopted.

Demand of End Users – Final energy consumption

The changed circumstances in the world energy market caused by geopolitical and economic factors, have influence on the development of national energy systems, too. In the changed conditions accompanied by price uncertainty and influence on the availability of energy sources, which are partly provided from imports, the main goal of the energy system is to ensure secure supply of end consumers with reduced the negative impact of energy production, transformation and consumption on the environment. One of the preconditions needed to achieve this goal is reduction of the amount of energy that needs to be delivered to consumers. This is primarily achieved by implementing energy efficiency measures in all segments of energy flows. In addition, reliance on own resources, primarily renewable energy sources, contributes to enhancement of the security of supply of end consumers.

In order to ensure security of supply of end consumers in different circumstances, the limits of the expected energy needs of end consumers were analyzed: higher final energy demand (Scenario BAU - low ambition of implementing energy efficiency measures with lower utilization of renewable energy sources) and lower final energy demand (Scenario S - high ambition of implementing energy efficiency measures, with wider utilization of renewable energy sources), These different demands define the area of expected final consumption in the considered period, and also the area of expected annual needs of each of the energy sources in final consumption. Additional assumptions that served as inputs for scenarios related to sectors of final energy consumption are given in Table 5.

Table 5 Additional assumptions for developing scenarios in the sectors of final consumption

Sector	BAU Scenario	Scenario S
Households	Continuation of the historical trends of increase of residential space, change of the number of households and the intensity of energy consumption.	Implementation of energy efficiency measures in buildings and energy rehabilitation of residential buildings (1% of buildings per year until 2030 and 2% per year thereafter) Wider utilization of heat pumps for heating: 15% share in individual systems by 2030, and continuous growth thereafter. Utilization of solar energy for domestic hot water heating: 5% share by 2030 and continuous growth thereafter
Industry	Energy consumption in industry follows the expected annual growth rate of industrial sub-sectors.	Implementation of energy efficiency measures, heat recovery
Transport	Energy consumption in transport follows the historical trend	Introduction of electric vehicles: 15% in share by 2030 and 20% by 2040 (in relation to the number of new vehicles) Introduction of biofuels and biomethane: share of 3% by 2030. Belgrade Metro in operation from 2030. Complete electrification of railway transport by 2040
Public and commercial	Energy consumption in the public and commercial sectors follows expected GDP growth rate	Energy rehabilitation of building stock (3% of buildings annually in 2022-2030 and 6% thereafter) Wider utilization of heat pumps for heating: 25% in share by 2030 and continuous growth thereafter (in relation to the heating surface area)

Sector	BAU Scenario	Scenario S
Non energy consumption	Consumption of energy sources follows the expected growth rate of chemical and petrochemical industry sub sector.	

Projections of total final consumption by sector for two analyzed scenarios are given in Figure 11, while Figure 12 shows the expected change of the structure of consumption by sector.

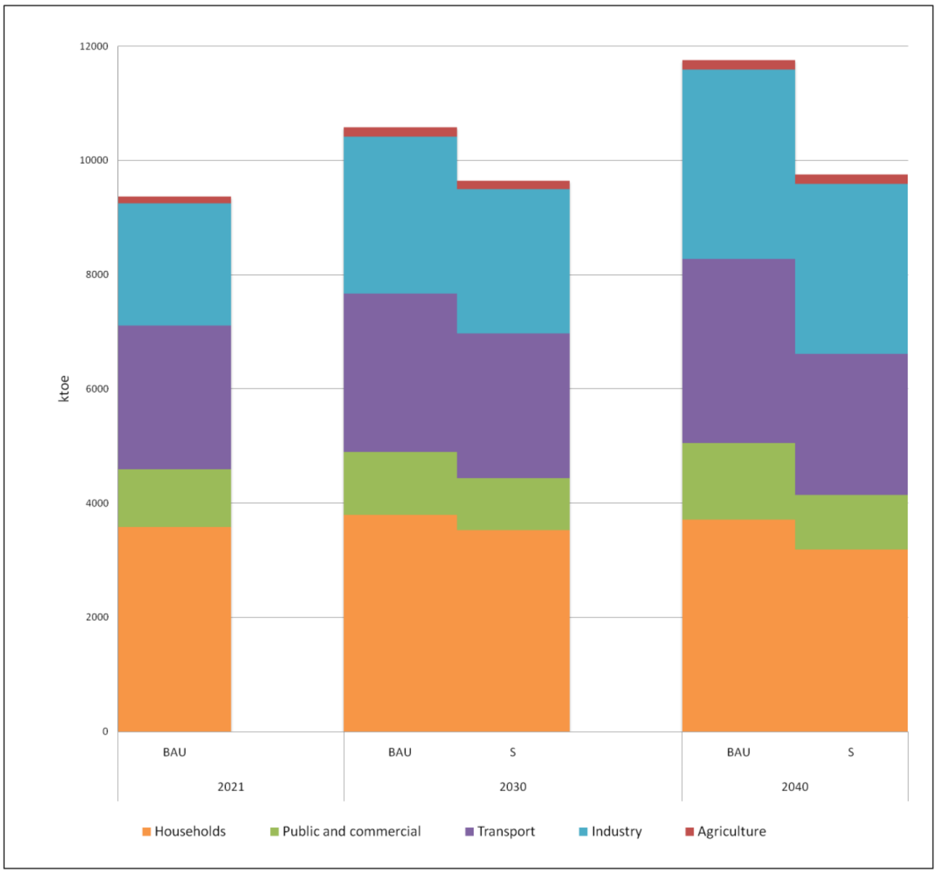

Figure 11: Projections of final consumption by scenario and by sector

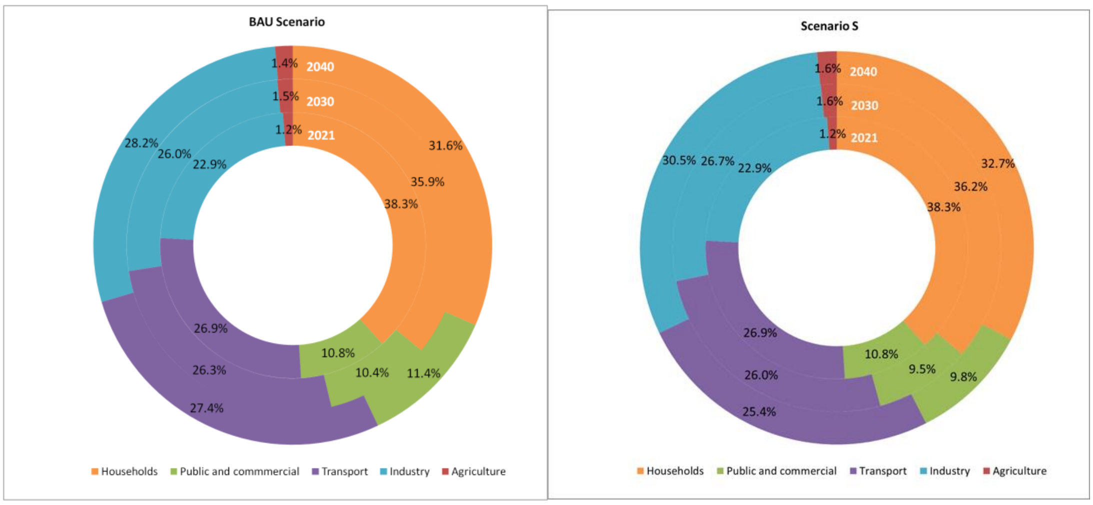

Figure 12: Structure of final consumption by scenario and by sector

If the development of energy sector would be based on the **BAU scenario**, the final consumption in the considered period would increase from 9.365,3 thousand tons of oil equivalents in 2021 to

11.759,3 ktoe in 2040, which is the highest expected consumption in the considered period. In the break down by sectors, the highest consumption would be in households (38,3% in 2021 and 31,6% in 2040), transport (26,9% in 2021 and 27,4% in 2040) and industry (22,9% in 2021 and 28.2% in 2040). The above presented structure remains unchanged during the considered period.

According to the assumptions of the **Scenario S**, the final energy consumption will increase in the considered period and reach 9750,3 ktoe in 2040, which is approximately 17% less compared to the BAU scenario. The expected consumption in households in 2040 of 3,190.4 ktoe is lower than in 2021 (3,583.2 ktoe). In other sectors, with the exception of transport, growth in final energy consumption is foreseen.

Regardless of the predicted decrease of consumption in households during the analyzed period, the largest share in consumption will be retained by this sector, whose share will decrease from 38,3% in 2021 to 32,7% in 2040. The reduction of consumption is the result of the implementation of energy efficiency measures and intensive utilization of heat pumps for heating. The largest increase of energy consumption is expected in industry: from 2,146.3 ktoe to 2,975.5 ktoe, which changes the structure of consumption by sector. Share of industry will increase from 22,9% to 30,5% in 2040. Estimated consumption in transport in 2040 is 2,472.2ktoe, while its share in 2040 will account 25,4%

Projections of the demands of energy sources/fuels in final consumption and structural changes by scenario and by energy source are presented in Figures 13 and 14.

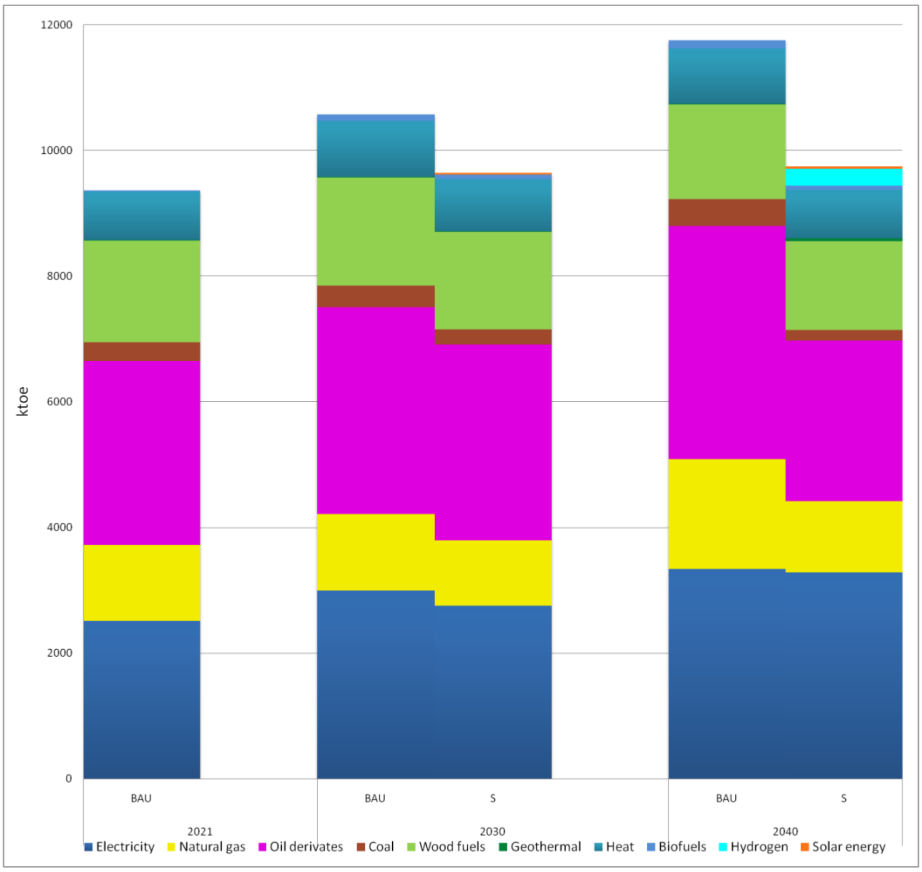

Figure 13: Projections of final consumption by scenario and by energy source

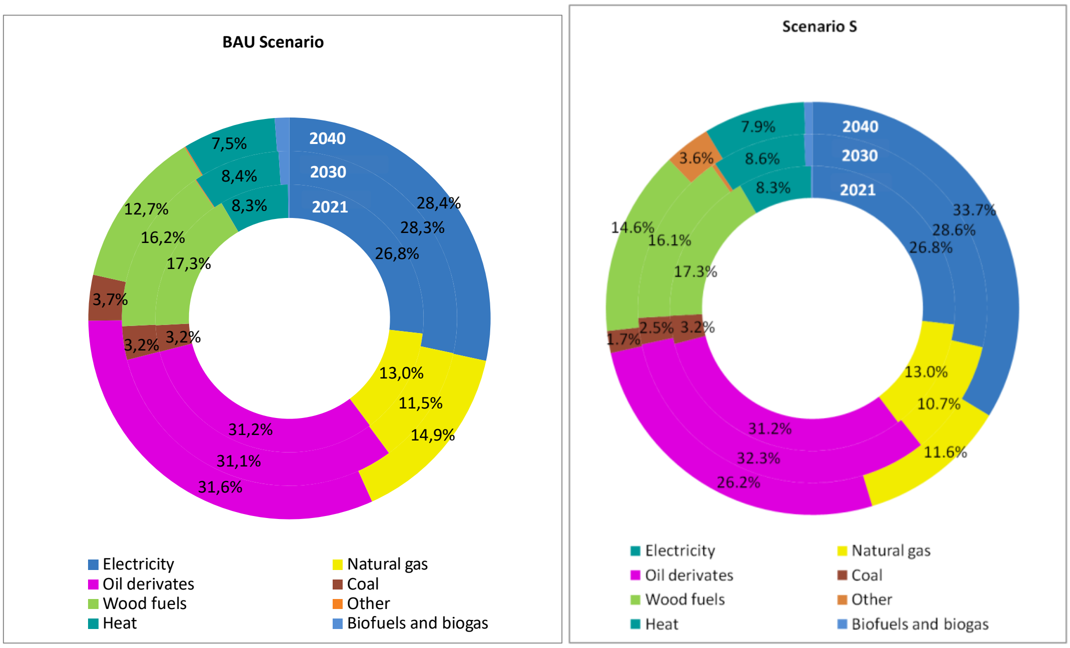

Figure 14: Structure of final consumption by scenario and by energy source

According to the assumptions of the BAU Scenario, the largest share in the final energy consumption will have oil derivatives with a share of about 31,5%, which remains unchanged during the considered period, followed by electricity with a share of about 27% and wood fuels, whose share decreases from 17,3% to 12,7%.

According to the projections of Scenario S, the consumption of oil derivatives would decrease from 2.923,4 ktoe in 2021 to 2.553,3 ktoe in 2040. The share of oil derivatives would decrease from 31,2% to 26,2% in the considered period. In absolute values, electricity would have the largest increase in consumption from 2,510.7 ktoe to 3,284.9 ktoe in 2040, which is an increase from 26,8% to 33,7% in the structure of consumption by energy source. This trend of increase in electricity consumption is primarily caused by the foreseen higher consumption in transport, as well as consumption for operation of heat pumps in households and the public and commercial sectors.

Total Primary Energy Supply

Projection of primary energy consumption is shown in Figure 15, while changes of structure by scenario and by fuel are given in Figure 16.

According to the BAU Scenario, the primary energy consumption in the considered period increases from 16.508,4 ktoe (year 2021) to 20.366,1 ktoe (year 2040). Coal remains the dominantly used primary energy source. Its consumption will increase from 6.984,5 ktoe to 9.149,7 ktoe in 2040. Oil consumption will increase from 4.034,7 ktoe to 4.713,4 ktoe, while natural gas consumption will increase from 2.661,1 ktoe to 3.499,1 ktoe.

According to the projections of the Scenario S, the primary energy consumption in the considered period will decrease to 15.297,0 ktoe (year 2040), which is a decrease of about 9% compared to the base year and about 26% compared to consumption according to the BAU scenario in the same year. Coal consumption is projected to decrease to 4.384,2 ktoe in 2040, which is a decrease from 42,3% to

29,1% in the primary energy mix. The share of oil decreases from 24,4% to 20,5%, while the share of natural gas increases from 16.1% to 18,4%.

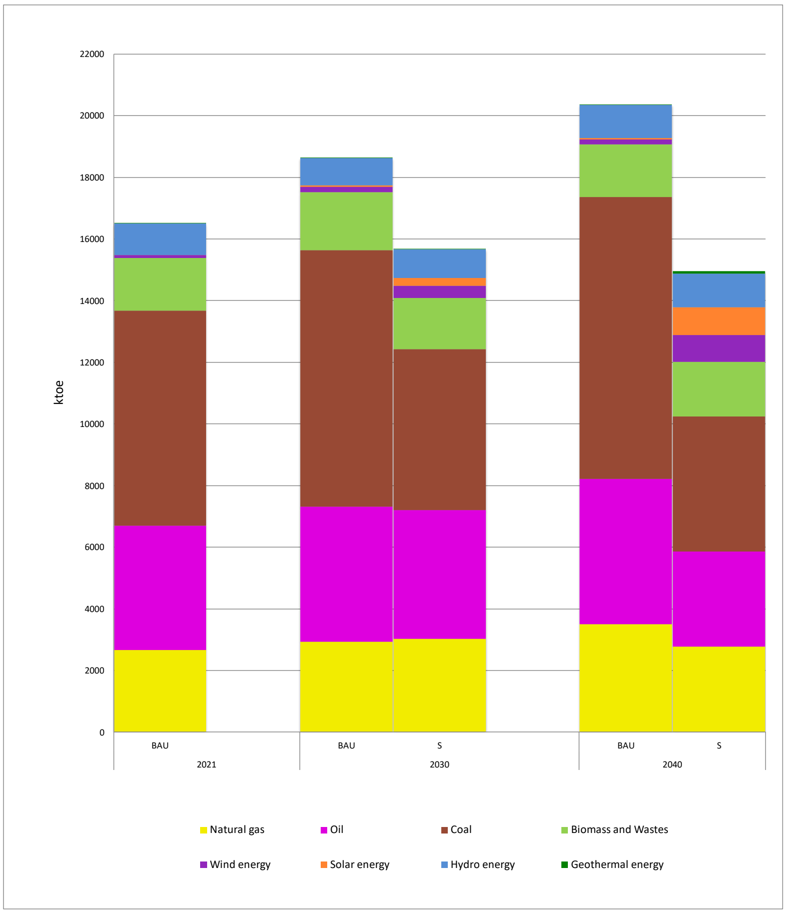

Figure 15: Projection of primary energy consumption by scenario and by energy source

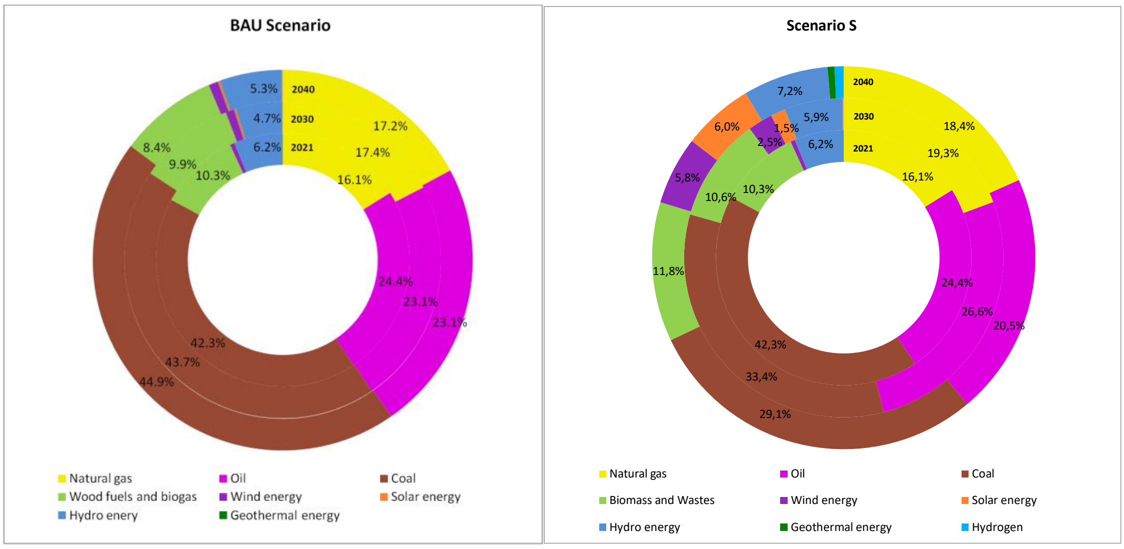

Figure 16: Structure of primary energy consumption by scenario and by energy source

Development of Energy Sectors until 2040

Electricity Sector

Objectives	➢ Security of electricity supply to the domestic market	➢ Continuous reduction of greenhouse gas emissions	➢ Increasing the use of RES	➢ Maintaining energy independence	➢ Increasing energy efficiency in the production, transmission and distribution of electricity
Measures	➢ Preventive maintenance, revitalization and modernization of power plants ➢ Use of high-quality coal in accordance with the designed boiler parameters	➢ Reduction of electricity production in coal-fired thermal power plants	➢ Changing the production portfolio, so that the share of RES in electricity production is as high as possible ➢ Development of the transmission and distribution network so that the greatest possible integration of RES is enabled	➢ Increasing the electricity production from domestic power plants ➢ Secure and reliable operation of the transmission network	➢ Reconstruction, construction and modernization in the production, transmission and distribution of electricity
Indicators	➢ Indicators of technical efficiency in power plants ➢ Losses in the distribution system	➢ Annual reduction of greenhouse gas emissions (measured in kg CO2/kWh)	➢ Share of electricity produced from RES	➢ Energy and financial indicators of reducing import dependence	➢ Technical losses of electricity in the distribution network
Stakeholders [14]	➢ Producers, transmission system operator, distribution system operator, suppliers, market operator ➢ End customers				

The electricity sector is the bearer of the most significant and biggest changes in the new Strategy compared to all other energy sectors and previous strategies. The most significant changes in this sector are foreseen in the portfolio of future electricity production and in the change regarding the structure of production capacities.

Decarbonization of the energy sector is closely related to the gradual abandonment of electricity production using fossil fuels, especially coal, as the largest emitter of carbon dioxide. The strategic commitment is the integration of RES, especially solar and wind energy into the system. However, the shutdown of conventional sources, which represent basic energy sources, together with a significant share of energy produced using the wind and the Sun, raises the question of the balance reserves of the power system necessary primarily for its stable operation and to cover intermittent production. Therefore, the transition process in the power industry must be well planned and managed so that it

[14] those to whom these measures refer and will have an impact; excludes public administration (at national, provincial and local levels) responsible for implementing and/or monitoring measures.

does not jeopardize the security of supply to consumers at any time, i.e. not to have a negative impact on the energy security of the Republic of Serbia.

Electricity Production Capacities

Coal-fired thermal power plants

In the coming period, the most significant changes in the electricity sector are foreseen in the way of electricity production, i.e. in the change of the structure of production capacities. Gradual abandonment of electricity production using fossil fuels is necessary due to the decarbonization process. However, security of supply is imperative, so the dynamics of thermal power plants will depend above all on energy security, so that it is not threatened at any moment.

The operation of the thermal power plants will be adapted to the current needs for electricity. This means that some units will work according to their maximum performance, while a number of them will work with reduced power or, in a later period, will be in reserve status. In order for the operation of these power plants to be in accordance with the needs of decarbonization, it is necessary to consider the application of technologies for the collection and storage of carbon dioxide. The possibility of working with reduced power will allow variability in the overall portfolio of electricity production. Of course, all this implies the assumption that renewable energy sources will be found in the production portfolio with a targeted (or higher) participation in electricity production of 45% in 2030, or 73% in 2040.

In order for all of this to be technically possible and in accordance with the regulations related to the area of emissions of harmful gases and dusty substances, it is necessary to carry out revitalization of the existing thermal units, including investments in the primary and secondary reduction of emissions of sulfur dioxide, nitrogen oxides, dusty substances and desulfurization of waste water. This also applies to units A1 and A2 in TENT A and both units in TPP Kostolac A. With the adoption of the Specific Implementation Plan of the Directive 2010/75/EU on Industrial Emissions, the possibility of compliance with the Conclusions on the best techniques for large combustion plants for these four units[15], namely for the TENT A1 and A2 until 2032 and TPP Kostolac A until 2030, which will enable the implementation of projects to reduce emissions of harmful gases and powdery substances.

When it comes to new thermal capacities, there is only a new unit B3 in TPP Kostolac B. According to the project documentation, the net capacity of this unit is 308 MW, and the expected annual electricity production is 2 TWh.

In the period until 2030, thermal power plants whose further operation would not be possible or justified will be decommissioned, taking into account the age of the machines and other techno-economic parameters. This applies for remaining four units in TPP Kolubara A, while TPP Morava will be either decommissioned or put in state of reserve shutdown. Their decommission will not significantly affect the amount of electricity produced in the power system of the Republic of Serbia, with the fact that the decommission of these units must be dynamically coordinated with the commissioning of new production facilities in order not to jeopardize energy security, while also taking

[15] Commission Decision (EU) 2021/2326 of 30 November 2021 establishing conclusions on the best available techniques (BAT) for large combustion plants in accordance with Directive 2010/75/EU of the European Parliament and of the Council

into account provision of heat energy for individual units of local self-governments, which is related to the operation of individual units.

Gas-fired power plants

The uptodate capacities of gas-fired power plants in the Republic of Serbia are the CHP Panonske (297 MW) and CHP Pančevo (188 MW). As the decommission of the CHP Panonske is likely, it is necessary to build new capacities in the area of Novi Sad. The planned gas power plant would have a capacity of 350 MW of electricity and 100 MW of thermal energy. In support of this new power plant, unit 2 will be retained in the existing CHP Novi Sad, as a reserve of the installed capacity of 120 MWel.

In addition to the mentioned new power plant at the location of the existing one in Novi Sad, the construction of a gas power plant in the vicinity of Niš is also possible. It is planned that this power plant will have a capacity of 150 MW of electricity and 100 MW of thermal energy.

Hydropower plants

Basically, hydropower plants belong to seasonally variable production capacities. Experience has shown that in the case of the power system of the Republic of Serbia, these variations range up to 3.3 TWh on an annual basis. However, fluctuations in production are predictable for daily and weekly forecasts, so strictly speaking, we usually do not call these sources variable, leaving this term for energy produced using the potential of the wind and the Sun.

When it comes to hydropower plants, the main intention is to preserve all existing capacities, along with revitalization with a possible increase in power, along with upgrading existing and building new capacities.

In the period up to 2030, the **revitalization of numerous hydro units** is foreseen, starting from 2025, when the successive revitalization of all 10 hydro units in HPP Đerdap 2 will begin, with a capacity increase of 5 MW per unit. This project will be implemented during the next decade as well, as the completion of the works and commissioning is expected in 2037. By 2030, there should be three revitalized units at HPP Potpeć and ten units at HPP Vlasinske, with a capacity increase of 6 MW and 8 MW, respectively. In the same period, the revitalization of both units at HPP Bistrica will be carried out. There will be no change in its capacity, but a complete replacement of the equipment, whose operational life has already expired, will enable reliable and safe operation in the future. The total expected additional capacity in these revitalizations is 77.7 MW (47.7 MW by the end of 2030) and an extended lifetime of the facilities of 30-40 years. In this way, an average annual increase in production from HPPs can be expected up to a maximum level of 0.272 TWh. In addition to the mentioned revitalizations, in this period the plan is also to **build a new hydro unit** in HPP Potpeć (G4), with an installed capacity of 14 MW.

In the period 2030-2040, the goal is to use the hydro potential of rivers Drina, Ibar and Morava.
The Republic of Serbia has the greatest opportunity for potential regional cooperation in the power sector regarding the joint use of hydro potential. The most significant potential is Drina River (Upper, Middle and Lower Drina)[16]. It is planned that the construction project of the new hydropower system

[16] The upper course of the Drina belongs territorially to the Republic of Srpska (BiH), while the middle and lower course of the Drina is a border river between the Republic of Serbia and the Republic of Srpska (BiH).

of the Upper Drina will be completed by 2032. This would mean that then three new HPPs will be connected to the grid - HPP Buk Bijela, HPP Foča and HPP Paunci. The total installed power will be up to 212 MW, and as the participation of JSC EPS in this project is 51%, the expected annual production that the Republic of Serbia can count on is about 350 GWh. The construction of hydropower plants on Ibar (121 MW) with an expected annual production of about 455 GWh, as well as on Morava (146 MW) with an expected annual production of about 645 GWh, is planned. Total installed capacity of hydropower plants scheduled for construction in the period 2031-2040 would amount to 360 MW, while the expected annual production from newly built HPPs could amount to around 1,450 GWh.

Variable (intermittent) RES

Variable renewable energy means capacities for the production of electricity from the wind and the Sun. The Strategy proposes to rely on relatively proven technologies that have taken root widely in practice and where the degree of study of numerous aspects has reached a good level.

In the period until 2030, an expansion of the construction of power plants that use wind and the Sun as primary energy is expected, so it is expected that in 2030 the total installed capacity of wind farms and solar (PV) power plants will be 3.5 GW, which represents a significant increase in the share of intermittent renewable energy sources in the total production of electricity. The projected gross capacity in wind farms is about 1.77 GW (with an annual production of 4.60 TWh), while in solar power plants it is 1.73 GW (with an annual production of 2.27 TWh). This means that with the installed capacities thus foreseen, the expected annual production amounts to 6.87 TWh.

In the period after 2030, a further increase in the installed capacity of wind farms and solar power plants is expected. By 2040, the total gross capacity wind farms and solar power plants is expected to be 10.97 GW, and the total production of electricity from intermittent sources is expected to be 19.04 TWh on an annual basis. Specifically, the projected gross capacity of wind farms is 3.6 GW (with an annual production of 9.36 TWh), while the projected gross capacity of solar power plants is 7.37 GW (with an annual production of 9.68 TWh).

The expected production of electricity according to energy sources is shown in Figure 17.

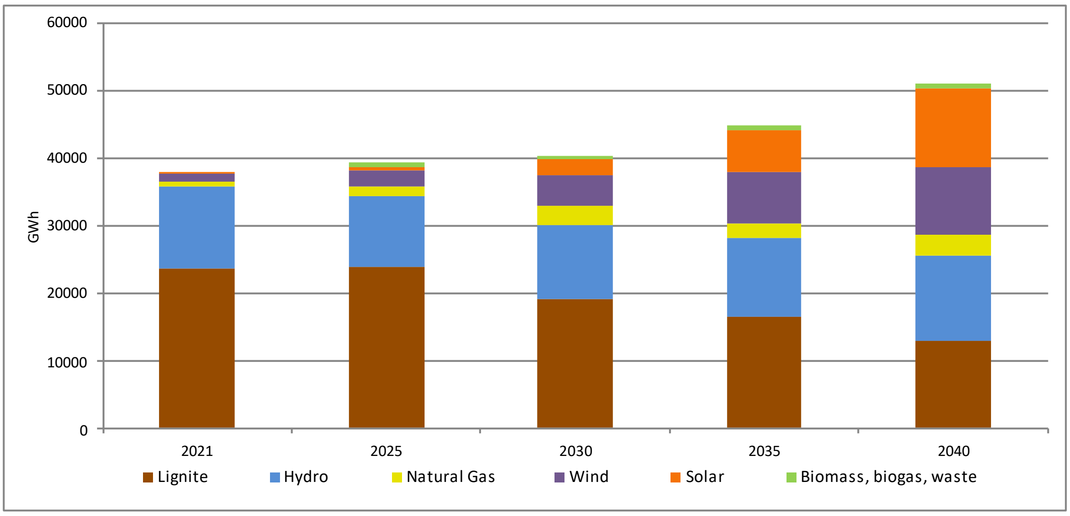

Figure 17: Electricity production according to energy sources until 2040

Balancing Reserve Capacities

The key strategic commitment in the power sector relates to a significant increase in the installed capacities that use RES, primarily wind power plants, solar power plants and hydropower plants. The installed capacity of these plants exceeds the capacity of the thermal power plants that remain on the grid many times over. For example, it is predicted that in 2040 there will be 2.52 GW of thermal capacity in operation, while the gross capacities in wind and solar power plants will grow to 10.97 GW. Also, as mentioned, new capacities in gas power plants are foreseen (350 + 120 MW). It could be concluded that the coverage of the final consumption planned for 2040 is not questionable, but the characteristic load diagram and its daily and seasonal unevenness may, in certain situations, call into question the reliability of the supply and coverage of base energy from intermittent sources.

The expected increase in the power of wind and solar power plants will make production from these sources make up 17.1% of the planned total electricity production in 2030. In order to maintain the stability of the power system, it is necessary to increase balancing reserve capacities along with the increase in the share of RES in the power system.

The introduction of wind farms and solar power plants of significant power into the electricity production mix leads to the suppression of power in operational thermal power plants. In other words, existing thermal power plants that remain active (in operation) will operate with reduced active power. That decrease in power in operational work represents at the same time an increase in the regulating reserve providing the up balancing service. Also, the new TPP Kostolac B3 will start its operation. The introduction of new unit in HPP Potpeć, but also the revitalization of the existing ones and the increase of gross capacity (four units in HPP Đerdap 2, all units in HPP Potpeć and all ten units in HPP Vlasinske) contribute to the increase of the balancing reserve. The regulating reserve provided by thermal power plants represents the most favorable and largest increase in the regulating reserve. It should not be forgotten that hydropower is a renewable energy source that has seasonally variable production and whose available capacity depends on hydrological circumstances.

For the reasons mentioned, the most reliable existing regulating resource in hydropower is pumped-storage hydropower plant Bajina Bašta. In the conditions of increased production from RES, such capacities need to be increased, so **by 2032, the construction of PHPP Bistrica (gross capacity 628 MW) is foreseen as a priority.** The construction of PHPP Bistrica is planned on the rivers Uvac and Lim. This PHPP would represent, next to PHPP Bajina Bašta, the most important regulatory resource in the system. In addition, due to their energy characteristics and position in the Uvac basin, PHPP Bistrica and the Klak reservoir would increase the quality of use of all hydropower plants on Uvac and Lim (HPP Uvac, HPP Kokin Brod, HPP Bistrica, HPP Potpeć). The documentation for this project is in the preparation phase, and the actual construction should start in 2025.

In the period 2030 to 2040, the expansion of RES is expected, so by 2040, the gross capacity of wind power plants is expected to increase to 3.60 GW and solar power plants to 7.37 GW Taking into account the significant amount of wind and solar power (41.3% of the planned total production in 2040), thermal units that remain on the grid will work with reduced power, which additionally contributes to the set goals of decarbonization, but also additionally increases the regulating reserve for the up balancing service. The reserve can also be increased by gas power plants, depending on how much base energy they cover. In this period, the revitalization of the remaining six aggregates in

HPP Đerdap 2 (total increase of 30 MW) and the construction of new power plants that would use the hydro potential of the Drina, Ibar and Morava are also foreseen.

Nevertheless, the most reliable resource of the regulating reserve remains PHPPs, so the construction of PHPP Đerdap 3 with an installed capacity of 1,800 MW is planned by 2040. Implementation of the construction project of PHPP Đerdap 3 implies regional cooperation with Romania. It is a big project that requires a lot of investment. This kind of project could in some period exceed the needs of the Republic of Serbia and it makes sense to look at it as a regional project. As the largest potential capacity for balancing variable RES, this project could also be studied from the point of view of covering the variable consumption from the capacity in Romania.

It is necessary to precisely determine the level of regulating reserve for various cases critical to maintaining the stability of the system. For these, but also for numerous other technical reasons, it is necessary to do a large number of study analyzes that would include static analyzes of power flows, testing of adequacy, n-1 contingency, short circuits, but also dynamic analyzes of system stability, as well as, for an example, power quality studies.

The proposed concept of building balancing reserve capacities ensures independence in the electricity production to the current extent, so practically completely. The domestic resource, coal, is being replaced by capacities that also use domestic energy sources: wind power plants, solar power plants, but also additional capacities in hydropower plants, with the provision of balancing reserve capacities in PHPP. According to the Law on the Use of Renewable Energy Sources, it is possible for the producer of electricity from RES to install within the power plant a battery storage with a capacity of at least 0.4 MWh/MW of the installed power of the power plant. Such storages could be charged in periods of excess power (providing the down balancing service) and emptied when they would provide the up balancing service. Of course, it is necessary to systematically solve the responde speed of the battery storage to the request of the system operator and to harmonize the control electronics of the storage with this. The investor's interest in installing a storage would be in billing for the system service, and it is also necessary to consider whether he could participate in the market with power reserves in the storage. Installed in this way, the battery storages would represent the local balancing capacities of RES power plants. At the same time, the environmental effect of disposing of used batteries must not be ignored, as well as the possible economic and environmental harmful consequences due to breakdowns on batteries of such large capacities.

The flexibility of the system largely contributes to the increase in the regulating reserve. Further development of the transmission and distribution network in order to increase capacity, interconnections, market development, controllable demand and expansion of customer-producers contribute to flexibility, better management of production resources and increase of reserves. Some of these measures refer to the power system itself, while others depend on the connection with other systems.

The performed software simulations show that the energy balance is closed within the system, without reliance on interconnection, that is, without dependence on imports.

In this sense, it was on the side of safety, i.e. the regulatory reserves of the Serbian power system were considered exclusively.

Transmission System

For the proper operation and development of the transmission system in the coming years, the operator of the transmission system will continue the implementation of activities that should enable an increase in the reliability and security of electricity supply for its customers. In this sense, projects regarding the electricity transmission can be divided into two groups:

- Construction and reconstruction projects of the internal 400, 220 and 110 kV network - include activities aimed at upgrading, expanding and modernizing existing capacities. This will mitigate the impact of the aging of the existing infrastructure, enable the connection of new power plants and consumers, and increase the efficiency of transmission system management.
- Projects of an international character - include increasing the capacity of corridors that have regional and pan-European significance:
  - Trans-Balkan Electricity Corridor – Phase 1,
  - Trans-Balkan Electricity Corridor – Phase 2,
  - Pannonian Corridor.

Trans-Balkan Electricity Corridor - the construction of a 400 kV power transmission system " Trans-Balkan Electricity Corridor is a project of the greatest national and regional interest. As part of the Phase 1, the construction of the double transmission line between the Republic of Serbia and Romania and the 400 kV transmission line TS Kragujevac 2 - TS Kraljevo 3 was completed. The construction of the following two sections remains:

- 400 kV double transmission line TS Obrenovac - TS Bajina Bašta and
- 400 kV regional interconnection Republic of Serbia - Bosnia and Herzegovina - Montenegro through the construction of a 400 kV double transmission line TS Bajina Bašta - TPP Pljevlja - HPP Višegrad, to which the future PHPP Bistrica would prospectively be connected.

In addition to the Phase 1, there is also the Phase 2 of the Trans-Balkan Corridor project, which consists of the following projects:

- North CSE Corridor,
- Central Balkan Corridor and
- 400 kV transmission line between the Republic of Serbia and Republic of Croatia.

North CSE Corridor - In addition to unburdening TS Beograd 5, this project should enable the evacuation of energy from new electricity production capacities (TPP Kostolac B3, wind farms in the area between Pančevo and Zrenjanin) and transit from the Romanian power system, i.e. an increase in cross-border transmission capacity. In addition, the project will contribute to unburdening the 110 kV network between TS Beograd 9 and TS Inđija. The North CSE Corridor project consists of the following sub-projects:

- BeoGrid2025 (TS 400/110 kV Beograd 50 with associated 400 kV and 110 kV junctions and double transmission line 400 kV TS Beograd 50 - PRP Čibuk 1) and
- 400 kV transmission line between the Republic of Serbia and Romania.

Central Balkan Corridor - With this project, the outdated 220 kV network from TS Niš 2 to TS Bajina Bašta is replaced with a 400 kV network, which increases its capacity, enables more secure power supply, creates preconditions for increasing the transit of electricity in the east-west direction and accelerates the evacuation of electricity from the area of the South Banana. Also, the project involves the implementation of new 400 kV interconnections to Montenegro and Bosnia and Herzegovina. The Central Balkan Corridor project consists of the following sub-projects:

- 400 kV transmission line between the Republic of Serbia and Bulgaria,
- 400 kV transmission line TS Kraljevo 3 – TS Kruševac 1 – TS Niš 2,
- 400 kV transmission line TS Kraljevo 3 - RP Požega - Vardište - country borders,
- double 400 kV transmission line TS Jagodina 4 – RP Drmno.

400 kV interconnection between Republic of Serbia and Republic of Croatia - The purpose of this transmission line is to ensure the security of power supply to TS 400/110 kV Sombor 3, and to provide the transmission system of Serbia with another interconnection between Republic of Serbia and Republic of Croatia.

Pannonian Corridor - The construction of the Pannonian Corridor should enable an increase in the capacity for electricity transmission across the Balkan Peninsula, in the north-south direction, which will contribute to the integration of the electricity market and increase the reliability of power supply to consumers in Bačka District and Srem District. Also, this project is expected to contribute to easier integration of renewable energy sources in the mentioned areas. The project consists of two phases:

- Phase 1 - construction of a new 400 kV double transmission line TS Subotica 3 - state border of Republic of Serbia and Hungary,
- Phase 2- reconstruction of TS Subotica 3, construction of a new 400 kV double transmission line TS Sombor 3 - TS Novi Sad 3 and construction of a new 400 kV double transmission line TS Sremska Mitrovica 2 - TS Beograd 50.

Distribution System

The development of the distribution part of the network should include a number of projects that will have a positive impact on the reliability, quality and security of electricity supply for all customers. Emphasis in all activities, among other things, must be given to increasing energy efficiency, where one of the priority measures is the reduction of distribution losses of electricity. Projects regarding the electricity distribution can be divided into two groups:

1. **Construction and reconstruction projects of electric power facilities,**

These are, above all, projects of construction and reconstruction of TS 110/X kV, TS 35/H kV and both 35 and 10(20) kV lines, along with projects of replacement of old and construction of new TS 10(20)/0.4 kV .

Increasing the capacity of the distribution network will enable the smooth connection of new users to the network, the quality of electricity supply will increase by reducing the number and duration of failures, the voltage conditions for users of the distribution system and the stability of work will improve, as well as the reliability of power facilities. Also, these projects envisage the replacement of old transformers with new ones, with reduced losses, which will further contribute to the reduction of technical losses of electricity. In addition, all these measures will ensure the reduction of technical losses of electricity, maintenance costs by installing equipment and materials with new technological solutions, as well as business costs through the modernization and automation of facilities. Finally, the construction and reconstruction of existing facilities in the distribution part of the network will create an opportunity for the installation of more environmentally friendly materials, which will have a positive impact on the ecological issues in the country.

2. **The project of advanced management of the distribution network**

This project includes the automation of the medium voltage network, the replacement of electromechanical meters with smart meters and the implementation of an integrated system for remote monitoring, diagnostics and management of the low voltage distribution network. The goal is to improve the existing distribution network management system in the coming period and lay the foundations for the application of new technological solutions.

Automation of power facilities, primarily medium voltage distribution networks - automation of medium voltage distribution networks will ensure more reliable and better quality electricity supply, remote management of the network, faster localization of faults and their repair. In addition, the automation of the distribution system will generally enable a significant reduction of losses, which will affect the possibility to connect to the distribution system as many RES as possible.

The implementation of economically justified forms of advanced measuring systems - involves the procurement and replacement of classic measuring devices with modern electronic measuring devices that have the ability to communicate (smart meters), as well as the procurement and establishment of systems (software and hardware) for their reading, management and data collection. In addition to consumption management, maximum load monitoring and the possibility of flexible pricing, the advantages of such a system are also improvements in the integration of RES, greater energy efficiency and better quality of electricity supply.

Table 6 shows the assessment of the financial resources needed for the realization of the main goals in the electric power sector until 2040.

Table 6: Assessment of the financial resources needed for the implementation of projects in the power sector[17]

Subfield	Activity	Investment (million EUR)
Revitalization of all hydro units in HPP Đerdap 2	Revitalization of all hydro units in period 2025 – 2037, increasing the capacity of each unit from 27 MW to 32 MW	213
Revitalization of HPP Vlasinske	Revitalization of all hydro units in period од 2025 – 2028, increasing the capacity of each unit by 2 MW	77.50
Adaptation and investment maintenance of HPP Bistrica	Adaptation and investment maintenance of hydromechanical, mechanical and electrical equipment, without increasing its capacity	36.1
Construction of HPPs	Construction of HPP on river Ibar(121 MW)	350
	Construction of HPP on river Morava (146 MW)	400

[17] Investments for the Kostolac B3 project are not shown in the table.

	Construction project of the Hydro Electric Power System of the Upper Drina (212 MW – share of JSC EPS 51%)	529 (share of JSC EPS 265)
Construction of a new unit with revitalization of the existing ones at HPP Potpeć	Revitalization of the existing three aggregates (with a total increase of the installed power of these aggregates by 6 MW) and the construction of aggregate number 4 in HPP Potpeć (14 MW)	65
Contruction of wind farms (3.2 GW)		4,480
Contruction of PV plants (7.3 GW)		8,760
Contruction of PHPP	PHPP Bistrica (628 MW)	1,100
	PHPP Đerdap 3 (1,800 MW)	1,400
Transmission network	Construction and reconstruction of the internal 400, 220 and 110 kV network	439.81
	Completion of the first phase of the Trans-Balkan Corridor	144.4
	Implementation of the BeoGrid 2025 project	81
	Construction of the Pannonian Corridor	108.5
Distribution network	Construction and reconstruction of distribution network	492.5
	Automation of medium voltage distribution network	144
	Replacement of electromechanical meters with smart meters	505
	Integrated system for remote monitoring, diagnostics and management of the low voltage distribution network	80
	Relocation of measuring points to public areas for unhindered access	511
Coal-fired thermal power plants	Revitalization of thermal units, together with projects in the field of environmental protection (desulfurization, reduction of nitrogen oxides, reconstruction of electrofilter plants and purification of waste water)	1,570
Gas-fired power plants	Construction of gas-fired CHP Novi Sad	400
	Construction of gas-fired CHP Niš	250
Total		**21,872.81**

Note 1: The prices for the construction of wind power plants and solar power plants are taken on the basis of current average prices for different subtypes of power plants, bearing in mind the expectation that these prices will decrease in the future. The costs shown in the table are predominantly borne by the investor, but there are also costs related to subsidies. The ratio of these costs will depend on the regulation that will follow this sector.
Note 2: The costs of investment maintenance of thermal power plants and other facilities until the end of the exploitation cycle.

Heating Sector

Objectives	➢ Secure and efficient supply of heat energy ➢ Energy efficiency improvement in heat production, distribution, and use	➢ Increasing the use of RES and waste heat	➢ Long-term sustainable business of energy entities	➢ Harmonization of the institutional and improvement of the regulatory framework
Measures	➢ Preventive maintenance, rehabilitation and modernization of the district heating system ➢ Use of highly efficient cogeneration plants	➢ Cessation of the use of coal and oil derivatives	➢ Approval of tariffs according to the request according to the justified costs ➢ Introduction of energy management system in accordance with Law on Energy Efficiency and Rational Use of Energy	➢ Defining the national and local level of competence in performing energy activities of production, distribution and supply of heat (enacting a special Law on Heat Energy); ➢ Developing a control mechanism for the adequate application of the law ➢ Increasing national and LSUs capacities in the heating sector
	➢ Use of heat storages ➢ Transition to low-temperature operating modes ➢ Transition to a 24-hour mode of heat supply ➢ Use of heat pumps ➢ Subsidies and grants ➢ Public – private partnership			
Indicators	➢ Efficiency of the production and distribution system ➢ Specific heat consumption	➢ Share of heat produced from RES and waste heat	➢ Profitability of energy company	➢ The share of households connected to DHS ➢ Specific heat consumption
Stakeholders	➢ Producers, distributors and suppliers of heat energy ➢ End customers			

The production of heat energy (in heating plants, thermal power plants and autoproducers) in the Republic of Serbia is mainly based on fossil fuels. The share of renewable energy sources (biomass and biogas) in the production of heat energy in 2021 was only about 1.8 %, and as a positive trend in the ecological sense, the increase in the use of natural gas compared to other fossil fuels can be emphasized. However, a high share of natural gas in the production of heat energy is not good from the aspect of energy security, especially since its import is tied to only one source of supply (Russia).

Some of the key, observed problems in the part concerning the district heating system (DHS) include the relatively high average age of the production and distribution systems, the relatively high specific heat consumption and the absence of a heat energy market. The growth rate of the number of newly connected heat energy customers is relatively low, and the transition to charging for heat energy according to consumption in residential and commercial space has not been implemented in all SDGs.

The district heating sector needs to respond to all the changes and challenges brought by the energy transition. For the sake of safe and reliable supply of heat energy to consumers, it is necessary to ensure permanent modernization of production and especially distribution systems, so that heat energy losses are reduced to a level comparable to the most advanced systems in EU countries (Denmark, Sweden, etc.). The system transformation of the DHSs should be implemented in accordance with the concepts of the 4th and 5th generation district energy system. It is necessary to carry out cross-sectoral connections of DHSs, electric power, and gas distribution systems, and also to provide appropriate professional staff for the realization of strategic goals.

By rehabilitating the existing distribution system and reducing losses by replacing worn-out sections with the installation of pre-insulated pipes, the sector can create significant potential for the growth of new customer connections. In this sense, it is particularly important to work on the planned development of the distribution network so that it follows the planned urban development of cities/municipalities. At the same time, an integral part of the urban planning process should be the strict separation of DHS's zones from zones with individual heating. With the development of better communication with potential buyers of heat energy in densely populated urban areas and billing of heat according to measured consumption, this would significantly contribute to the increase in the number of heat energy customers. It is estimated that in the period until 2040, the number of connections to DHSs can be increased by 15 to 25% compared to the current situation.

District heating systems play a significant role in protecting the environment and improving air quality in urban areas. Shutting down individual solid and liquid fuel burners and switching consumers to district heating from centralized systems with highly efficient energy production from gaseous fuels (natural gas, biogas, landfill gas, potentially hydrogen) significantly reduces local pollution. A particularly positive effect of the district heating system on air quality is achieved by using RESs that are not based on combustion processes (solar energy, geothermal energy), and electric heat pumps.

In order to harmonize with the development of the electricity sector, during the period of implementation of the Strategy, there could be a withdrawal from the use of thermal energy capacities that supply certain cities with heat energy (Obrenovac, Požarevac, Lazarevac). It is necessary to ensure the supply of heat energy to consumers by making maximum use of locally available RES and waste heat for base load, and natural gas for peak load.

The planned process of introducing RES in SDG should include smaller production capacities that use fuel oil and coal (Bajina Bašta, Priboj, Kosjerić, etc.), where the use of locally available biomass is mainly planned. In the case of medium-sized heating plants that use coal (Kruševac, Bor), but also systems that are dominantly based on the use of natural gas (Novi Sad, Belgrade, Niš, etc.), considering the required amounts of energy, biomass as RES is less convinient, and the emphasis is on the use of large heat pumps, municipal waste (Belgrade, Novi Sad, Niš) and solar energy (Novi Sad), that is on the combination of different heat sources and heat storages in so-called “smart heating network”. Heat pumps are especially important for DHSs to enable the utilization of heat that could not be used in any other way (locally available waste heat from industry, service processes, sewage systems, wastewater treatment systems, surface water, etc.). The goal, for the next decades, especially in the bigger DHSs, is the integration of different RES and waste heat-based energy sources, daily and seasonal heat energy storages, as well as a so-called “smart electricity grid “connected with local, RES-based electricity production, in the way to provide optimal “green mix” for heating and cooling of cities (Figure 18).

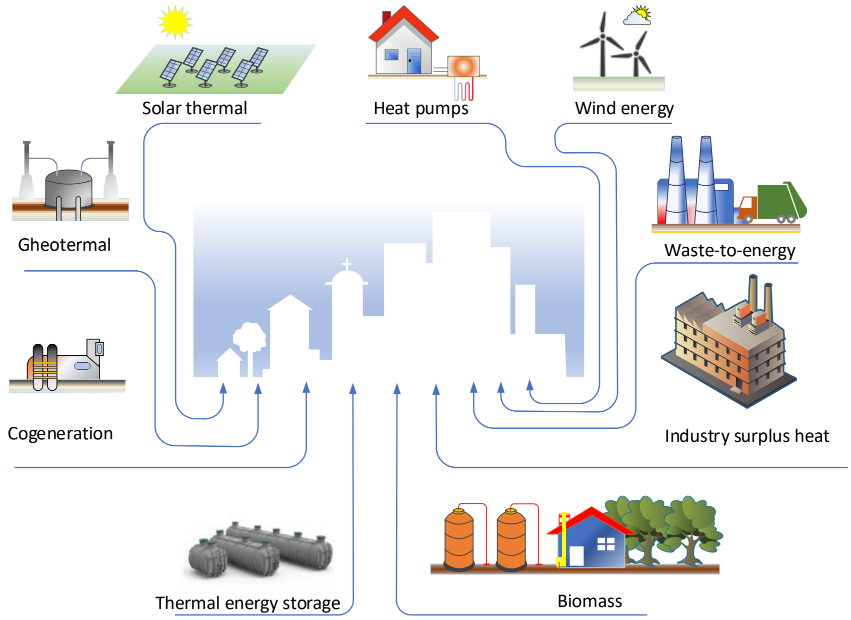

Figure 18**: Integration of highly efficient heat energy sources and renewable sources of electrical and heat energy in district heating (and cooling) systems**

Figure 19 shows the expected changes in the structure of energy sources used for the production of heat energy until 2040.

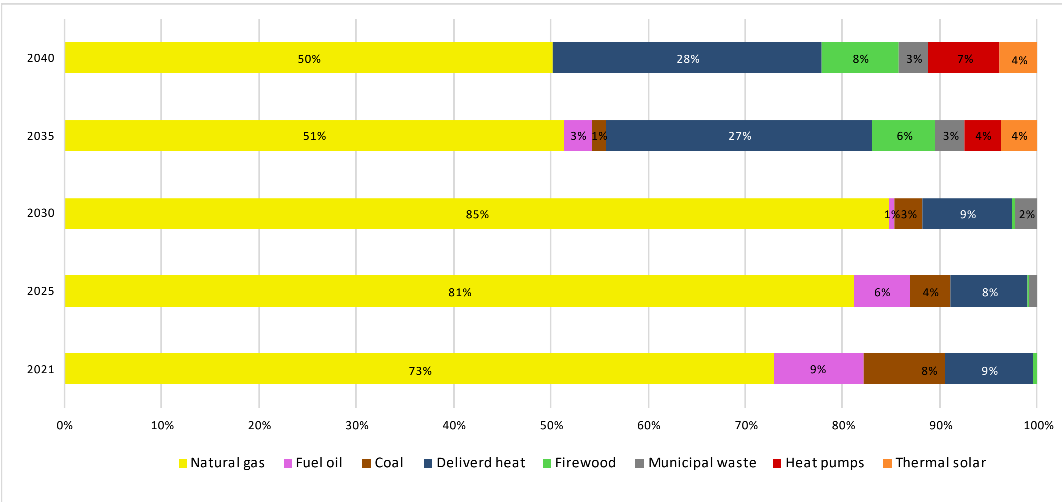

Figure 19: Projection of changes in the structure of sources for the production of heat in DHSs, 2021-2040.

In order for the aforementioned transformation to be possible, it is necessary to ensure appropriate changes in the regulatory and institutional framework. The division of responsibilities between the local and national levels in the heat energy sector and the treatment of the activity of supplying heat energy as a communal activity, often leads DHS and customers of heat energy to confusion in the application of legal solutions (with regard to the possibility of connection in certain zones of municipalities/cities and associated connection costs, suspension of heat energy delivery and disconnection from DH network, application of the Methodology for determining the price of heat supply to the end customer, incentive measures for the use of RES in heat production, improvement of the energy properties of buildings, etc.). Adopting a special Law on Heat Energy would avoid the dispersion of regulations dealing with heat energy and would create a legal framework for the development and regulation of local heat energy markets.

Strengthening the capacity of local self-government units implies, in addition to the permanent education of existing energy managers, and the organization of a special department for energy with appropriate professional capacities for creating local energy policy. Energy departments in local self-government units would work on the development of the heat energy market, creating the so-called "low-energy cities" and achieving a sustainable supply of heat energy that makes maximum use of locally available renewable energy sources. This department should enable the exchange of experiences, the improvement of practical knowledge and the implementation of joint projects related to heat energy, which include a wide range of interested parties-from consumers and producers of heat energy, to equipment suppliers, experts, the academic community, the non-governmental sector, etc.

The currently most applied flat-rate billing system for heat energy is economically unacceptable from the point of view of both heat energy buyers and DHS, because it does not clearly reflect the costs incurred in the production, distribution and supply of heat energy. As soon as possible, it is necessary to strictly apply the Methodology for determining the price of the supply of heat energy to the end customer at all DHSs for all groups of customers, and in accordance with the Law on Energy, it is necessary to ensure the realization of the control function of the Ministry in charge of energy affairs in its implementation. In order to facilitate this process, in parallel with it, for buildings with extremely high specific consumption, a feasibility analysis of energy rehabilitation measures should be conducted and, accordingly, dedicated support programs should be developed. Strict implementation of the billing system according to the measured consumption of heat energy will lead to more efficient use of heat energy and will be a stimulus for the wider application of energy efficiency measures, both on the consumption side and on the production and distribution side of heat energy. In parallel with this measure, the establishment of a social protection program for vulnerable customers will enable “social policy” to be moved out of the energy sector.

Table 7 shows the assessment of financial resources needed for the implementation of projects in district heating systems until 2040.

Table 7: Estimation of investments in the heating sector

Activity	Investment (Million EUR)
Reconstruction, modernization and construction of production systems	390
Revitalization and construction of distribution systems	295
Revitalization and construction of heat substations	75
Total	**760**

RES Sector

Objectives	➢ Greater use of RES for electricity production	➢ Greater use of RES for heat production	➢ Greater use of RES in transport
Measures	➢ Financial and other incentives for the development of RES capacities (water, wind, solar energy, etc. ➢ Informing and educating the public ➢ Simplified and fast procedures for customer requests to move to the prosumer category ➢ Increasing the energy efficiency of the network	➢ Financial and other incentives for the development of RES capacity for heat production	➢ Providing the necessary infrastructure ➢ Adjustments of the electrical distribution network for the electromobility ➢ Intensification of national incentives for the mass use of electric vehicles
Indicators	➢ Share of electricity produced from RES in the total electricity production	➢ Share of produced thermal energy from RES in the total heat production	➢ Share of RES in transport
Stakeholders	➢ Producers, transmission system operator, distribution system operator, suppliers, market operator ➢ End customers		

The Republic of Serbia has significant potential of renewable energy sources for the electricity and heat production, as well as for use in transport.

The use of RES, especially wind and solar energy, for the electricity production is a basic assumption of the energy transition. Therefore, the focus of the Strategy is the intensification of electricity production from these sources. With the use of hydropower potential, it is the basis for the gradual decarbonization of the electricity sector and the expected discontinuation of the use of coal for the production of electricity by 2050.

Considering the great interest of the public in small hydropower plants, it is important to note that the most economically favorable locations have already been used and they will not play a significant role in the overall development of RES.

Of the other RES for the electricity production, the potential of biomass should not be neglected, primarily biogas from agricultural and industrial production, as well as municipal waste, landfill gas, etc. In addition to the energy importance, the planned facilities are also of great importance from the aspect of solving environmental problems of disposal of municipal and other, renewable waste from agricultural and industrial production.

Capacities for the electricity production from renewable sources are presented, by year, in Figure 20, while Figure 21 shows the expected annual production of electricity from these sources.

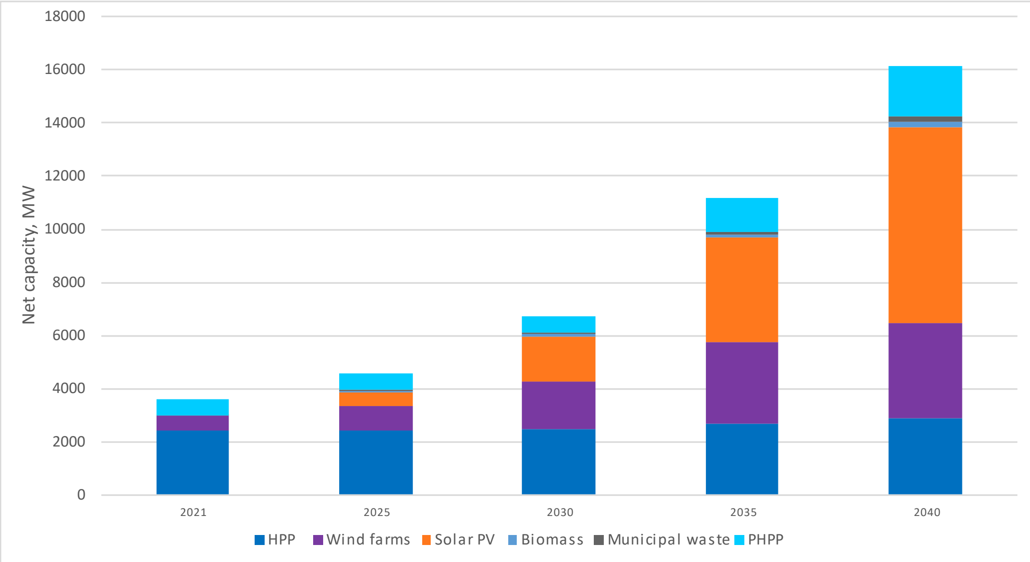

Figure 20: RES capacities for electricity production until 2040[18]

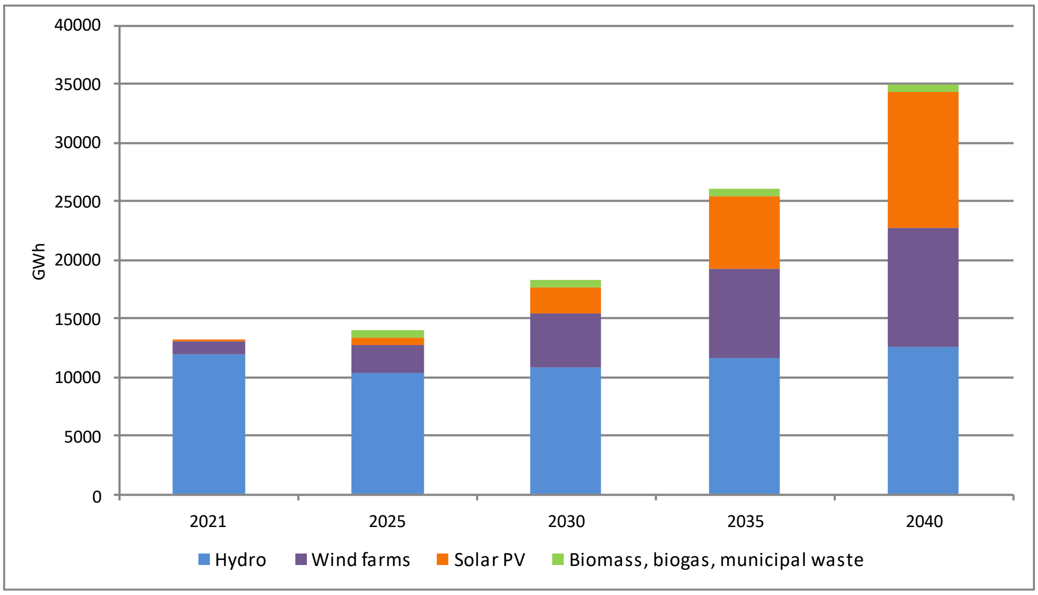

Figure 21: Expected electricity production from RES until 2040

In the proposed scenarios for the development of the electric power sector, the optimization of the structure of renewable energy sources was carried out in such a way as to ensure the necessary level of balance capacities while maintaining the energy independence of the electricity supply. In this regard, it is important to keep the ratio of the installed power of wind power plants and solar power plants close to optimal due to their complementarity in production. The spatial dispersion of wind and solar power plants should be insisted upon in order to mitigate the impact on the system due to changing weather conditions.

The transition to more intensive use of RES for electricity production involves a series of technical problems in power systems, both in the operational planning of the system and in terms of maintaining the power quality. The strategy envisages the suppression of electricity production from thermal units. Nevertheless, some of them remain in operational condition and are connected to the

[18] PHPPs do not represent classic production capacities, but are used as balance reserve capacities.

power system in order to increase the power and energy reserve in the system, which is of particular importance for the stability of the system in conditions of intermittent production of electricity from renewable sources. However, to ensure stability, it is necessary to build new balancing capacities – pump-storage hydropower plants. In addition to the existing PHPP Bajina Bašta, it is necessary to implement PHPP Bistrica project by 2032, while PHPP Đerdap 3 should also be connected to the transmission network by 2040.

A significant resource for ensuring system flexibility is a flexible demand. Study research shows that the resources of flexible demand in the residential sector in the Republic of Serbia amount to about 25%, which is a significant potential for balancing daily variations in RES production. This resource is of particular importance for balancing the excess energy produced in rooftop solar systems. Additional capacities for ensuring the flexibility of the system can be batteries that are connected to the grid via energy converters and are used for daily/weekly energy storage.

An increase in the use of renewable energy sources (RES) in the electricity production will be accompanied by a significantly higher use of RES in heat production. Decarbonization of the power sector enables the application of heat pumps in heating plants, households and the public and commercial sector to gain its full meaning. In order for the effect of their application to be maximal, it is necessary to insist on using the geothermal potential of petrogeothermal sources at shallower depths and ambient heat. This is especially important for individual consumers, outside DHS, who currently use coal and fuel oil for heating, as well as inefficient systems with firewood and electricity. Incentive measures should help the energy rehabilitation of their buildings and the installation of heat pumps.

It is certainly possible to use geothermal energy directly. In addition to the already known potentials related to natural sources of hot water and existing hydrothermal wells, it is necessary to consider and valorize the potentials of abandoned oil and gas wells for the production of heat and/or electricity.

During the projected period, wood biomass retains a dominant share among RES for the heat production. However, the share of certain sectors of consumption is changing. Due to the use of more efficient combustion devices and partial substitution with heat pumps and other forms of RES, consumption in households is decreasing, while consumption in heating plants is increasing. It is necessary to work on improving the biomass market - to introduce quality standards, certification of equipment installers, etc. In order for the use of biomass to be sustainable, it is necessary to work on restoring the forest fund, planting dedicated biomass energy plantations, etc.

Utilization of the available RES potential from agricultural production, municipal waste, wastewater treatment plants, etc. can be effectively achieved by building biogas plants for the production of electricity and/or heat. It is reasonable to expect the use of biogas in industrial plants and in the public and commercial sectors.

The construction of a large solar thermal plant in the district heating system in Novi Sad should be a significant impetus for the use of smaller solar systems for hot water preparation and heating in households and commercial buildings.

Figure 22 shows the structure of RES use in individual heating systems (households and the public and commercial sector) in the period up to 2040.

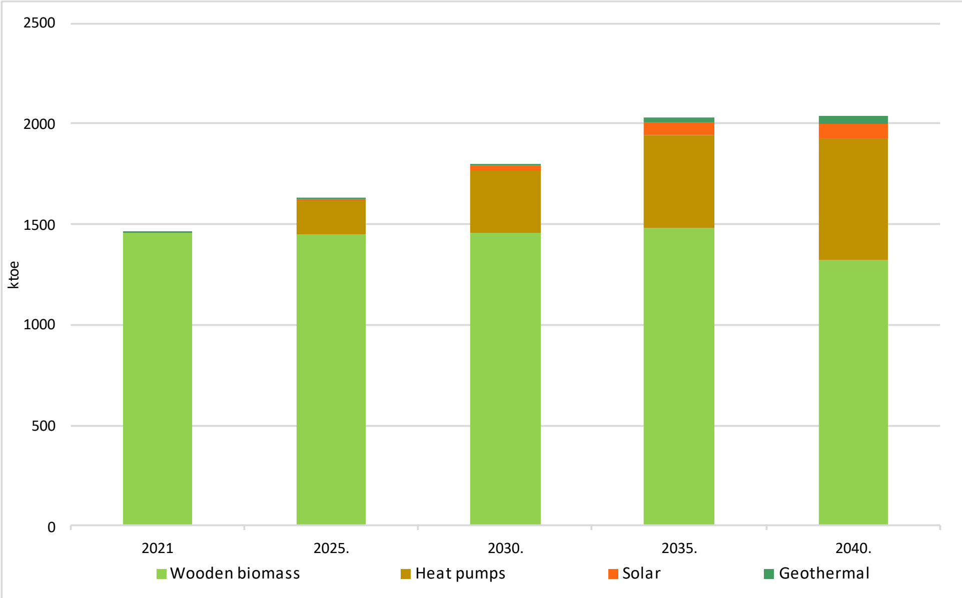

Figure 22: RES for heat production until 2040

Transport represents a very important sector of energy consumption, and the use of renewable energy sources in this sector is of great importance. Renewable energy sources in the transport sector are currently present indirectly, through electricity, that is, the use of RES for the production of electricity. The use of electricity in transport has an undoubted positive effect on the reduction of local pollution, while the effect on the reduction of carbon dioxide emissions depends on the share of RES in the production of electricity. Considering the significant increase in the share of renewable energy production by 2040, further electrification of the transport sector will have a positive impact on the energy and climate goals of the Republic of Serbia. In this sense, the complete electrification of railway transport and public transport in general (metro system in Belgrade, electric buses, etc.) is very important, as well as the expected increase in the use of electric and hybrid vehicles in individual passenger transport.

It is necessary to monitor the trends in the use of RES in the transport sector in the neighboring countries, EU members, and to start the drafting of legislation and the construction of infrastructure necessary for the mass use of electricity in the transport sector, in accordance with adequate changes in the power sector. The potential of the Republic of Serbia for the production of second-generation biofuels is relatively modest, so this sector cannot be significantly decarbonized based on domestic production. Given the expected large production of electricity from renewable energy sources, the potential for the production of hydrogen that would be used in transport exists.

According to the Law on the Use of Renewable Energy Sources, incentives for the production of electricity from renewable sources are implemented in a certain incentive period through the system of market premiums and the system of feed-in tariffs and refer to the price of electricity, the assumption of balance responsibility, the right to priority access to the system and others incentives prescribed by law. The market premium is a type of operational state aid that represents an addition to the market price of electricity that users of the market premium deliver to the market and which is determined in eurocents per kWh in the auction process. Feed-in tariff is a type of operational state aid that is granted in the form of an incentive purchase price guaranteed per kWh for electricity supplied to the power system during the incentive period and can only be acquired for small plants and demonstration projects. Both mentioned incentive systems refer exclusively to newly built or reconstructed power plants, and incentives can be acquired for all or part of the power plant's capacity. In the thermal energy sector, it has been specified for which type of renewable energy sources incentives can be obtained (heat pumps, biomass, solar energy, geothermal energy), while in the transport sector, conditions have been created for the allocation of incentives for the production of advanced biofuels. The incentive policy needs to be further developed and improved in accordance with the practice in EU countries, but taking into account national specificities and the potential of individual RES.

Table 8 shows the assessment of financial resources needed to achieve the goals in the RES sector until 2040.

Table 8: Assessment of investments in RES

Subsector	Investment (million EUR)
RES in electricity production	17,146.6 Shown in the Electricity sector
RES in heating and cooling	867 Shown in Heating sector and Energy efficiency sector
RES in transport	30
Total RES	**18,043.6** Includes investments in several sectors

Energy Efficiency

Objectives	➢Improvement of energy efficiency in all consumption sectors
Measures	➢Financial incentives for the purchase of energy-efficient devices and technologies in all consumption sectors ➢Continuous improvement of the regulatory framework and its alignment with EU regulations regarding energy efficiency ➢Strengthening the capacity of all institutions involved in the implementation of policies in the field of energy efficiency ➢Improvement of regulations related to the energy properties of buildings ➢Application of "green procurements" that set requirements regarding energy efficiency in the public and commercial sectors ➢Application of the energy management system in the field of industrial energy, public sector energy and buildings ➢Compliance with the new EU standards for vehicle emissions and transition to more efficient vehicles ➢Improvement of the system for monitoring and tracking the consumption and saving of final energy ➢Informing and educating the public ➢Conducting energy audits and energy efficiency measures
Indicators	➢Primary energy consumption ➢Final energy consumption
Stakeholders	➢All consumption sectors (households, public and commercial sector, transport, industry, etc.)

The revised Energy Efficiency Directive (EU) 2023/1721, which was adopted in July 2023, reflects the high importance the EU attaches to energy efficiency. The directive establishes the principle of "Energy efficiency first" as a fundamental principle of EU energy policy, emphasizing its central role in the creation and implementation of energy policies, and decisions on investments in it. The strategic determination of the Republic of Serbia to implement energy efficiency measures is one of the basic prerequisites for a successful energy transition towards a safe, reliable and environmentally acceptable form of energy and energy supply. The potential for increasing energy efficiency exists in all consumption sectors. The optimal scenario of development and increase in energy efficiency in all sectors of consumption can contribute to the reduction of final consumption compared to the continuation of current practice (BAU scenario) of about 930 thousand toe by 2030, that is, over 2 million toe by 2040. The structure, by consumption sector, is shown in Figure 23.

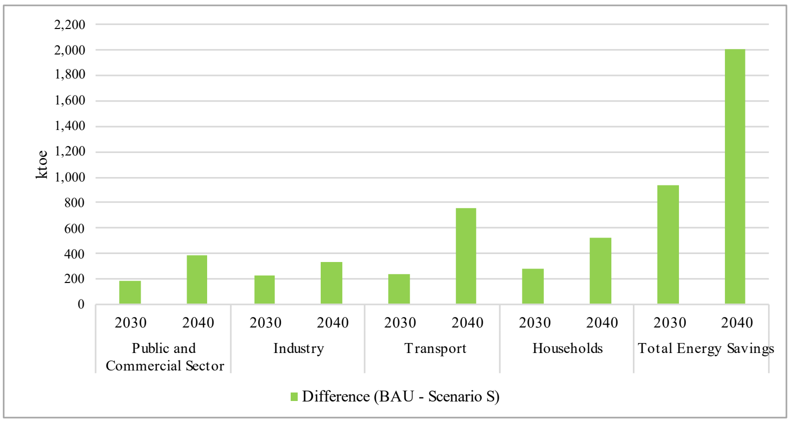

Figure 23: Evaluation of final energy savings in the case of intensive application of energy efficiency measures and energy development according to Scenario S compared to the BAU Scenario

Energy consumption in households accounts for more than one third of the final energy consumption in the Republic of Serbia. In this sector, more than 70% of energy is used for space heating and hot water preparation. For this reason, a key factor in improving energy efficiency in households should be measures related to the improvement of the thermal properties of housing infrastructure and the application of more efficient heating systems. Energy renovation of buildings (reconstruction/renovation of roofs and facades, installation/replacement of insulation, replacement of windows, etc.) can significantly contribute to reducing the required energy used for heating, both in single family houses and in residential buildings intended for collective housing. Regulations concerning the construction and reconstruction of buildings must be permanently harmonized with the EU legislation in this area, especially with the one concerning the so-called nearly zero-energy buildings (NZEB) and zero-emission buildings (ZEB).

About half of households in the Republic of Serbia use solid fuels (coal and firewood) for heating, and most of these fuels are burned in old and inefficient furnaces and boilers, with a very negative effect on the environment. Therefore, the Strategy proposes to completely abandon the use of coal for heating in urban areas by 2040 and switch to more efficient devices for burning biomass and other heating technologies (heat pumps), which are more efficient and cleaner. In order to achieve this goal, it is necessary for the state and local governments to provide appropriate incentives that would speed up the process of device replacement.

Saving energy in households is also achieved by replacing existing home appliances with devices of higher energy efficiency and by correcting the daily habits of the population. With the adoption of the Regulation on eco-design[19] and the Regulation on energy labeling of products that affect energy consumption[20], based on the Law on Energy Efficiency and Rational Use of Energy[21] (ZEERUE), regulatory conditions were created in the Republic of Serbia for placing on the market only products that meet the minimum energy criteria efficiency, as well as the promotion of products that are the most efficient. For the full implementation of these regulations, it is necessary to pass all the necessary regulations, as well as start the process of their implementation. At the same time, this process must be accompanied by the process of building capacities for their application, as well as the implementation of educational campaigns for all interested parties, including the general public. In this way, at the moment when the full implementation of the adopted regulations begins, all actors will already be trained.

Improving energy efficiency in the public-commercial sector is one of the essential prerequisites for successful promotion of energy efficiency. The public sector should set an example for the successful implementation of projects and the application of energy efficiency measures. In addition to the introduction of the energy management system as a key policy measure for the implementation of projects of thermal reconstruction of buildings and the introduction of more efficient heating/cooling systems, it is necessary to work on promoting activities such as the so-called green procurements, as well as procurements with requirements regarding energy efficiency, modernize the public lighting system, etc.

[19] Regulation on eco-design of products that affect energy consumption (Official Gazette of RS No. 132/2021)
[20] Regulation on energy labeling of products that affect energy consumption (Official Gazette of RS No. 21/2023)
[21] Law on Energy Efficiency and Rational Use of Energy (Official Gazette of RS No. 40/2021)

For the improvement of energy efficiency and energy saving in industry, the application of the energy management system is of the greatest importance. Through the systematic management of energy and energy flows, the introduction of new, more energy-efficient technologies, the reconstruction of existing installations and equipment, the use of waste heat from plants and production processes and renewable sources for the production of electricity, heating and cooling, significant energy savings can be achieved that contribute to overall efficiency functioning of the industrial entity. Along with the development of the energy management system, mandatory implementation of energy audits should contribute to the determination and quantification of economically viable energy efficiency measures for industrial facilities, production processes or services. The implementation of the Energy Labeling Regulation can also greatly contribute to the promotion and inclusion of aspects of energy efficiency and environmental protection in all phases of product development and design.

Considering the high degree of return of financial resources in a relatively short period of time, the industrial sector is expected to make the greatest contribution in terms of reaching the set goal of cumulative savings of final energy, which is provided for in Article 7 of Directive 2012/27/EU (consolidated version), in period until 2030. It should be emphasized here that for the successful realization of the set goal, it is crucial to provide financial mechanisms for encouraging energy efficiency measures in the industrial sector, with a special emphasis on the segment of small and medium-sized enterprises.

In terms of saving energy and reducing the negative impact on the environment, the most important measures to be applied in the transport sector are the application of the latest EURO standards in terms of emissions for new and used vehicles, the rejuvenation of the vehicle fleet, the promotion and stimulation of the use of energy-efficient and environmentally friendly vehicles. type of fuel (biofuels, green hydrogen), electrification of road transport, greater use of rail transport in the transportation of passengers and goods, modernization of water transport infrastructure, as well as the development of intermodal transport. One of the important prerequisites for increasing energy efficiency in the transport sector is the development of infrastructure for supplying vehicles with environmentally friendly types of alternative fuels, as well as infrastructure that will support active forms of transport such as cycling and walking.

Achieving goals in the field of energy efficiency requires the implementation of a large number of different measures in all parts of society and, accordingly, the investment of significant financial resources for measures that are often not possible to finance from one's own sources. Facing these challenges should be facilitated by a wide range of financial support for these purposes - income from the budget based on energy efficiency fees, loans, funds from the European Union, multilateral and other international funds, public-private partnerships, ESCO companies, and other available financial instruments. The largest part of the mentioned funds should be channeled through the Directorate for Financing and Encouraging Energy Efficiency (EE Directorate), which was established in 2021 according to ZEERUE. For the successful preparation and implementation of energy efficiency projects in all segments of consumption, the EE Administration should ensure the wide availability of incentives for the implementation of energy efficiency measures and efficient management of available funds. Therefore, work must be done to strengthen the capacity of the EE Administration through, among other things, support for its accreditation for the use of EU funds and other funds and consideration of the possibility of improving its legal status, which would enable the application of various financing mechanisms and the unification of all available public financing streams into one fund.

Efficient use of energy and improvement of energy efficiency should also contribute to the reduction of energy poverty, which is the result of a combination of low household income, high consumption of income on energy and insufficient energy efficiency. It is mainly about households that live in residential buildings with poor energy performance. Due to lack of financial means they use use low-quality solid fuels for space heating and hot water preparation. That is why it is necessary to prepare and continuously implement special programs for the implementation of energy efficiency measures for energy-dangerous and other customers in order to reduce energy poverty, and above all to support the thermal modernization of residential units and the active use of renewable energy sources.

An established system of adequate monitoring of achieved savings and relevant statistical data is an essential prerequisite for continuous improvement of energy efficiency. By looking at the effects of the applied measures and comparing them with other countries in the environment, a realistic picture of the achieved level of energy efficiency is obtained, as well as measures that give positive results, so that they can be stimulated for further application and areas in which it is necessary to intensify their application. An important step in monitoring energy savings has already been made through ZEERUE by defining the appropriate methodology for calculating savings, as well as establishing supporting information systems.

All energy efficiency measures must be accompanied by constant information and education of the public in order to raise awareness about the importance of rational use of energy and knowledge about the potential of savings through the use of more energy efficient devices and technologies. It is essential that this activity covers all target groups, taking into account gender equality and non-discrimination (eg campaigns and information materials prepared in minority languages, adapted to girls and boys, women and men, persons with disabilities, etc.). The mentioned activity should be implemented through information campaigns, trainings at different levels of education, including the introduction of relevant subjects into the compulsory education system, by organizing seminars, workshops and lectures.

Table 9 shows the estimation of financial resources needed for the realization of goals in the energy efficiency sector until 2030.

Table 9: Estimation of investments in the energy efficiency sector

Subfield	Investment (million EUR)
Financing programs for the renovation of the construction fund	4,328.8
Installation of solar systems in new buildings and buildings that are being renovated	636.7
Promotion of energy-efficient devices in households	1,493.8
Financing programs for the modernization of highly efficient cogeneration and district heating and cooling systems	35.0
Financing programs for the energy improvement of street lighting	1,668.8
Incentives for the energy efficiency of passenger and light vehicles	4,373.2
Incentives for the energy efficiency of freight transport	1,596.0
Incentives for the energy efficiency of railway transport	255.8
Improvement and expansion of public transport infrastructure	505.4

Incentives for energy efficiency in the industrial sector	3,366.0
Incentives for energy efficiency in the agriculture sector	2,678.0
Total	**2,937.5**

Natural Gas Sector

Objectives	➢ Secure supply of the required amount of gas	➢ Development of the natural gas market	➢ Diversification of supply sources and directions of supply
Measures	➢ Increasing existing gas storage and building additional ➢ Interconnection with neighbor transport systems ➢ Preventive maintenance and rehabilitation of existing main gas pipelines	➢ Gas sector reform ➢ Building of transport and distribution systems ➢ Modernization of measurement system	➢ Interconnection with neighboring transport systems
Indicators	➢ (N-1) infrastructure standard	➢ Share of gas sales in the free market	➢ Import Route Diversification
Stakeholders	➢ Suppliers and public supplier ➢ Transport and Distribution System Operators ➢ Gas storage operator ➢ End consumers		➢ Suppliers and public supplier ➢ End consumers

Import dependency in the natural gas sector in the Republic of Serbia is very high (78,6% in 2021). There have been no significant discoveries of new natural gas deposits in recent years, and most of the existing gas fields are in the final stage of production.

Two scenarios of gas consumption until 2040 are presented in Figure 24. The continuation of existing practices in energy consumption (BAU scenario) leads to a consumption of almost 4.5 billion m^3 in 2040. In the scenario of intensive decarbonization of the energy sector (Scenario S), intensive implementation of energy efficiency measures, and strong growth of electricity production from RESs, annual natural gas consumption is lower. In the structure of consumption, the share of gas used for electricity production increased.

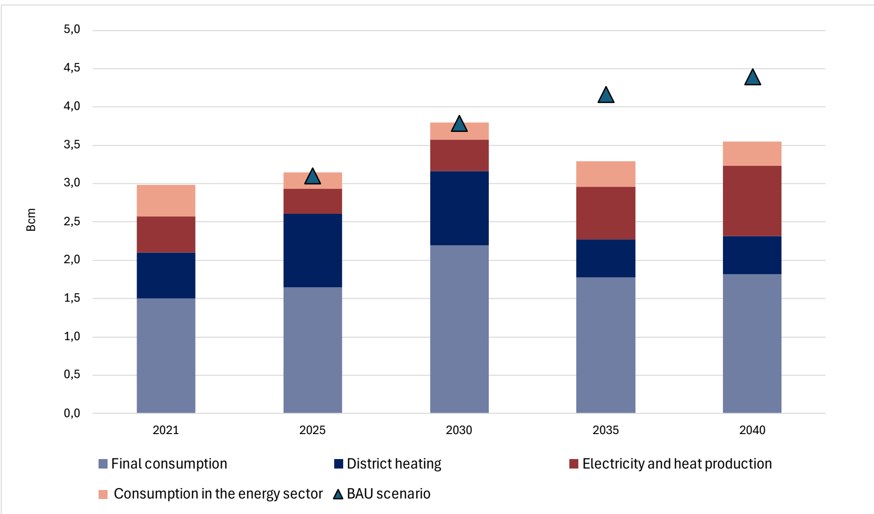

Figure 24: Projections of natural gas consumption in the Republic of Serbia

The construction and start of operation of the gas pipeline (gas interconnector) from the border with Bulgaria to the border with Hungary, and its connection with the transport system of the Republic of Serbia in 2021, have significantly enhanced the infrastructure aspect of national gas supply security. The operation of this gas pipeline fundamentally changed the route of supply and way of functioning of the gas system in Serbia. It provided gas supply from Russian Federation across Bulgaria, together with previously, used for decades, routes across Ukraine and Hungary. The operation of this new pipeline has fulfilled the N-1 infrastructure standard in Serbia. Furthermore, the Republic of Serbia has become a more significant transit country for natural gas, as Russian gas now flows through Serbian territory to consumers in Hungary and Bosnia and Herzegovina.

However, relying solely on one direction of supply has a negative impact on the energy security of the Republic of Serbia. Therefore, a priority is to establish the capability for natural gas supply from alternative sources. By utilizing the Bulgarian route for supplying consumers in Serbia, the full technical capacities of the Horgos entry point can be utilized for gas imports from the European gas network through the Hungarian transport system. Additionally, it is crucial to establish additional interconnections with neighboring transport systems (Bulgaria, Romania, Croatia, North Macedonia, etc.). These interconnections, together with the implemented interconnection with Bulgaria, will enable gas supply from the BRUA pipeline (Bulgaria, Romania, Hungary, Austria), Trans-Anatolian and Trans-Adriatic pipelines, LNG terminals in Greece and Croatia, as well as production fields in Romania.

The supply from various sources (Russia, Azerbaijan, LNG terminals, etc.) will inevitably result in the presence of natural gas in the market with different physical, chemical, and thermodynamic characteristics. Therefore, it is essential to establish appropriate regulations for the intake of this gas into the domestic gas network and to construct refining/blending facilities that will enable the seamless use of this gas in existing devices and facilities.

The aims of increasing the gas storage capacity in the Republic of Serbia include resolving the issue of seasonal uneven consumption, increasing supply security, and providing infrastructure for mandatory gas reserves. Mandatory gas reserves are introduced to ensure full supply to all consumers in the Republic of Serbia in the event of a 30-day complete interruption in gas supply from other transport systems. To meet the requirements for supply security, it is estimated that storage capacities between 1 and 1.5 billion m^3 are necessary. Besides ongoing activities related to increasing the commercial volume of the underground gas storage (UGS) facility in Banatski Dvor to 0.75 billion m^3, it is necessary to consider abilities for further increasing this UGS and construction of new UGS in Vojvodina (Itebej, Tilva, etc.) and central Serbia (Ostrovo, etc.).

Regular monitoring, maintenance, revitalization, further construction, and improvement of the transport system are prerequisites for reliable gas supply. With the completion of the interconnection with Bulgaria (Dimitrovgrad-Niš gas pipeline), the initiation of the project to build an interconnection with North Macedonia, and the connection to the interconnector gas pipeline from the Bulgarian-Serbian border to the Serbian-Hungarian border, the main gas pipeline Niš – Velika Plana – Batajnica provides reliable and quality supply for all consumers in the Republic of Serbia. Given the age of the existing sections of this gas pipeline, it is necessary to conduct a detailed technical assessment of its condition and subsequently perform a techno-economic evaluation of the feasibility of its upgrade and modernization, or the construction of a new gas pipeline along a parallel route. In addition, the construction of transport systems in the western (Valjevo, Loznica), south-west (Novi Pazar, Prijepolje, Nova Varoš, Priboj), south (Vranje), and eastern (Bor, Zaječar, Pirot, Knjaževac, Prahovo) parts of

Serbia will enable gas supply to industries and other consumers such as heating plants, households, and the commercial/public sector in these areas.

Parallel with the development of the transport system, the distribution systems should be constructed and extended, enabling more intensive gas utilization in households, commercial and public sectors. Natural gas is environmentally more acceptable than other solid and liquid fossil fuels. Utilization of natural gas together with the utilization of RES should be part of the pollution reduction in urban areas, particularly during winter months. One of the options in this sense is the use of green hydrogen (obtained from RES) mixed with natural gas in distribution systems.

Natural gas can be efficiently used for combined electricity and heat generation in industries, public and commercial sectors, as well as for electricity production in combined cycle power plants. CHP in Pančevo refinery is the first facility with a combined cycle in Serbia, but the existing transport system and its capacity enable the possibility for the construction of additional facilities at other locations. This possibility should be considered at the locations of coal-fired power plants that will be decommissioned (Morava, Kostolac A), as well as in the larger industrial centers. These facilities could also be considered for biogas or green hydrogen cofiring.

The realization of the planned activities in the natural gas sector is largely dependent on the sector reform process. This reform involves the consistent unbundling of transport, distribution, storage, and supply activities. It is necessary to consider the possibility of changing the management model of the transportation system (transforming from an "independent system operator" to an "independent transportation operator"). Additionally, in the gas distribution sector, it is necessary to ensure the consolidation of existing distribution companies or their merger with other utility companies through regulatory and other incentives, all with the aim of achieving their financial sustainability.

The estimation of investments necessary for the achieving of goals in the natural gas sector until 2040 is presented in Table 10.

Table 10: Estimation of investments in the natural gas sector

Subfield	Activity	Investment (Million EUR)
Interconnections	Romania (Mokrin – Arad) Bosnia and Herzegovina (Inđija - Mačvanski Prnjavor) Croatia (Gospodjinci – Bačko Novo Selo - Sotin) North Macedonia (Vranje - Klećevce)	179
Transport system	Leskovac -Vladičin Han-Vranje Paraćin-Boljevac -Rgotina - Negotin -Prahovo (Bor, Zaječar, Knjaževac) Mokrin -UGS Banatski Dvor - UGS Itebej - Pančevo - Beograd jug Niš -Velika Plana-Batajnica-Horgoš (compressor stations Batajnica and Batočina) Zlatibor – Prijepolje (Nova Varoš, Priboj) Beograd – Valjevo – Loznica MMS Horgoš MMS Loznica MMS Banatski Dvor	1,157

Gas storage	Increasing the capacity of UGS Banatski Dvor and the construction of UGS Itebej	250
Distribution system	Construction of distribution pipelines	216.5
Total		**1,802.5**

Oil Sector

Aim	➢Ensuring a secure supply of oil and oil products that meet EU standards		
Measures	➢Increase of mandatory reserve ➢Construction of missing storage capacities for all types of derivatives that are stored for the needs of mandatory reserves	➢Refinery modernization	➢Construction of oil and oil products pipelines
Indicators	➢Number of days of average consumption secured from mandatory reserves ➢Number of days of average import secured from mandatory reserves	➢Depth of oil processing	➢Construction indicator
Stakeholders	➢Directorate for Commodity Reserves ➢JSC Transnafta ➢End customers	➢JSC NIS ➢Oil traders ➢End customers	➢JSC Transnafta ➢JSC NIS ➢Oil traders ➢End customers

In the oil sector, the import dependence of the Republic of Serbia is very high (75,5% in 2021). The share of indigenous production in meeting consumption demand is relatively low. The oil import is mostly related to a single direction – an oil pipeline from Omišalj terminal (Krk island, Republic of Croatia).

Projections of oil production and consumption in the Republic of Serbia until 2040 are presented in Figure 25. Expected electrification and changes in the consumption structure in the transportation sector after 2030 will result in a significant reduction in oil consumption compared to the BAU scenario.

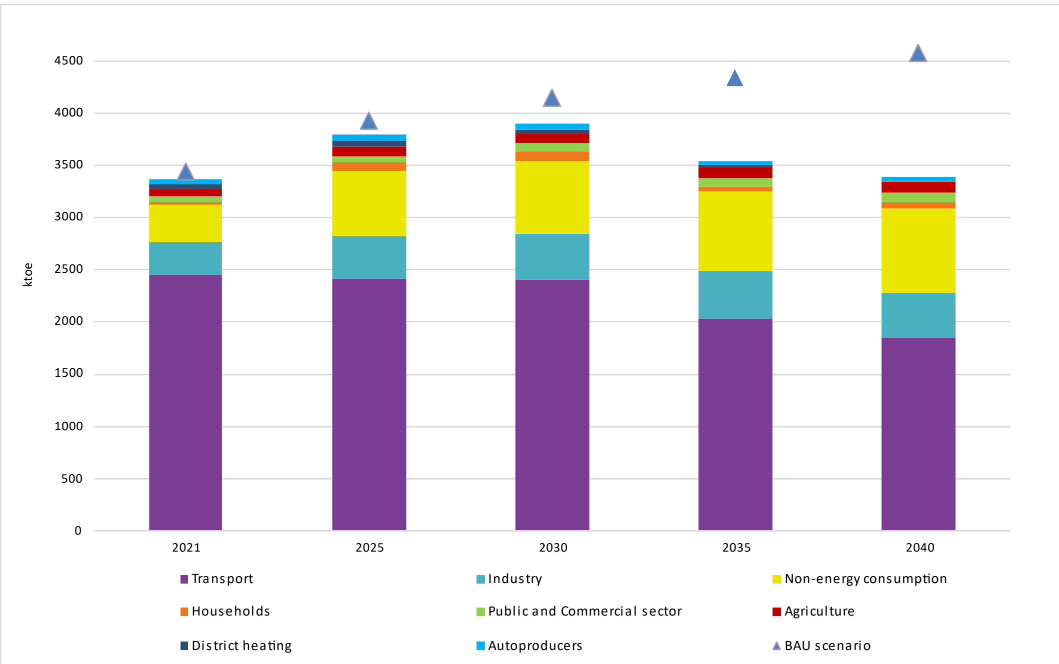

Figure 25: Projections of consumption of oil derivates in the Republic of Serbia

Indigenous oil production in the Republic of Serbia reached its peak in 2013. Since then, it has been experiencing a constant, natural decline. The production level is kept by increasing production from development wells in existing gas deposits and by the implementation of enhanced oil recovery methods at existing wells. The decline in production is expected to be partially offset by discoveries of new deposits. Consequently, new exploration projects will be continued, and the existing production systems will undergo reconstruction and modernization to enhance their efficiency.

To enhance crude oil supply security, during the implementation period of this Strategy, a new oil pipeline to Hungary is planned for connection to the international oil pipeline Druzhba. The new supply route from Hungary means the construction oil pipeline (direction Szazalombatta-Algyo-Roszke-Novi Sad) with an annual capacity of 5.5 million tones per year. The connection with the existing oil pipeline will be established in Novi Sad, enabling oil transportation to the Pančevo Oil Refinery. Potentially, there is also the possibility of expanding this project, which needs to be analyzed in detail. This pertains to the construction of an oil pipeline to Thessaloniki and Durres, in order to enable the supply and transportation of oil in these directions.

Utilization of oil shale, along with biofuels, offers the potential to reduce import dependency in the oil sector. It is necessary to undertake all necessary activities, including assessing the geological, mining, processing, and financial aspects of their exploitation, with a particular emphasis on detailed analysis of environmental impacts.

The oil market in the Republic of Serbia is free, and price regulation only applies to access to oil transportation systems via pipelines. The price of oil derivatives in the coming period will primarily be determined by crude oil prices and refinery margins on the international market, which, although difficult to predict, have a long-term increasing trend.

The increased utilization of alternative fuels (biofuels, hydrogen, etc.), the adoption of electric vehicles in passenger cars, greater utilization of rail transport and public transportation in cities, and the construction of the metro system in Belgrade, along with the implementation of energy efficiency measures in all areas of oil derivatives consumption, will have a significant impact on the production and consumption of motor fuels. Regardless of the expected decrease in the consumption of petroleum-derived fuels for heating and transport, they will still have a significant share in the total energy consumption, as well as in non-energy consumption, i.e. the use of certain oil derivatives as raw materials in the chemical and petrochemical industry, paint and coatings industry, in the construction industry, etc. Therefore, the process of the refinery sector modernization will be continued. The further modernization process of the Pančevo Oil Refinery includes the reconstruction of the catalytic cracking plant and the construction of a plant to produce high-octane gasoline components, further enhancing the value of the refinery products.

The necessary and expected development of the oil sector implies ensuring a regular supply and increasing the security of the supply of oil and oil derivatives following the forecast trend of consumption. For now, in the Republic of Serbia, besides mandatory reserves, there are only commercial and operational reserves owned by oil companies. The goal is to establish storage of mandatory reserves of oil and oil derivatives in the Republic of Serbia by 2027 in an amount corresponding to 90 days of net imports or 61 days of internal consumption (using the higher value). Efforts are being made to ensure physical storage in the territory of the Republic of Serbia, and through option contracts, a certain amount of mandatory reserves in the territory of other countries. Based on the analysis of financial and other indicators of the provision of the required storage capacity, which was carried out in 2023, it was determined that the necessary (missing) storage capacity could be reached in the fastest way and with the lowest expenditure of public funds, through a public-private partnership procedure.

The further development in the field of oil derivatives transport in the Republic of Serbia primarily involves activities related to the construction of an oil products pipeline system (Pančevo – Smederevo – Jagodina – Niš and Pančevo – Novi Sad - Sombor). Compare to the existing transport of motor fuels from the refineries to centers of consumption, this project will enable more efficient transport, reduction of losses, increased security of supply, and reduction of negative impact on the environment.

The estimation of investments necessary for the achieving of goals in the oil sector until 2040 is presented in Table 11.

Table 11: Estimation of investments in the oil sector

Subfield	Activity	Investment (Million EUR)
Oil and natural gas exploration and production*	Exploration in the country with the aim of finding new deposits Application of new technologies and production methods	1,208
Oil refinery processing	Increasing the depth of oil processing and further modernization of Pančevo Oil Refinery	1,097
Mandatory oil reserves	Construction of oil derivative storage facilities (Pančevo, Kovin, Donji Ledinici)	56
Oil derivates market	Modernization of existing and building of new petrol stations Construction of new storage facilities Modernization of main filling stations Procurement of modern transport vehicles	750
New supply routes for crude oil	Construction of oil pipelines to Hungary	156
Pipeline system across the Republic of Serbia	Construction of sections Pančevo - Smederevo and Pančevo - Novi Sad	35
Total		**3,302**

** It is a mining activity, but it is mentioned because of its importance for the work of the energy sector.*

Coal Sector

Goals	➢ Secure and reliable supply of coal to the power generation facilities	➢ Securing the coal in sufficient amount and of required quality for final consumption and generation of heat energy
Measures	➢ Completion of investment cycle at existing open cast mines and opening of replacement coal production capacities ➢ Introduction of integral system for coal quality management	➢ Optimization and concentration of underground coal production in profitable facilities
Indicators	➢ Ratio of achieved and planned investments ➢ Ratio of insufficient quality coal amount at the power plant input and overall coal production ➢ Ratio of achieved and planned amounts of excavated overburden	➢ Ratio of achieved and planned investments in PC UCE
Stakeholders	➢ EPS JSC	➢ PC UCE, EPS JSC, final consumers/buyers

Annual coal production in the Republic of Serbia in previous period was 35-38 million tonnes of lignite, around 400,000 t of coal from underground mines and 200,000 t from underwater production (Kovin). Coal processing encompassed around 400,000 t of dried coal (lignite). Some of the open cast mines (Drmno, Tamnava West Field) are in the full production stage, but some of the planned investments are still not completed (equipment acquisition – bucket wheel excavators and self-propelled belt conveyors, dewatering facilities, and similar). Some of the open cast mines are in the stage of investment construction – replacement capacities (Field E, Radljevo), also with partly completed planned investments where basic equipment is not acquired neither planned infrastructure works and objects are finished. Depending on the selected exploitation scenario and new limitations on the Drmno open cast, it is possible to open West Kostolac open cast mine as a replacement mine for Drmno and quality improvement and additional supplier of TPPNT. Field G is in the final stages of the production and reserves shall be depleted until the beginning of 2026.

Currently, power supply in the Republic of Serbia is strongly dependent on secure supply of coal. Completion of on-going investment cycle shall create preconditions for secure supply of coal to the thermal power plants in the future. Further on, relatively small investments can develop larger generation capacities and coal supply to the power plants. The issue of low lignite quality in some parts of the Kolubara basin shall be solved by selective excavation, homogenization and with introduction of integral management system, as well as by supplying a certain amount of more quality coal from the Kostolac basin. There is also the possibility of coal production from the Novi Kovin mine, whose exploitation capacity is 3 million tons per year.

Planned reduction of electricity generation from thermal power plants will result in gradual reduction of coal production – Scenario S (Figure 26). Since some TPP generation blocks are in reserve and planned only for occasional production, projections of coal energy that can be provided from domestic mines in the case of activation and operation of power plants that should be in reserve are also presented in Figure 26.

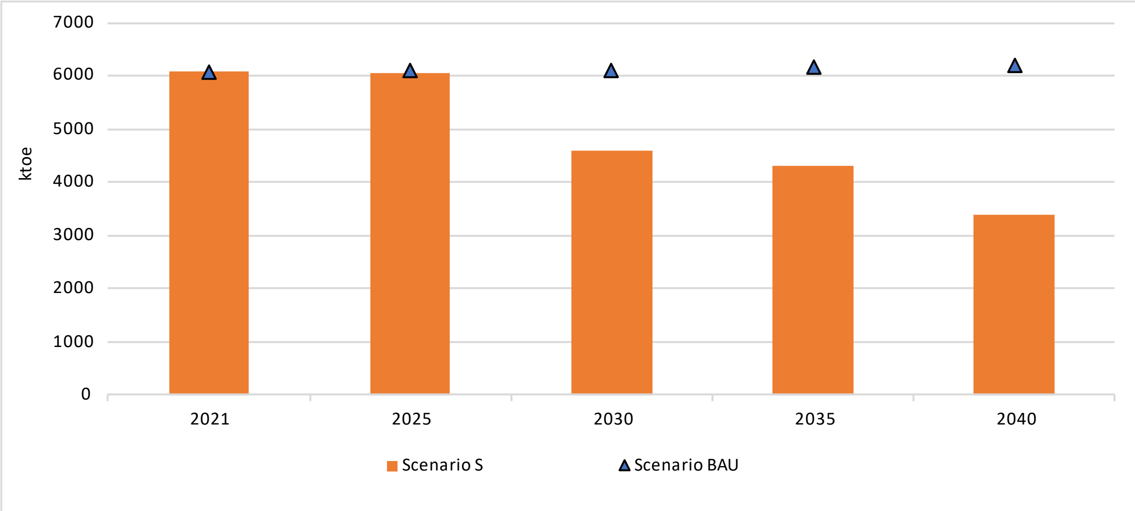

Figure 26: Projection of coal energy for electricity generation

Coal production for final consumption and production of heat energy shall be gradually lowered. Beyond 2040 coal should not be used in households, public and private sectors, including district heating systems. It is estimated that the demand for brown coal and dry lignite will be halved by 2040, in relation to the reference year 2021. Therefore, it is necessary to optimize and rationalize production in underground coal mining, close non-viable mines with almost depleted reserves and invest in viable and profitable mines.

Remaining coal reserves should acquire strategic character, since process of energy transition includes uncertainty to some extent, as well as intermittence and stochastic availability of some renewable sources of energy. It is necessary to make investment in precocious overburden excavation and slope stabilization. Coal prepared for excavation can be considered as strategic reserve for enabling quick commencement of production in critical situations.

Investment estimation for completion of goals in coal sector until 2040 is given in Table 12.

Table 12: Investment estimation in coal sector

Subfield	Activities	Investment (millions EUR)
Construction completion on replacement open cast mines	Open cast mine Field E	600
	Open cast mine Radljevo	300
Completion of updated investment cycle on existing open cast mines	Open cast mine Tamnava West Field	55
	Open cast mine Drmno	370 (190)*
	Open cast mine West Kostolac	453**
Restructuring and rationalization of underground coal mining		60
Total		**1,838 (1,658)**

** Completed Feasibility Study on Coal Exploitation at Drmno Open Cast Mine - Updated. Investments differ in relation to selected designed solution.*
*** Completed Feasibility Study on Exploitation of West Kostolac deposit*

Hydrogen in the Energy Transition

One of the significant problems of the energy transition is securing sufficient so-called “green” energy in the consumption sectors which have a limited capability of using electrical power. Energy consumption in the transport sector, especially by air, water, and freight road transportation, as well as in specific industrial processes, is almost exclusively dependent on using liquid and gaseous fuels. This is why it is essential to develop and use “Power to Gas (P2G)” and “Power to Liquids (P2L)” technologies that allow the production of hydrogen, ammonia, methane, and synthetic liquid fuels (kerosene and diesel) using electric energy derived from renewable energy sources. At the same time, if they are using excess power from renewable sources, these technologies provide the ability to store energy. The key element to the chemical processes that take place in the mentioned technologies is hydrogen.

Nowadays, industrialized production of hydrogen is, for the most part, based on well-known thermo-chemical processes, that use biomass and fossil fuels as raw materials. Natural gas reformation is currently the optimal, the most efficient, and the most used hydrogen production method. The degree of usefulness of reforming is 65-85%. During this process, however, carbon dioxide is emitted. The so-called “green” hydrogen, which is created by water electrolysis using electrical power produced from renewable sources is considered an ecologically clean fuel, from the perspective of carbon dioxide emissions. The degree of usefulness of obtaining hydrogen by water electrolysis is about 70%. Technologies for obtaining hydrogen by splitting water at high temperatures with the help of nuclear reactors and solar power and in development stages. It is possible to produce hydrogen through biological and other processes, but they are of little significance for mass production in their current development stages.

Compared to other gaseous fuels, hydrogen has some pronounced specifics. Compared to other fuels, hydrogen has the highest specific heat capacity per unit mass, but a small heat capacity per unit volume. Hydrogen has very wide flammability limits in the air (4 - 76%) and almost an order of magnitude higher normal laminar flame propagation speed compared to fossil fuels. Therefore, when burning hydrogen, there is an increased risk of flame entrainment in the conditions of a previously prepared mixture with air. Another problem is the harder perceptibility of the flame and the identification of the local release of hydrogen into the environment, as well as its influence on the materials with which it comes into contact. The presence of hydrogen in natural gas increases emissions of NOx. It is necessary to develop dedicated devices for burning pure hydrogen, while for burning mixtures of natural gas, or liquid petroleum gases and hydrogen in a higher percentage, it is necessary to reconstruct the existing devices for burning gaseous fuels.

The storage of renewable energy in the chemical energy of hydrogen provides the possibility for flexibility and robustness of the energy system, as well as better utilization of renewable energy. There are numerous methods for storing hydrogen - from underground storage, similar to natural gas, compression in tanks, liquefaction at low temperatures, introduction into natural gas pipelines, to sorption in new materials. There is research on the possibility of mixing hydrogen with natural gas in pipelines. The problems that might appear with the introduction of hydrogen into conventional gas pipelines are an increase in the risk of fire, aggravating the compatibility of gaseous fuels with the materials they’re in contact with, and increases in the risk of corrosion and potential accidents.

It is possible to use hydrogen in practically all energy systems: in thermal power plants, fuel cells, gas turbines, internal combustion engines, gas appliances for households, and industry (Fig. 29). The use of hydrogen in fuel cells to produce electricity and heat is a commercialized technique. Proton fuel cells are the most common type of fuel cells used in mobile and stationary energy systems and households. The world's leading companies in the field of vehicle and aircraft production agree on the policy of sustainable development in transport, but they do not yet agree on the issue of choosing between electric batteries or hydrogen as energy carriers. It can be assumed that hydrogen will be the primary choice in air, water, and freight road transport.

The possibility of hydrogen application and its importance in the process of transition and decarbonization of the energy sector is great. When this transition will occur and how quickly depends on an entire range of factors - the availability of electricity from RES and the costs of producing "green" hydrogen, the costs of development of transport infrastructure, the cost of procuring vehicles that use hydrogen, the safety of using such technologies, etc.

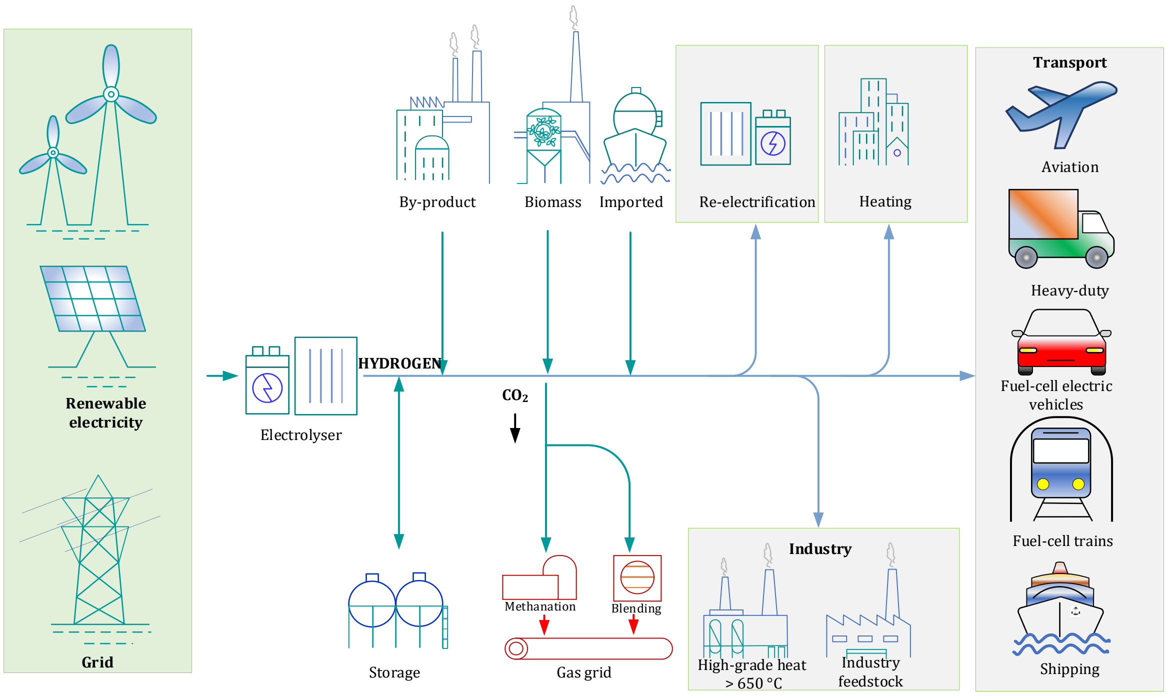

Figure 27: The role of hydrogen in a decarbonized energy system

The current high costs of green hydrogen production limit the possibility of commercial application and do not justify the introduction of large incentives for its production, infrastructure development and application, until the incentives can be reproduced in the domestic economic structure and contribute to its development. It is expected that the development of hydrogen technologies funded by developed countries will lead to lower costs, especially during this decade. This will provide the conditions to support the production and application of hydrogen, with financial assistance and participation in European Union projects or by engaging own resources. These funds will be directed primarily to projects that can mobilize domestic scientific and research potential and other participants in their implementation.

The Republic of Serbia should keep up with the development of the hydrogen transition in Europe - through the establishment of legal regulations, strengthening of technological and scientific research potential in the field of hydrogen technologies, partnership with other countries. Accordingly, the Republic of Serbia should adapt its energy policy to the production and use of hydrogen in time and, following the example of the EU countries, adopt a special strategic document (Hydrogen Strategy) to plan development in this area.

The following can be singled out as priorities in the field of hydrogen transition in the near term:

- Harmonization **of legal regulations**; Legislation regarding the production, transport, storage and use of hydrogen in the Republic of Serbia already exists to some extent, but its significant improvements and additions are necessary. A package of regulations should be adopted that specify the details of the functioning of the market, ensure the implementation of EU law in this area and enable the introduction of a system to encourage the production of green hydrogen with the use of available funds from international funds and donors. In addition to energy, regulations that need to be changed concern construction (planning and construction), safety (fire protection, flammable gases), environmental and climate protection, industry (technical requirements, standardization), transport (road, rail) and others. The new regulations should remove obstacles in the development of the hydrogen market, encourage a gradual increase in the use of renewable energy sources to obtain green hydrogen, and create a regulatory framework for the use of hydrogen as an alternative fuel in transportation. Lower public policy documents need to plan and implement the following activities:
  - Adoption of the appropriate standard for the quality of lead as a gas;
  - Definition of safety standards on hydrogen for production, storage, transport and use (process equipment, transport systems and fire prevention measures);
  - Transposition and implementation of the Directive on infrastructure for alternative fuels (2014/94/EU) - in the part of hydrogen application in transport;
  - Introduction of financial, customs and tax benefits, guarantees of origin and facilitation of administrative procedures in areas directly and indirectly related to the production, transport, storage and use of hydrogen;
  - Harmonization of data monitoring in the field of hydrogen technology with modern Eurostat requirements and adoption of the EU methodology for monitoring and certifying green hydrogen production.
- **Strengthening of human resources and capacity for efficient production, transport, storage and use of hydrogen**; The specific properties of hydrogen also require adequate professional knowledge of engineers and technicians who design or manage the operation of plants in which hydrogen is produced or used. For this reason, the study of technologies for the production and use of hydrogen should be included in the teaching programs in a timely manner, and in the meantime, special training for operators to work with devices and systems for its storage, transport and combustion should be organized.
- **Strengthening the scientific and research potential in the field of hydrogen technologies;** In the process of introducing hydrogen into the energy sector, the Republic of Serbia should use positive experiences from EU countries and actively participate in international scientific research projects and programs in the field of hydrogen. Available domestic funds should be targeted in those projects that create a new link in the hydrogen value chain and reduce dependence on imported technologies.

Regarding hydrogen production in the Republic of Serbia, by 2030 the construction of a demo facility for the production, storage, and use of hydrogen can be expected. With the increase in electricity production from renewable energy sources and with the expected reduction in the price of electrolyzers, it is rational to expect the beginning of the commercial production of "green" hydrogen and its primary use in the transport sector and in industrial processes (ammonia production, oil refineries, methanol production, application in ironworks and cement industry, etc.). Ideally, electrolyzers would be supplied directly from locally available renewable energy sources and would be located next to industrial consumers and frequent transport routes. Also, the possibility of decarbonizing some of the existing hydrogen production plants by retrofitting them with carbon capture and storage technologies should be considered.

Nuclear Energy

In the Republic of Serbia, the Law on the Prohibition of the Construction of Nuclear Power Plants[22] is still in force. The Republic of Serbia does not have balance reserves of nuclear raw materials and there is no regulatory and administrative framework that would regulate the construction and operation of nuclear power plants, facilities for the production of nuclear fuel and facilities for the processing of spent nuclear fuel. There is no scientific or engineering cadre to monitor the construction and operation of these facilities, and educational programs dedicated to nuclear energy have been canceled.

However, from the point of view of the basic development goals and priorities of energy development, nuclear energy could significantly contribute to decarbonization and increase the competitiveness of the energy sector. Nuclear energy is a clean energy source from the point of view of the emission of gases with the greenhouse effect and local pollutants, and it also enables the diversification of the electricity production structure at a reasonable price - high capital expenditures are compensated by low variable production costs in the long term. From the point of view of energy security, it is almost entirely about imported technology, based on imported fuels. However, nuclear units represent a very reliable source of energy, intended to cover the base load, which positively affects the stability of electricity production with zero emission of pollutants into the air. From that aspect, nuclear power plants could take over the role of the existing thermal energy capacities that use coal in the energy system of the Republic of Serbia. In addition to classic nuclear power plants, where the capacity of individual reactors is usually 1000-1500 MW, today small modular reactors - nuclear fission reactors with capacity of 300 MW or less - are also in the phase of intensive development. These prefabricated reactors should ensure the economy of serial production and a significantly shorter construction time compared to classic plants.

The technologies currently used in nuclear power plants (III and III+ generations) and strict standards of nuclear safety and radiation protection ensure safe operation of nuclear power plants and storage of nuclear waste. That is why nuclear energy is recognized as an important factor in the climate neutrality of the EU until 2050. In principle, the acceptance and use of nuclear energy could bring the following benefits to the Republic of Serbia:

- fulfillment of existing and future goals of integrated climate and energy policy
- reduction of emissions of all pollutants and GHG from the electricity production sector
- diversification of primary energy supply routes
- replacement of obsolete production units that use coal in the power system
- reliable and stable energy supply and acceptable electricity prices for consumers
- economic incentive for regional development
- the development of domestic industry and new specializations and technologies in the entire supply chain of components and products.

The public debate, initiated by the signing of a memorandum of understanding on the implementation of nuclear energy development in the Republic of Serbia with the professional and scientific community, includes security, legal, organizational, scientific research, engineering and all other aspects of the use of nuclear technology. Special attention must be paid to the disposal and processing of spent nuclear fuel and the impact of this technology on the environment.

[22] Official Gazette of FRY, No. 19/95 and Official Gazette of RS, No. 85/2005 – other law

During the public debate, a multidisciplinary study assessing the impact of the introduction of nuclear energy on the economic and social development of the Republic of Serbia will be analyzed, as an important analytical document for understanding nuclear energy in countries with a developed nuclear program and its possible development directions in Serbia. The document defines the main elements of the process of introducing nuclear technology into the energy industry with considered options, challenges and obstacles related to the regulatory framework, capacity building and technology transfer, infrastructural requirements, impact on the environment and security, finance and socio-economic development. Considering the importance and far-reaching nature of the decision on the introduction of nuclear energy, the amendments to the Energy Law establish an institutional framework, i.e. the Directorate as a body within the Ministry of Mining and Energy, which will be responsible for the management and coordination of nuclear policy, in cooperation with all relevant actors. In the case of a final decision to start the construction of a nuclear power plant, it will be necessary to pass a special law that will regulate the area of nuclear energy use, which will, among other things, define the new role of the Directorate with all the powers of the Commission for the Preparation and Development of the Nuclear Energy Program, as defined and recommended by the International Atomic Energy Agency (IAEA) and following international best practices. In the coming period, the Government will start the process of building the necessary institutional, professional and regulatory framework for the use of nuclear energy and the treatment and disposal of spent nuclear fuel. This is a necessary prerequisite for creating the necessary investment environment for the introduction of nuclear technologies in the Serbian economy.

According to the guidelines of the International Atomic Energy Agency (IAEA), there are three stages in the development of infrastructure for a nuclear power program:

- Stage 1: Consideration before making the decision for nuclear program starting
  This is the initial phase, and it lasts until the candidate state, fully informed and educated, commits to the development of a nuclear energy program.
- Stage 2: Preparatory works for the contracting and construction of the nuclear power plant after the political decision is made.
  At the end of this phase, the candidate country must be ready to tender/negotiate the contract for the first nuclear power plant.
- Stage 3: Activities related to the first nuclear power plant construction and commissioning. This is the final stage of development, during which the commissioning of the first nuclear power plant is expected.

In the Integrated National Energy and Climate Plan, the S-N scenario, which predicts the participation of nuclear energy in the energy mix of the Republic of Serbia, was considered, with a conservative forecast of the commissioning of the nuclear power plant in 2045. Bearing in mind the road map for the development of the nuclear program, as defined by the IAEA, as well as the planned lifting of the moratorium on the construction of nuclear power plants in the Republic of Serbia, if all the necessary activities before the start of construction, as well as the realization of the construction project itself, would be carried out within the defined deadlines, the construction and commissioning of a nuclear plant can also be considered in the period up to 2040, which would then have implications for the corresponding energy balances in the power, natural gas and renewable energy sectors.

Framework and Assessment of the Impact of Possible Changes of the International Position of Serbia and the Integration Processes on Energy Development

The development of the Republic of Serbia in the energy sector is directed by ratified international contracts and national laws.

The international legal framework contains international laws that establish the energy sector and field of environment and climate, human rights, international trade, transport, and investments. Establishing the balance between the effects of the energy cycle, from production to energy consumption, reaching the security of energy supply, and providing sustainable development is one of the crucial international regulation trends, the most comprehensive being international agreements concluded within the UN and international contracts between EU and Republic of Serbia.

Although not directly affecting the energy sector, regulations that affect environmental protection and effects on climate resulting from industrial processes, affect the conduction of activities in the energy sector, specifically on the production, transport, sale, and consumption of energy and energy sources. In this field, the crucial regulations are the United Nations Framework Convention on Climate Change, which includes the Kyoto Protocol and the Paris Agreement, as well as other international agreements related to or affecting the energy sector, concluded under the auspices of the United Nations.

Although the Republic of Serbia is not a member of international organizations such as the Organization for Economic Co-operation and Development, the International Energy Agency, the World Trade Organization and other similar organizations, rules they make indirectly affect the legal framework of the Republic of Serbia, through the process of harmonizing the regulations of the Republic of Serbia with the legal framework of European Union.

Regarding the energy sector, the international position of the Republic of Serbia is conditioned by its membership in the Energy Community, the Stabilization and Association Agreement with the European Union, the acquisition of candidate status for EU membership, and the 2012 opening of accession negotiations on EU membership.

With the decisions made by the Ministerial Council of Energy Community, in 2021 the transposition process of EU regulations from the Regulations package ”Clean energy for all Europeans” for Contracting parties, including the Republic of Serbia, has begun. The subject of these regulations is the harmonization of the energy sector with climate protection in five domains, as follows: 1) Increase of energy efficiency in all segments, primarily in buildings 2) Decarbonization and the increase in the use of renewable energy sources 3) Energy security, 4) Research and innovations and 5) competitiveness of energy market. Analyzing these regulations, it can be concluded that there is a significant rise in the level of regulation of the market and the growing role of the administrative bodies in this market, whose creation began with the implementation of the market liberalization principle.

In 2021, the Ministerial Council of the Energy Community adopted the Decarbonization Roadmap for the Contracting Parties of the Energy Community. The aims of this Roadmap are directed at the affirmation of energy and climate goals and realization of the climate neutrality, which should be realized by the middle of this century in the Energy Community, establishment of dialogue between EU and Contracting Parties about the decarbonization priorities, advancement in accepting the ”carbon pricing” system by Contracting parties of Energy Community, and the creation of joint political message about decarbonization and encouragement of the use of non-fossil fuels. Roadmap has established the transposition dynamic of the EU legal framework, which refers to the decrease of the influence the energy sector has on climate change and through that additional harmonization of Energy community policy with the EU politics in this field.

At the moment of gaining full membership in the EU, the energy sector of the Republic of Serbia will face the obligation to introduce and implement the EU Emissions Trading System (EU ETS). This is the first and largest international greenhouse gas emissions trading system. In the energy sector, the EU ETS includes carbon dioxide originating from the production of electricity and thermal energy, as well as from oil refinery processing.

Even before joining the EU, the Republic of Serbia should actively work on preparing for the introduction of “carbon pricing”. The first step on that path is the construction of the necessary regulatory and institutional framework for monitoring, reporting and verification of emissions, which would be fully complementary to the EU ETS. The next step is the introduction of a system of carbon pricing from the sectors covered by the EU ETS, whereby the price of the emission, as carbon tax, would be determined by the Government of the Republic of Serbia or some other legal entity that it would delegate. The carbon tax would gradually increase and approach the price in the EU ETS, as entry into the EU approaches. In any case, it is necessary to build regulatory, institutional, and organizational capacities for collecting funds and directing them to projects, measures and activities that lead to the decarbonization of the energy sector and the economy as a whole, that is, they help the "green" transition of the entire society. In this process, with the acknowledgment of priniciples stated by United Nations Framework Convention on Climate Change, the Republic of Serbia must seek international support. First of all, financial, professional and any other necessary assistance for the implementation of this measure should be provided through negotiations with the EU.

By establishing the cost and price of emissions, and therefore by assigning a financial value to each ton of emissions avoided, the issue of climate change is being included in the financial plans of companies. There is no doubt that this mechanism will affect and require the restructuring of not only the energy sector (primarily electricity production, but also thermal energy from fossil fuels), but also all energy-intensive industrial sectors (ferrous metallurgy, chemical industry, non-metal industry, etc.). Increased production costs will undoubtedly lead to an increase in the prices of electricity and, in turn, other products and services.

However, most of the funds collected on this basis would have to be used for specific projects to reduce greenhouse gas emissions and mitigate climate change - use of renewable energy sources, collection and storage of CO_2, mitigation of social consequences of increased energy costs, energy efficiency improvement, etc. In addition, the high cost of emissions creates a favorable investment environment for investments in innovation and the application of cleaner technologies with lower carbon emissions. This creates opportunities for employment and sustainable economic growth, improving economic competitiveness.

Certain EU member states (including all the Republic of Serbia’s neighbor states), that were in a similar situation as the Republic of Serbia is at the moment, had significant help from the whole EU, through the right of free allocation for the purpose of modernization of energy facilities and participation in EU Modernization fund. Equalizing the legal position of Energy Community Contracting Parties with the legal position of EU member states, with both of them participating in the same energy market, is of special importance for further development not only of the energy sector but the economy as a whole. For the Republic of Serbia, the use of very high current prices (expected to go even higher) from the EU ETC in the near future is not acceptable, the reason being the buyers of electrical energy can't accept high prices of electrical energy that will result from that. Fast coal phaseout is not possible in the regions in which most of the citizens depend on it. Substitution with gas is uncertain from the point of supply security, as well as price, leading to the costs of carbon emission being paid by coal-fueled TPP being undoubtedly transferred to final buyers. Enough duration of the transitional period is crucial until the cost of emission equal to the EU ETC price is reached. Even in the case of faster EU entry, in which case entry into EU ETC becomes an obligation, a transitional period with free emission permits should be demanded in the negotiations, as was the case for EU members with the lowest national product per capita, also supported through the mechanisms of a just transition within the cohesion and solidarity policy of the EU bloc.

The introduction of internal carbon pricing in the energy sector of the Republic of Serbia would, to some extent, represent a preventive response to the expected introduction of the so-called carbon taxes on imports (i.e. "carbon border tax" or "carbon border adjustment mechanism") by the EU. It is expected that this tax will be applied to the import of products from a energy-intensive industrial sectors - cement, iron and steel, aluminum and artificial fertilizer, as well as to the import of electricity. At a later stage, it is expected that the products of the chemical industry and refineries will also be covered by this tax.

The introduction of the carbon pricing mechanism in the energy system of the Republic of Serbia would help to approach the problem of greenhouse gas emissions comprehensively, so that all decisions made, and activities carried out aim to decarbonize the economy as a whole. This will enable the continuity of the Serbian economy's presence on the EU market, increase its competitiveness and strengthen Serbia's prospects for EU membership.

Analysis of the Effects of Implementing the Strategy

Energy development conditions the development of all areas of the economy, as well as general social and civilizational development. Priority is given to the influence of energy related to the key contents of macroeconomic development (economic growth, employment, level of gross domestic product, the ratio of imports and exports, etc.), but also to issues related to regional cooperation, technological and scientific research development, innovations, etc. Energy development directly affects the entire production infrastructure (mining, industry, transport, construction, agriculture).

At the same time, one should always keep in mind the fact that the development of energy, as much as it can stimulate economic growth, can also slow it down. Therefore, the most likely scenario is that, during the energy transition in the Republic of Serbia, due to the gradual decrease in the share and activity of the coal industry, there will first be a slowdown in overall economic activity and a decrease in employment in the energy sector. However, this would only happen in the short and medium term, while in the long term the planned restructuring of the domestic energy sector would encourage investments, sustainable growth, and productive employment.

Macroeconomic Indicators

Macroeconomic development consists of economic growth, structural and market changes. It refers to the territorial distribution of economic facilities, (un)employment and the level of purchasing power of the population, foreign trade balance. The current state of Serbia's economy represents the overall outcome of bad circumstances (dissolution of the SFR Yugoslavia, sanctions and hyperinflation, NATO bombing, chaotic privatization), as well as development efforts made in different periods.

No strategy makes sense if it does not result in permanent policies and assumptions for socioeconomic and technological development. The new Energy Development Strategy should be the driving force behind the creation and strengthening of domestic accumulation, which will promote the future growth of micro, and then macroeconomic indicators. The new Energy Development Strategy of Serbia contains the potential for quality and sustainable economic growth, more productive employment, a more environmentally friendly energy sector, and energy stability, which is also reflected in acceptable import dependence.

Growth Prospects in the Context of the New Energy Strategy

The prospects for Serbia's economic growth in the medium term are very contradictory. On one hand, already in 2021, it seemed that the global economy was permanently emerging from the pandemic recession. However, new circumstances, especially inflation and the intense increase of the prices of energy equipment and facilities, and natural gas and electricity prices on the European market, as well as the escalation of geopolitical conflicts, including the war between Russia and Ukraine at the beginning of 2022, have significantly changed the prospects for growth in the coming years.

The prospects for growth should be considered in the light of the following facts:

- only in a relative sense can it be said that the world is economically coming out of the covid-crisis. Namely, the economic activity of the largest part of the planet has adapted to the conditions of the new normality, so that already in 2021, the world economy has officially come out of depression. However, this does not mean that stable growth is guaranteed in the coming years, primarily due to new limiting factors for global trade and technological cooperation, the most important of which is the prolongation of the very destructive war in Ukraine, as well as the further tightening of international relations.

- the Serbian economy, judging by the relatively lively economic activity, in 2021, at least statistically speaking, is slightly less affected by the consequences of the covid-crisis, but with the prospects that it will be hit by a new crisis to a greater extent than other countries in our region due to geopolitical tightening, and in connection with the European Union's policy of sanctions against Russia. Namely, previously it was quite promising, but now the above-average economic growth of Serbia in the medium term is very questionable, both in relation to the region and in relation to the growth of the Serbian economy in the second decade of the 21st century.
- the new post-pandemic economic policy and projected economic development, in most of the world, are being traced in the sign of a "green" economic transition. In that direction, changes in the energy sector are also intensifying. Particularly relevant for Serbia are energy transition programs that rely on structural changes to increase the share of RES, as well as energy efficiency improvement programs. However, global developments, as a priority goal, ahead of all policies, set elementary satisfaction of the energy needs of the population of the country and the economy, that is, the functioning of key energy systems.
- finally, the new, far higher prices of all energy sources, as well as energy raw materials and equipment, lead to higher costs of production and restructuring of the energy sector. This reduces the prospects for economically sustainable operation of energy systems, especially district heating systems and electricity supply systems. This also increases the value of imports of key energy sources, which increases the country's foreign exchange and payment deficit, as well as the state's fiscal deficit, and reduces potential real GDP, or at least lowers growth rates.

Investments and Employment

In the context of major structural changes in Serbia's energy sector, under relatively normal international conditions, significant investments in the energy sector are expected, both in new capacities for production, transmission, and the use of energy from renewable sources, as well as in projects of energy infrastructure, transmission systems, transport and distribution systems, smart systems energy networking, urban energy, transport, construction, etc. With appropriate plans for energy restructuring and demonopolization, those projects could bring a significant inflow of domestic and foreign investments. We are talking about investments, on one hand, in devices for emission reduction from existing and still active TPP, soil protection, neutralization and provision of ash sites, tailings reclamation, etc., as well as in new RES capacities (hydropower and pumped-storage hydropower plants, solar power plants, wind farms), that is, in the modernization of the district heating system.

Just the renovation of existing housing stock, including energy efficiency measures, opens the possibility for investments in the amount of 20 to 40 billion euros in the next 30 years. Thanks to these investments, according to the optimal scenario, Serbia's GDP would increase by 3.73% to 6.63% per year in the period from 2021 to 2050, while the share of budget revenues generated by these investments in GDP would amount to between 1.12% and 1.99% per annum.

If a favorable investment climate is established, with a smart and proactive energy policy and better functioning of institutions, investments in new green capacities, in energy efficiency and infrastructure, will create conditions for relatively quick, but limited, employment in new workplaces. This can be achieved by actively and thoughtfully encouraging employment, directly connecting workers and employers (through state-public or private employment services), improving the skills and abilities of workers (through various training programs, which adapt the worker's profile to the needs of the market), improving the quality of the labor supply (by providing scholarships to young and educated people and by creating new jobs - by organizing public works on the realization of new environmentally friendly energy projects).

Total employment in the energy sector, during the initial few years of energy restructuring and transition, should decrease. Namely, due to the gradual reduction of the capacity for the production of electricity from lignite, employment will first decrease, only to later increase slightly, primarily due to the increase in involvement in the reclamation of coal mines, the production of electricity from solar panels, installed in suitable parts of the coal mine, but also in other industrial branches, agriculture and tourism, based on the comprehensive and fair energy transition program.

The decline in employment in the power sector would lead to an increase in the unemployment rate, but, based on the restructuring, employment in the "green" energy sector would gradually increase, as well as in other supporting sectors that have greater employment potential (utility and service activities, transport, telecommunications, food, and other light industry) so that the balance of the energy transition in total employment by 2040 would be positive. More specifically, it is estimated that by 2040, around 3 to 5 thousand young people with higher education should be newly employed in the mentioned areas, throughout Serbia, mostly in technical and natural sciences. The building renovation program has a particularly high potential to reduce unemployment.

In this way, the overall economic effects based on the energy transition will be increased by reducing the costs of health care, safety, and externalities caused by soil, air and water pollution. At the same time, technological development will be promoted, and the existing technological gap compared to economically developed countries will be alleviated.

Import Dependence

Energy security is a generally accepted category of energy sustainability, which depends on a number of composite factors. Only one of them is import dependence, which means the share of net imports (the difference between energy imports and exports) in the total amount of primary energy needed. Serbia's deficit in this regard changes from year to year, but the average dependence on imports is around 35%. However, if the value of energy equipment, "know-how", that is, technology, science and knowledge were to be calculated in some way, import dependence would be greater.

One analytical point of view underlines, not without grounds, the fact that energy independence is essential for the country, in order to respond to security challenges, supply crises, and wars. However, today there is no national energy industry that is not integrated into the environment, through the import and export of energy and energy products, energy equipment, technology, etc. Another problem is that the category of import dependence does not take into account the historically inevitable and relatively frequent turbulence in the international energy market. The latest changes in the energy markets, and especially the uncertainties after the outbreak of a new war in Europe, mean that the price of electricity, gas, and crude oil can increase short-term and mid-term several times. Such an intense increase in energy import costs, in the case of a "bad" scenario, leads to significantly more intense, negative financial consequences to import dependence in the current and future years, compared to the previous series.

From the point of view of the adopted development scenario, regardless of a slight increase in the consumption of natural gas (primarily due to greater use for electricity generation and balancing the operation of RES production facilities) and of the expected decline in the indigenous production of oil and natural gas, in the following decades, the significant changes in the import dependence of the Republic of Serbia are not expected. The reason for this lies primarily in the expected decrease in energy demands, due to applied measures of energy efficiency and the change of structure of the energy sources used for the production of electrical and heat energy.

Regional Development

The biggest challenge of the new energy strategy will be related to the regional and local development consequences of the energy transition, especially the restructuring of the current state electricity capacities. Namely, heating plants based on lignite in central Serbia are mainly located in two wider locations: Kolubara (municipalities of Lazarevac, Ub, Obrenovac), as well as Pomoravlje (Kostolac). There are also local socio-economic structures and economies of Svilajinac (thermal power plant), Despotovac, Aleksinac and Sjenica (mines). All these local environments are quite dependent on the exploitation and the use of coal. The gradual closure of thermal capacity and mines in these areas leads to problems of ensuring economic sustainability, ways of economic transformation and the survival of families and individuals. The just energy transition, as a principle that has already given appropriate results in Europe and the world, implies the harmonization and acceptability of local restructuring measures of the coal sector, as well as harmonized measures of transformation of the employment system and work of the sector.

Local communities must be provided with a chance for sustainable economic development, which would compensate for losses due to the cessation or reduction of electricity production from lignite. The transition fund of local communities affected by the energy transition in Serbia will be financed from carbon taxes, which should be introduced as soon as possible in accordance with the elementary principle "the polluter pays", but in the way but in a way that doesn't threaten the affordability of energy for the population and competitiveness of the economy. Also, the regional development of particularly affected local communities should be financed from European funds for the promotion of the green transition within the "Green Agenda for Western Balkans”, for the countries with a GDP per capita significantly lower than the EU average, which is a key criterion for supporting a just transition. Finally, a part of environmental taxes, directed to the Green Fund of the Republic of Serbia, should, under certain stimulating conditions, be directed to citizens who give up jobs in the coal sector to the sectors of "green" energy (RES, energy efficiency), or processing industry, agriculture, and tourism.

Also, the systematic and intensive application of energy efficiency measures in the building sector could stimulate the generation of new jobs and balanced regional development.

Technological and Scientific Research Development and Innovation

Technological development will significantly contribute to a more rational use of limited natural resources, through the reduction of the consumption of production elements, the application of new, cleaner technological procedures, the reduction of the emission of pollutants into the environment, the improvement of procedures for the purification of accumulated stocks of pollutants, as well as the improvement of procedures for recycling waste. At the same time, technological innovations will play a key role in ensuring an energy supply that will follow the growth of energy needs and be in line with sustainable development.

In innovative economies, knowledge is the most important resource, which they, through innovative processes, incorporate into new products and consequently become more competitive. That is why it is necessary to invest at least twice as many public resources systematically and in the long-term in the field of scientific research and development work. Thereby, in accordance with the good EU practices (for example the eligibility criteria of the Horizon Europe for the Gender Equality Plan), it is necessary to take into account gender equality, to ensure that women are evenly represented in all science bodies and work groups. Encouraging domestic scientific and research work will result in the creation and application of many useful organizational and technological innovations, which will be the supporting link of the future development of important segments of energy in Serbia:

- on the supply side (cleaner sources of energy and sustainable production, including biomethane and hydrogen);
- on the demand side (smart cities, energy-efficient buildings and industry, environmentally friendly transport and sustainable consumption);
- in the field of optimization of energy systems (smart grids, integration of variable renewable sources, including advanced energy storage technologies).

Innovation contributes to the wider availability of the application of alternative technologies, which will achieve the desired transformation of Serbia's energy sector from "dirty" (based on fossil fuels) to cleaner and to a greater extent "green" energy (dominated by renewable energy sources).

To achieve the required degree of technological, scientific, and research development as well as innovations, it is necessary to provide close cooperation and synergy between energy companies, the business sector, and scientific research organizations, as well as connecting with EU funds, development, and scientific research programs. A good framework could be public calls of the Science Fund of the Republic of Serbia, which need to include topics of essential interest for the development of the energy sector.

Serbia's energy sector can become a chance for growth and employment, but it can also affect Serbia's further lagging behind the development trends of modernization of the world and Europe. Therefore, the Strategy creates a stimulating ambient and defines development policies and plans for the energy sector development, that will be made further concrete through SIP in a form that will affect structural changes and the development of the whole economy. Namely, the energy policy is only a part of the policy and strategy of structural adjustment to the world post-covid economy and green industrial transformation of the world economy. In this context, coordinated changes in transport, urban infrastructure, and communications should be observed. Smart infrastructure, transport, housing and heating, as well as networked technological systems for controlling energy consumption and managing energy processes, will be one of the biggest challenges of the new energy policy, economy and culture.

In the next three decades, the energy sector will undergo fundamental changes, passing through areas and challenges that are still insufficiently explored, and in which it must at all times demonstrate functionality in all conditions, and ensure the security and availability of energy. Therefore, the strategic interest and need is to continuously review and redirect projections of the energy future by own professional capacities. It is also necessary to possess exceptional knowledge, skill, and persistence in order to achieve the most favorable solutions for energy and climate in the processes related to accession to the European Union.

To that end, capacities for strategic energy planning should be established, that is, organized and strengthened, in order to continuously adapt policies and ensure an adequate response to growing uncertainties.

The Social Dimension of the New Energy Strategy

The energy development strategy of the Republic of Serbia should provide prerequisites for a different scenario of sustainable and prospective growth and development in the long term. The transformation of energy, as a fundamental economic activity and the basis of the entire economy and its modernization, represents a challenge for the economy, technology, and society as a whole. Nevertheless, the biggest challenges await Serbia in terms of social sustainability of the planned strategic coordinates of the energy transition.

To put it simply, the social dimension of transition in the energy sector is just as important as the macroeconomic one, which concerns market liberalization, deregulation, and privatization. In order for the energy transition of the Serbian energy sector to take place in a sustainable way, it is necessary to harmonize its social consequences with the expected structural changes in technological and economic systems.

The social consequences of changes in Serbia's energy sector are manifold. One aspect of those consequences relates to the new energy system and prices, conditioned by new energy policies and laws. The second aspect includes employment, earnings and lifestyle of people, primarily employees of energy companies and their families.

Energy Prices and Their Social Tolerability

The transition of Serbia's energy sector, in the context of the implementation of a new energy strategy, takes place in the turbulent time, first due to changes in demand and the restructuring of global energy markets, and then due to a series of geopolitical challenges, leads to a sudden and uncertain increase in prices certain forms of energy. The new, increased social sensibility about ecological and climate problems, further influences the fact that the prices of energy from "dirty" sources (fossil fuels, especially coal) soon become burdened with carbon taxes and other costs, based on the application of the "polluter pays" principle. And the price of "cleaner" natural gas on the international market, including in Serbia, will increase in the long term. The height of the price of crude oil in the period of the post-covid recovery of the world economy will probably continue to rise, due to an increased global demand, but certainly not to the extent that the price of natural gas is rising. The time of cheap energy in most of the world, and especially in energy deficit countries, such as Serbia, has definitely passed.

The social tolerability of the consequences of rising prices of oil derivatives on the Serbian market is traditionally higher than the prices of heating or electricity. However, the reversal of trends that occurred in mid-2021, in a large part of Europe, shows that the extreme price increases of gas and electricity, and consequently heating, as well as oil derivatives, are reflected in the standard, as well as in production costs. In Serbia, such cost impact has been mitigated by a gradual, multiple price increase, but it is definite that in the conditions of the prolongation of the war and the energy crisis of the war in Europe, new impacts of leveling prices and costs will additionally affect both the population and the operations (profitability) of companies, and indirectly and public finance. On that basis, the new fiscal crisis could have a significant impact on the general social condition of Serbia, including on social conditions in the energy sector.

Another major challenge, which could threaten the planned effective transition of Serbia's energy sector, is the pessimistic perspective of the current global confrontations, especially between NATO and Russia, which leads to the escalation of economic and energy restrictions, and endangering energy cooperation, especially in Europe. An obvious problem is the increase in prices of energy equipment and materials, as well as technical services required for the implementation of energy efficiency projects. Uncertainties regarding the availability and directions of supply of energy, as well as delays in deliveries on regional markets, can both endanger and encourage the transition of the domestic energy sector.

The new energy prices will certainly increase energy poverty, as well as the level and forms of overall poverty in Serbia. It is all the more important that energy poverty is properly observed, evaluated and registered in a systematic way, using social maps of families and individuals, also taking into account perspective of gender, and increasing the number of protected customers through the implementation of the Regulation on Vulnerable Energy Customers.

Social problems can objectively slow down the pace of energy transition. One of the reasons for slowing down/postponing changes may stem from the prioritization of the so-called crisis supply of heat and electricity, at the expense of system reforms, based on social pressures. Another reason for the slowdown in energy transition could be political populism, i.e. the dominance of the entrenched principle of non-reproach to workers, trade unions, the local population or voters.

That is why it is important that the Strategy outlines realistic and sustainable energy transition goals, with well-considered and analyzed social consequences. At the same time, within the accompanying documents and activities related to the implementation of the Strategy, it is necessary to work additionally on the gradual reduction of the fiscal burden of certain energy prices. It is also necessary to work on educating the population and the economy, especially those employed in energy companies, and, without any populism, open a debate on the social benefits and costs of the energy transition in the short and long term.

The cost impact of higher energy prices will follow the transformation of the energy sector and the entire economy of Serbia for some time, to a greater extent than other economies of a similar level of development. This is primarily due to the disparity in electricity prices for the economy and households, as well as the inertia of state regulation, which means that these prices do not reflect the objective, total costs of production, nor the costs of all externalities.

Electricity for Households

Households, overall, are the largest consumer of electricity in Serbia. In practice, this means that a significant part of electricity is consumed inefficiently, as well as that a good part of the total production costs are not compensated due to depressed "social" prices. Because of this, the investment potential of the electrical sector is reduced and the capacity for energy transition is reduced. That is why the Strategy insists on the gradual but continuous elimination of disparities, primarily through the following approach:

(1) Continuously increasing the price of electricity is necessary, not only for resolving current, economically damaging price disparities but also for the purpose of initiating a new investment cycle in the energy sector. This cycle is partially linked to the integration of RESs, the costs of which will need to be borne by end-users – both citizens and industry.

That fact would have to (negatively) affect the cost of living, that is, the standard of the population. However, if GDP growth at an average rate of close to 3% is ensured during the whole decade, this fact should enable an increase in real wages and employment, which would cushion the impact on the standard based on the consumption of more expensive electricity.

(2) The second positive effect of the real increase in the price of electricity could come from an increase in energy efficiency, primarily based on savings in the household sector, in the public sector (state consumption), as well as in the economy, due to higher prices. People save to a greater extent what is expensive and what they pay directly from their pockets, so we should expect a gradual cessation of the practice of (exclusive) non-payment of bills that are passed on to society, the local community or energy companies. At the same time, the higher price of electricity will provide funds for technological modernization and, on that basis, the reduction of losses in distribution and transmission.

Just Energy Transition

The most important focus of the strategy refers to the so-called just (the term "fair" is also used) energy transition, which mostly refers to the social acceptability of restructuring measures, transitioning to new technologies and processes, as well as gradually reducing electricity generation using coal.

Another problem of a socially just energy transition concerns the right of the poorest citizens to a minimum of free energy, in accordance with the recommendations of the UN and the EU. For the realization of this principle, only better operational activity of the state administration is needed, as well as appropriate software solutions for records, i.e. strict control of possible abuses.

The green energy transition in Serbia means, first of all, the gradual shutdown of certain capacities and the establishment of new, more efficient and environmentally friendly ones. The most unfavorable position is the perspective of the capacity of energy obtained from coal. It is understood that employees in this sector are the social group most exposed to special costs and losses from such a transition.

The unions understand that a just energy transition "includes a comprehensive political strategy that will make it impossible for workers to get the upper hand in the necessary transition of global industry." This means "pressuring state governments to implement social policies and laws that will protect workers at the exit door of dirty industries, investing in job creation in new industries, and obliging employers to assume their share of responsibility and duty" (ILO).

The resistance to any system of reforms on the part of that sector stems from the informal coalition of workers, management and the local community, and its feeling that there will be a disruption of inherited relations. That is why the transition (even a fair one) of this part of Serbia's energy sector will be a very complex and gradual process, which requires an appropriate legal-political, socio-cultural and strategic framework, with the coordination of the profession, civil sector, management and employees. The first step on this road is the adoption of the Action plan for a just transition, which should represent a legal and political framework for a just transition, especially in the sense of attracting investments and retraining the employees.

The transformation of the entire system of electricity production, distribution and supply should be nationally harmonized, economically rational, ecologically and socially tolerable, technologically harmonized, but above all economical. It is not possible to implement the energy transition based on the populist policy of cheap electricity from coal. This is especially not possible with unproductive and irrational expenditures of public energy companies. Putting all costs, as well as the business systems of these companies under professional social control, is a priority assumption of a just energy transition.

Achieving demonopolization and the principle of cost transparency of all public systems will not be an easy task. The resistance of the employees to the transition measures, and even to any discussion about the energy transition that implies a reduction in the number of employees, i.e. moving to other jobs, is something that is expected, but also not in accordance with the good practice of reforms.

In the first phase of the just energy transition, precisely due to different criteria and operationalization of the concept and content of "justice and fairness", in order to implement the strategy, social control of the reorganization and rationalization of the public power system will be necessary, preferably by mixed bodies of state services, trade unions and experts. Namely, a lot depends on the perception of management and trade union representatives. It is even more important to work on the preparation of the concept with trade unions and sector managers, especially those employed at coal mines, it is understood in cooperation with experts of various professions, needed for professional and social dialogue.

Experience shows that a just transition is impossible without a transition fund. The transition fund, for the needs of energy transformation, should have a basically green character, but also an emphasized social content. The "greening" of energy is a goal that will not take root without appropriate social support. This means that working with people in the transition of employment will require technical and social assistance, whether it is about new "green" jobs or shutting down certain services. The number of employees in the state sector of the electricity industry would have to begin to pass the rationality criteria check in parallel with the reduction of the volume of production.. It goes without saying that it will not be easy. Much better education is needed for participants in the energy transition, energy users, and the population in general, especially in the affected local communities..

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Energy Sector of the Republic of Serbia after 2040

The consideration of the energy development of the Republic of Serbia after 2040 can be seen as a vision, which is not binding in terms of concretely defined goals, measures and activities, but which is a logical consequence of the previous energy development envisaged by this Strategy. In this sense, the energy balances and indicators for 2045 and 2050 are considered.

By achieving the proposed development goals and realizing the optimal energy development scenario, the Republic of Serbia would enter the fifth decade of the 21st century with a significantly changed structure of all sectors, but above all the power sector. The share of RES in electricity production should be greater than 70% by 2040. In the production of heat energy and in the final consumption of energy (households, transport, industry), the share of RES is significantly lower, i.e. does not exceed 20% in the same period. However, it should be kept in mind that the current participation of RES in the production of heat energy in large systems is less than 1%, and in the final energy consumption about 16%, and that is almost exclusively as wood biomass. Essentially, the energy transition in the power sector is the driver of changes in these energy sectors as well. Only with a significantly changed structure of electricity production, the application of heat pumps for heating/cooling and the electrification of transport gain their full meaning, and in the future, the production of green hydrogen becomes rational.

A major challenge in the period after 2040 will be finding an adequate replacement for the use of fossil fuels, predominantly oil and natural gas, in energy-intensive industrial branches, whose significant growth is predicted in that period. The decline in the value of the share of RES in the heating/cooling sector after 2040 is mostly a consequence of the impossibility to see from the current perspective a quantitatively adequate replacement for the significantly higher, projected needs in oil and natural gas in industry. However, with more commercially acceptable production of green hydrogen and more intensive production of biomethane, i.e. new technological solutions in the industry, which can be expected in the decades ahead, it is possible to change the trend. Future revisions of strategic and other energy documents will certainly show RES shares in the heating/cooling sector after 2040 similar to those in the electricity generation and transport sectors.

The implementation of energy efficiency measures is crucial determinant of energy development until 2040. Suggested measures for the improvement of energy efficiency should reduce losses in energy transmission, transport and distribution systems, as well as indicators of specific energy consumption in households, industry, the commercial sector, transport and other sectors, to values close to the average values for EU countries.

The implementation of key infrastructure projects (PHPP Bistrica, electricity and gas interconnections, opening of replacement coal mines, and investments in the projects of primary and secondary emission reduction in TPP) should ensure that the supply of energy and energy sources until 2040 is secure and reliable, with minimal negative impact to the environment, whereby the energy security of the Republic of Serbia at no time be questioned. At the same time, the development until 2040 and the fulfillment of the set goals should ensure that the Republic of Serbia achieves a significant degree of climate neutrality by 2050.

For such development, full compliance with the EU emissions trading system, as well as compliance with EU climate and energy regulations by 2040. is of utmost importance. Energy companies and companies in the Republic of Serbia should be fully reformed so that they can monitor and lead the energy transition process. It is even more important that by 2040 the process of just socio-economic transition of the mining regions becomes a reality, as well as the implementation of the programs to eliminate energy poverty. It is precisely these processes that will represent the biggest challenge in the further decarbonization of the energy sector until 2050.

With the complete fulfillment of all the goals of infrastructural, regulatory and institutional development proposed by the Strategy, for the development of electric power after 2040, it is important to consider the possibility of applying technologies for the collection and storage of carbon dioxide from the combustion process, bearing in mind the development process of these technologies and their contribution to the sustainability of the operation of thermal power plants. Further increase in the capacity of solar and wind power plants will require the construction of PHPP Bistrica and PHPP Đerdap 3, as well as the use of other sources of flexibility for their integration. It is still possible to use the hydro potential, primarily of the Drina River. Depending on the previously described strategic decisions related to the use of nuclear energy, the first nuclear power plant in the Republic of Serbia could appear on the grid before 2050.

Such a change in the electric power sector would enable the transformation of other energy sectors with the aim of their significant decarbonization. It is expected that in the period after 2040, green hydrogen production and storage technologies will be available and commercially available to a significant extent. The use of green hydrogen in industry and transport, the electrification of transport, the application of heat pumps and hydrogen for heating purposes are technologies that can already be seen and together with energy storage systems in PHPP, hydrogen or batteries, can be connected to the image of an almost completely carbon neutral energy system . The use of oil and natural gas would remain present in non-energy consumption for the needs of industry, while it would be significantly reduced for other needs.

The experience of technological progress in the last decades teaches us that in the period of the next twenty or more years, technological changes may be unfathomable from today's perspective. Therefore, for development before and after 2040, it is important that public institutions and all energy entities in the Republic of Serbia achieve close cooperation with educational and scientific institutions and that they jointly develop personnel capable of following energy trends, adopting, applying and improving new energy technologies.

Table A1: Total Energy Balance in 2025, Scenario BAU

Total Energy Balance in 2025 Scenario BAU [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Heat**	**Total**
Primary production	6.991,5	831,9	-	296,2	-	895,2	8,1	1.923,9	22,9	30,8	165,3	34,6	27,9	-	11.228,4
Import	552,7	3.013,3	699,8	2.093,0	70,0	-	-	28,9	-	-	-	-	-	-	6.457,7
Export	-13,1	-	-468,9	-	-218,3	-	-	-57,1	-	-	-	-	-	-	-757,4
Gross inland consumption	**7.531,0**	**3.816,3**	**242,7**	**2.389,2**	**-148,3**	**895,2**	**8,1**	**1.895,7**	**22,9**	**30,8**	**165,3**	**34,6**	**27,9**	**-**	**16.928,7**
Refineries	-	-3.816,3	3.639,5	-112,0	-	-	-	-	-	-	-	-	-	-	-288,8
CHP and Autoproducers	-11,5	-	-88,6	-80,3	170,1	-	-	-7,6	-	-2,4	-	-	-0,2	-	-20,5
Facilities for electricity generation	-6.774,4	-	-145,2	-	3.466,6	-895,2	-	-37,0	-	-	-165,3	-34,6	-27,9	-	-4.613,1
District heating plants	-40,6	-	-52,3	-718,0	-	-	-	-	-	-	-	-	-	738,5	-72,4
Blast furnace plant	-268,5	-	-	-	-	-	-	-	-	-	-	-	-	-	-268,5
Hydrogen production															-
Consumption in the energy sector	-	-	-	-49,9	-323,9	-	-	-	-	-	-	-	-	-28,9	-402,7
Losses	-	-	-	-15,5	-374,0	-	-	-	-	-	-	-	-	-81,4	-470,9
Transformation output	**-7.094,9**	**-3.816,3**	**3.353,4**	**-975,7**	**2.938,8**	**-895,2**	**-**	**-44,7**	**-**	**-2,4**	**-165,3**	**-34,6**	**-28,2**	**628,2**	**-6136,9**
Households	61,6	-	40,1	198,0	1.318,0	-	-	1.600,7	-	-	-	-	-	466,9	3.685,4
Public and commercial sector, other users	8,8	-	69,5	194,9	538,8	-	1,2	21,5	-	17,2	-	-	-	121,6	973,5
Transport	-	-	2.515,8	6,4	51,6	-	-	-	22,9	-	-	-	-	-	2.596,7
Industry	282,8	-	424,0	474,8	834,5	-	-	163,1	-	6,2	-	-	-	216,9	2.402,3
Agriculture	-	-	90,8	18,4	27,5	-	6,9	1,4	-	5,0	-	-	-	-	150,0
Final Non-Energy consumption	2,9	-	620,0	229,1	-	-	-	-	-	-	-	-	-	-	852,0
Energy available for final consumption	**356,1**	**-**	**3.760,2**	**1.121,6**	**2.770,4**	**-**	**8,1**	**1.786,8**	**22,9**	**28,4**	**-**	**-**	**-**	**805,4**	**10659,9**

*Includes forest and agricultural biomass

Table A2: Total Energy Balance in 2030, Scenario BAU

Total Energy Balance in 2030 Scenario BAU [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Heat**	**Total**
Primary production	7.809,1	671,2	-	377,1	-	897,8	10,3	1.823,8	73,3	38,7	165,3	43,7	37,0	-	11.947,3
Import	523,6	3.708,3	618,1	2.558,8	85,7	-	-	77,4	-	-	-	-	-	-	7.571,9
Export	-12,9	-	-594,7	-	-252,2	-	-	-53,7	-	-	-	-	-	-	-913,6
Gross inland consumption	**8.319,7**	**4.355,1**	**31,5**	**2.935,9**	**-166,5**	**897,8**	**10,3**	**1.847,5**	**73,3**	**38,7**	**165,3**	**43,7**	**37,0**	**-**	**18.605,6**
Refineries	-	-4.355,1	4.154,5	-127,3	-	-	-	-	-	-	-	-	-	-	-327,9
CHP and Autoproducers	-21,0	-	-85,7	-143,1	177,2	-	-	-18,9	-	-1,7	-	-	-6,9	-	-100,1
Facilities for electricity generation	-7.608,9	-	-125,4	-	3.777,8	-897,8	-	-38,7	-	-	-165,3	-43,7	-30,1	-	-5.132,1
District heating plants	-40,6	-	-40,1	-842,2	-	-	-	-	-	-	-	-	-	835,7	-87,2
Blast furnace plant	-212,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-212,8
Hydrogen production															-
Consumption in the energy sector	-	-	-	-46,8	-364,0	-	-	-	-	-	-	-	-	-36,1	-446,9
Losses	-	-	-	-18,9	-404,0	-	-	-	-	-	-	-	-	-90,0	-512,9
Transformation output	**-7.883,3**	**-4.355,1**	**3.903,2**	**-1.178,2**	**3.187,0**	**-897,8**	**-**	**-57,6**	**-**	**-1,7**	**-165,3**	**-43,7**	**-37,0**	**709,6**	**-6819,9**
Households	34,2	-	47,3	268,2	1.373,8	-	-	1.568,3	-	-	-	-	-	506,4	3.798,1
Public and commercial sector, other users	0,2	-	77,9	240,8	574,4	-	2,6	32,7	-	20,3	-	-	-	147,4	1.096,3
Transport	-	-	2.605,6	6,4	91,7	-	-	-	73,3	-	-	-	-	-	2.777,1
Industry	311,5	-	464,8	686,7	928,4	-	-	112,0	-	11,7	-	-	-	232,4	2.747,4
Agriculture	-	-	96,3	19,3	29,1	-	7,6	1,4	-	5,0	-	-	-	-	158,8
Final Non-Energy consumption	3,3	-	693,8	264,6	-	-	-	-	-	-	-	-	-	-	961,8
Energy available for final consumption	**349,2**	**-**	**3.985,7**	**1.486,0**	**2.997,5**	**-**	**10,3**	**1.714,4**	**73,3**	**37,0**	**-**	**-**	**-**	**886,1**	**11539,5**

*Includes forest and agricultural biomass

Table A3: Total Energy Balance in 2035, Scenario BAU

Total Energy Balance in 2035 Scenario BAU [1000 toe]	Coal and Coal products	Oil	Oil products	Natural gas	Electricity	Hidro Energy	Geothermal Energy	Biomass*	Biofuels	Biogas	Wind Energy	Solar Energy	Municipal solid waste	Heat	Total
Primary production	8.355,5	486,3	-	309,5	-	951,1	12,4	1.757,0	77,6	45,6	165,3	43,7	37,7	-	12.241,8
Import	494,9	3.553,3	611,2	3.006,8	44,2	-	-	65,9	-	-	-	-	-	-	7.776,3
Export	-12,4	-	-281,4	-	-228,6	-	-	-50,4	-	-	-	-	-	-	-572,8
Gross inland consumption	**8.838,0**	**4.021,4**	**332,7**	**3.316,4**	**-184,4**	**951,1**	**12,4**	**1.772,5**	**77,6**	**45,6**	**165,3**	**43,7**	**37,7**	**-**	**19.445,4**
Refineries	-	-4.021,4	3.835,4	-118,0	-	-	-	-	-	-	-	-	-	-	-304,1
CHP and Autoproducers	-9,6	-	-37,3	-108,9	148,8	-	-	-12,2	-	-1,0	-	-	-5,5	-	-25,6
Facilities for electricity generation	-8.130,3	-	-81,9	-61,1	4.016,9	-951,1	-	-41,3	-	-	-165,3	-43,7	-32,2	-	-5.490,1
District heating plants	-40,8	-	-38,5	-860,3	-	-	-	-	-	-	-	-	-	843,6	-96,0
Blast furnace plant	-162,7	-	-	-	-	-	-	-	-	-	-	-	-	-	-162,7
Hydrogen production															-
Consumption in the energy sector	-	-	-	-34,6	-388,4	-	-	-	-	-	-	-	-	-37,3	-460,3
Losses	-	-	-	-20,8	-421,1	-	-	-	-	-	-	-	-	-91,5	-533,4
Transformation output	**-8.343,4**	**-4.021,4**	**3.677,7**	**-1.203,8**	**3.356,2**	**-951,1**	**-**	**-53,5**	**-**	**-1,0**	**-165,3**	**-43,7**	**-37,7**	**714,9**	**-7072,1**
Households	32,7	-	40,4	294,7	1.353,1	-	-	1.545,1	-	-	-	-	-	504,9	3.770,9
Public and commercial sector, other users	0,2	-	87,4	297,8	624,8	-	4,1	37,3	-	23,9	-	-	-	142,8	1.218,4
Transport	-	-	2.752,7	7,2	131,1	-	-	-	77,6	-	-	-	-	-	2.968,6
Industry	357,3	-	443,8	918,8	1.012,7	-	-	55,2	-	15,5	-	-	-	216,9	3.020,2
Agriculture	-	-	99,1	20,1	30,3	-	8,4	1,4	-	5,3	-	-	-	-	164,6
Final Non-Energy consumption	3,6	-	771,7	294,3	-	-	-	-	-	-	-	-	-	-	1.069,6
Energy available for final consumption	**393,8**	**-**	**4.195,1**	**1.832,9**	**3.152,0**	**-**	**12,4**	**1.639,0**	**77,6**	**44,7**	**-**	**-**	**-**	**864,6**	**12212,3**

*Includes forest and agricultural biomass

Table A4: Total Energy Balance in 2040, Scenario BAU

Total Energy Balance in 2040 Scenario BAU [1000 toe]	Coal and Coal products	Oil	Oil products	Natural gas	Electricity	Hidro Energy	Geothermal Energy	Biomass*	Biofuels	Biogas	Wind Energy	Solar Energy	Municipal solid waste	Heat	Total
Primary production	8.682,0	245,5	-	249,1	-	1.075,3	13,1	1.634,9	83,8	55,2	165,0	43,2	46,6	-	12.293,9
Import	477,5	3.927,1	776,0	3.250,0	42,5	-	-	72,1	-	-	-	-	-	-	8.545,2
Export	-9,8	-	-221,2	-	-245,3	-	-	-46,8	-	-	-	-	-	-	-523,1
Gross inland consumption	**9.149,7**	**4.158,1**	**555,3**	**3.499,1**	**-202,8**	**1.075,3**	**13,1**	**1.660,2**	**83,8**	**55,2**	**165,0**	**43,2**	**46,6**	**-**	**20.366,1**
Refineries	-	-4.157,8	3.965,1	-122,3	-	-	-	-	-	-	-	-	-	-	-315,0
CHP and Autoproducers	-16,5	-	-84,6	-106,8	125,9	-	-	-25,3	-	-1,0	-	-	-12,2	-	-120,4
Facilities for electricity generation	-8.436,8	-	-6,0	-62,8	4.282,3	-1.075,3	-	-43,5	-	-	-165,0	-43,2	-34,4	-	-5.584,7
District heating plants	-41,6	-	-41,3	-906,7	-	-	-	-	-	-	-	-	-	889,0	-100,6
Blast furnace plant	-169,6	-	-	-	-	-	-	-	-	-	-	-	-	-	-169,6
Hydrogen production															-
Consumption in the energy sector	-	-	-	-20,5	-402,9	-	-	-	-	-	-	-	-	-44,4	-467,8
Losses	-	-	-	-21,3	-447,6	-	-	-	-	-	-	-	-	-94,1	-563,0
Transformation output	**-8.664,4**	**-4.157,8**	**3.833,2**	**-1.240,3**	**3.557,7**	**-1.075,3**	**-**	**-68,8**	**-**	**-1,0**	**-165,0**	**-43,2**	**-46,6**	**750,5**	**-7.321,0**
Households	27,5	-	54,2	331,8	1.395,1	-	-	1.394,1	-	-	-	-	-	508,7	3.711,4
Public and commercial sector, other users	0,2	-	103,4	352,5	672,8	-	4,5	42,0	-	26,5	-	-	-	139,7	1.341,8
Transport	-	-	2.983,4	6,7	151,4	-	-	-	83,8	-	-	-	-	-	3.225,4
Industry	408,9	-	468,6	1.037,5	1.088,7	-	-	57,1	-	22,5	-	-	-	230,2	3.313,5
Agriculture	-	-	100,6	20,3	30,8	-	8,8	1,4	-	5,3	-	-	-	-	167,2
Final Non-Energy consumption	4,1	-	846,9	323,2	-	-	-	-	-	-	-	-	-	-	1.174,2
Energy available for final consumption	**440,7**	**-**	**4.557,1**	**2.072,0**	**3.338,8**	**-**	**13,4**	**1.494,7**	**83,8**	**54,2**	**-**	**-**	**-**	**878,7**	**12.933,5**

*Includes forest and agricultural biomass

Table A5: Total Energy Balance in 2045, Scenario BAU

Total Energy Balance in 2045 Scenario BAU [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Heat**	**Total**
Primary production	8.938,6	149,5	-	188,2	-	1.075,3	13,6	1.600,5	89,6	54,0	164,3	41,8	80,5	-	12.395,9
Import	467,9	4.226,4	813,3	3.483,1	34,9	-	-	78,3	-	-	-	-	-	-	9.103,9
Export	-9,3	-	-158,1	-	-255,6	-	-	-43,5	-	-	-	-	-	-	-466,5
Gross inland consumption	**9.397,2**	**4.364,4**	**653,5**	**3.671,3**	**-220,7**	**1.075,3**	**13,6**	**1.635,4**	**89,6**	**54,0**	**164,3**	**41,8**	**80,5**	**-**	**21.033,2**
Refineries	-	-4.364,4	4.162,1	-128,3	-	-	-	-	-	-	-	-	-	-	-330,6
CHP and Autoproducers	-16,0	-	-108,4	-98,2	82,4	-	-	-24,8	-	-0,7	-	-	-11,9	-	-177,7
Facilities for electricity generation	-8.708,6	-	-31,8	-62,8	4.490,5	-1.075,3	-	-77,6	-	-	-164,3	-41,8	-68,5	-	-5.740,2
District heating plants	-42,0	-	-55,4	-950,4	-	-	-	-	-	-	-	-	-	942,5	-105,3
Blast furnace plant	-174,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-174,4
Hydrogen production															-
Consumption in the energy sector	-	-	-	-14,1	-414,9	-	-	-	-	-	-	-	-	-55,4	-484,4
Losses	-	-	-	-22,7	-464,5	-	-	-	-	-	-	-	-	-96,0	-583,2
Transformation output	**-8.941,0**	**-4.364,4**	**3.966,5**	**-1.276,4**	**3.693,5**	**-1.075,3**	**-**	**-102,5**	**-**	**-0,7**	**-164,3**	**-41,8**	**-80,5**	**791,1**	**-7.595,8**
Households	0,7	-	44,9	390,5	1.376,9	-	-	1.365,5	-	-	-	-	-	508,3	3.686,8
Public and commercial sector, other users	-	-	101,7	403,9	735,6	-	4,8	48,0	-	27,5	-	-	-	137,6	1.459,1
Transport	-	-	3.204,8	4,8	171,7	-	-	-	89,6	-	-	-	-	-	3.470,9
Industry	443,3	-	488,4	1.145,5	1.142,2	-	-	51,1	-	20,5	-	-	-	245,5	3.536,6
Agriculture	-	-	101,3	20,8	31,3	-	8,8	1,4	-	5,3	-	-	-	-	168,9
Final Non-Energy consumption	4,3	-	909,0	346,8	-	-	-	-	-	-	-	-	-	-	1.260,2
Energy available for final consumption	**448,3**	**-**	**4.850,1**	**2.312,3**	**3.457,8**	**-**	**13,6**	**1.466,0**	**89,6**	**53,3**	**-**	**-**	**-**	**891,4**	**13582,5**

*Includes forest and agricultural biomass

Table A6: Total Energy Balance in 2050, Scenario BAU

Total Energy Balance in 2050 Scenario BAU [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Heat**	**Total**
Primary production	7.591,7	98,9	-	136,6	-	1.185,6	13,6	1.592,6	94,1	57,1	361,4	202,5	119,9	-	11.454,1
Import	457,6	4.274,6	1038,3	3.885,8	45,9	-	-	83,1	-	-	-	-	-	-	9.785,3
Export	-8,6	-	-136,4	-	-284,7	-	-	-40,1	-	-	-	-	-	-	-469,8
Gross inland consumption	**8.040,7**	**4.364,4**	**898,8**	**4.022,4**	**-238,8**	**1.185,6**	**13,6**	**1.635,6**	**94,1**	**57,1**	**361,4**	**202,5**	**119,9**	**-**	**20.769,6**
Refineries	-	-4.364,4	4.162,1	-128,3	-	-	-	-	-	-	-	-	-	-	-330,6
CHP and Autoproducers	-23,9	-	146,2	-99,4	88,4	-	-	-35,6	-	-0,5	-	-	-17,4	-	57,8
Facilities for electricity generation	-7.339,5	-	60,0	-168,6	4.595,6	-1.185,6	-	-113,2	-	-	-361,4	-202,5	-102,5	-	-4.817,8
District heating plants	-42,0	-	-55,4	-944,4	-	-	-	-	-	-	-	-	-	937,7	-104,1
Blast furnace plant	-190,4	-	-	-	-	-	-	-	-	-	-	-	-	-	-190,4
Hydrogen production															-
Consumption in the energy sector	-	-	-	-9,3	-362,6	-	-	-	-	-	-	-	-	-55,7	-427,6
Losses	-	-	-	-25,8	-480,3	-	-	-	-	-	-	-	-	-96,5	-602,6
Transformation output	**-7.595,8**	**-4.364,4**	**4.312,8**	**-1.375,8**	**3.841,1**	**-1.185,6**	**-**	**-148,8**	**-**	**-0,5**	**-361,4**	**-202,5**	**-119,9**	**785,6**	**-6.415,2**
Households	0,7	-	42,5	445,4	1.344,2	-	-	1.348,8	-	-	-	-	-	505,6	3.687,3
Public and commercial sector, other users	-	-	106,8	455,2	798,0	-	4,8	57,6	-	28,4	-	-	-	128,3	1.579,0
Transport	-	-	3.384,4	31,3	210,4	-	-	-	94,1	-	-	-	-	-	3.720,3
Industry	489,2	-	514,2	1.261,6	1.206,6	-	-	49,2	-	22,9	-	-	-	264,2	3.807,9
Agriculture	-	-	101,3	20,8	31,3	-	8,8	1,4	-	5,3	-	-	-	-	168,9
Final Non-Energy consumption	4,5	-	954,4	364,0	-	-	-	-	-	-	-	-	-	-	1.323,0
Energy available for final consumption	**494,4**	**-**	**5.103,6**	**2.578,3**	**3.590,6**	**-**	**13,6**	**1.457,0**	**94,1**	**56,6**	**-**	**-**	**-**	**898,1**	**14286,4**

*Includes forest and agricultural biomass

Total Energy Balance - Scenario S

Table A7: Total Energy Balance in 2025, Scenario S

Total Energy Balance in 2025 Scenario S [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Hydrogen**	**Heat**	**Total**
Primary production	6.263,5	824,0	-	296,2	-	895,2	9,1	1.668,1	29,6	19,1	199,2	70,9	26,3		-	10.301,2
Import	552,7	3.021,2	724,2	2.212,0	136,4	-	-	35,6	-	-	-	-	-		-	6.682,1
Export	-13,1	-	-578,5	-	-331,9	-	-	-57,1	-	-	-	-	-		-	-980,6
Gross inland consumption	**6.803,1**	**3.845,2**	**145,7**	**2508,2**	**-195,9**	**895,2**	**9,1**	**1.646,6**	**29,6**	**19,1**	**199,2**	**70,9**	**26,3**		**-**	**16.002,7**
Refineries	-	-3.816,3	3.639,5	-112,0	-	-	-	-	-	-	-	-	-		-	-288,8
CHP and Autoproducers	-7,9	-	-3,8	-66,4	156,4	-	-	-1,2	-	-1,0	-	-	-		-35,3	42,8
Facilities for electricity generation	-6.042,8	-	-17,9	-190,2	3.346,9	-895,2	-	-26,2	-	-	-199,2	-59,0	-26,3		219,5	-3.890,4
District heating plants	-40,8	-	-52,1	-761,9	-	-	-	-2,4	-	-	-	-	-		766,7	-90,5
Blast furnace plants	-262,7	-	-	-	-	-	-	-	-	-	-	-	-		-	-262,7
Production of hydrogen	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Consumption in the energy sector	-	-	-	-49,9	-341,5	-	-	-	-	-	-	-	-		-31,1	-422,5
Losses	-	-	-	-13,9	-410,8	-	-	-	-	-	-	-	-		-78,8	-503,5
Transformation output	**-6.476,3**	**-4.019,8**	**3.683,8**	**-1.194,3**	**2.751,0**	**-895,2**	**-**	**-29,8**	**-**	**-1,0**	**-199,2**	**-59,0**	**-26,3**		**841,0**	**-5.621,1**
Households	63,5	-	83,8	159,8	1.154,0	-	-	1.433,3	-	-	-	3,8	-		519,5	3.417,8
Public and commercial sector, other users	8,6	-	57,1	173,9	485,1	-	2,2	18,2	-	15,5	-	8,1	-		107,0	875,6
Transport	-	-	2.414,0	6,5	36,9	-	-	-	29,6	-	-	-	-		-	2.487,0
Industry	268,7	-	413,2	448,3	872,1	-	-	163,9	-	-	-	-	-		214,5	2.380,7
Agriculture	-	-	90,3	17,0	31,8	-	6,9	1,4	-	4,5	-	-	-		-	151,9
Final Non-Energy consumption	2,4	-	621,0	508,4	-	-	-	-	-	-	-	-	-		-	1131,8
Energy available for final consumption	**343,2**	**-**	**3.679,4**	**1313,9**	**2.580,1**	**-**	**9,1**	**1.616,8**	**29,6**	**20,0**	**-**	**11,9**	**-**		**841,0**	**10445,1**

* Includes forest and agricultural biomass

Table A8: Total Energy Balance in 2030, Scenario S

Total Energy Balance in 2030 Scenario S [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Hydrogen**	**Heat**	**Total**
Primary production	4.717,0	665,0	24,4	377,0	-	932,0	11,9	1.637,2	49,2	25,8	396,5	241,1	45,4		-	9.122,5
Import	523,6	3.690,1	581,8	2.648,8	125,9	-	-	35,3	-	-	-	-	-		-	7605,5
Export	-12,9	-	-787,5	-	-180,1	-	-	-53,7	-	-	-	-	-		-	-1.034,2
Gross inland consumption	**5.227,7**	**4.355,1**	**-181,3**	**3.025,8**	**-54,2**	**932,0**	**11,9**	**1.618,8**	**49,2**	**25,8**	**396,5**	**241,1**	**45,4**		**-**	**15693,8**
Refineries	-	-4.355,1	4.154,3	-127,3	-	-	-	-	-	-	-	-	-		-	-328,1
CHP and Autoproducers	-4,8	-	-1,4	-113,7	133,8	-	-	-0,2	-	-0,7	-	-	-		24,1	37,1
Facilities for electricity generation	-4.578,7	-	-18,2	-217,4	3.380,1	-932,0	-	-45,4	-	-	-396,5	-241,2	-45,4		163,1	-2.931,5
District heating plants	-32,7	-	-22,9	-769,3	-	-	-	-21,4	-	-	-	-	-		743,3	-103,0
Blast furnace plants	-47,8	-	-	-	-	-	-	-	-	-	-	-	-		-	-47,8
Production of hydrogen	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Consumption in the energy sector	-	-	-	-46,8	-269,9	-	-	-	-	-	-	-	-		-28,7	-345,4
Losses	-	-	-	-5,0	-401,3	-	-	-	-	-	-	-	-		-69,3	-475,5
Transformation output	**-4.662,5**	**-4.576,1**	**4.181,7**	**-1.279,5**	**2.842,7**	**-932,0**	**-**	**-67,0**	**-**	**-0,7**	**-396,5**	**-241,2**	**-45,4**		**832,6**	**-4343,9**
Households	33,2	-	95,1	190,6	1.165,7	-	-	1.442,4	-	-	-	14,6	-		548,2	3.489,6
Public and commercial sector, other users	0,2	-	79,3	212,3	487,4	-	4,3	17,7	-	16,0	-	9,8	-		90,5	917,5
Transport	-	-	2.399,7	13,4	41,3	-	-	-	49,2	-	-	-	-		-	2.503,6
Industry	203,6	-	450,0	603,6	1.029,9	-	-	90,3	-	4,8	-	-	-		193,9	2.576,0
Agriculture	-	-	95,5	16,0	33,4	-	7,6	1,4	-	4,3	-	-	-		-	158,4
Final Non-Energy consumption	2,4	-	695,0	710,4	-	-	-	-	-	-	-	-	-		-	1407,8
Energy available for final consumption	**239,4**	**-**	**3.814,6**	**1.746,3**	**2.757,7**	**-**	**11,9**	**1.551,8**	**49,2**	**25,1**	**-**	**24,4**	**-**		**832,6**	**11053,0**

* Includes forest and agricultural biomass

Table A9: Total Energy Balance in 2035, Scenario S

Total Energy Balance in 2035 Scenario S [1000 toe]	Coal and Coal products	Oil	Oil products	Natural gas	Electricity	Hidro Energy	Geothermal Energy	Biomass*	Biofuels	Biogas	Wind Energy	Solar Energy	Municipal solid waste	Hydrogen	Heat	Total
Primary production	4.802,6	482,0	-	309,5	-	1.001,4	27,5	1.741,1	56,1	16,8	655,9	596,3	78,5	127,1	-	9.894,6
Import	360,0	2.432,0	691,2	2.310,1	410,5	-	-	-	-	-	-	-	-	-	-	6.203,8
Export	-	-	-	-	-457,1	-	-	-	-	-	-	-	-	-	-	-457,1
Gross inland consumption	**5.162,6**	**2.914,0**	**691,2**	**2.619,5**	**-46,6**	**1.001,4**	**27,5**	**1.741,1**	**56,1**	**16,8**	**655,9**	**596,3**	**78,5**	**127,1**	**-**	**15.641,3**
Refineries	-	-2.914,3	2.974,0	-100,3	-	-	-	-	-	-	-	-	-	-	-	-40,6
CHP and Autoproducers	-53,8	-	-44,3	-51,0	27,1	-	-	-9,5	-	-5,5	-	-	-	-	84,8	-52,3
Facilities for electricity generation	-4.711,2	-	-	-493,4	3.830,5	-1.001,4	-	-98,1	-	-	-655,9	-533,3	-54,9	-	299,4	-3.418,2
District heating plants	-12,0	-	-23,4	-396,3	-6,5	-	-	-55,7	-	-	-	-29,3	-23,6	-	491,1	-55,8
Blast furnace plants	-165,6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-165,6
Production of hydrogen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Consumption in the energy sector	-2,2	-	-	-147,1	-322,7	-	-	-	-	-	-	-	-	-	-50,0	-522,0
Losses	-0,9	-	-118,2	-19,9	-407,3	-	-	-	-	-	-	-	-	-	-75,4	-621,7
Transformation output	**-4.945,8**	**-2.914,3**	**2.788,1**	**-1.208,0**	**3.121,2**	**-1.001,4**	**-**	**-163,3**	**-**	**-5,5**	**-655,9**	**-562,6**	**-78,5**	**-**	**749,9**	**-4.876,2**
Households	-	-	49,7	176,7	1.166,5	-	10,0	1.445,5	-	-	-	22,2	-	-	501,7	3.372,3
Public and commercial sector, other users	-	-	78,1	217,3	513,3	-	9,6	33,9	-	6,9	-	11,5	-	-	58,3	928,9
Transport	-	-	2.037,8	5,0	189,5	-	-	-	56,1	-	-	-	-	127,1	-	2415,5
Industry	205,6	-	447,8	711,5	1.169,4	-	-	97,2	-	-	-	-	-	-	189,9	2821,4
Agriculture	-	-	101,0	13,9	35,4	-	7,9	1,2	-	4,3	-	-	-	-	-	163,7
Final Non-Energy consumption	11,5	-	764,3	286,6	-	-	-	-	-	-	-	-	-	-	-	1.062,4
Energy available for final consumption	**217,2**	**-**	**3.478,8**	**1.411,1**	**3.074,1**	**-**	**27,5**	**1.577,8**	**56,1**	**11,2**	**-**	**33,7**	**-**	**127,1**	**749,9**	**10.764,4**

* Includes forest and agricultural biomass

Table A10: Total Energy Balance in 2040, Scenario S

Total Energy Balance in 2040 Scenario S [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Hydrogen**	**Heat**	**Total**
Primary production	4.226,3	243,0	-	249,0	-	1.085,7	43,7	1.741,1	52,3	19,9	867,7	990,9	79,2	-	-	9.532,8
Import	157,9	2.483,1	700,0	2.578,8	-	-	-	-	-	-	-	-	-	115,0	-	6.034,8
Export	-	-	-	-	-108,0	-	-	-	-	-	-	-	-	-	-	-108,0
Gross inland consumption	**4.384,2**	**2.726,1**	**700,0**	**2.827,9**	**-108,0**	**1.085,7**	**43,7**	**1.675,1**	**52,3**	**19,9**	**867,7**	**990,9**	**79,2**	**115,0**	**-**	**15.459,7**
Refineries	-	-2.726,3	2.782,2	-93,8	-	-	-	-	-	-	-	-	-	-	-	-37,9
CHP and Autoproducers	-59,0	-	-26,4	-58,0	16,2	-	-	-6,4	-	-8,5	-	-	-	-	97,6	-44,5
Facilities for electricity generation	-4.012,7	-	-	-673,2	4.318,3	-1.085,7	-	-178,4	-	-	-867,7	-917,4	-54,9	-	301,4	-3.170,3
District heating plants	-	-	-	-398,6	-13,1	-	-	-71,8	-	-	-	-30,2	-24,3	-	502,8	-35,2
Blast furnace plants	-24,5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-24,5
Production of hydrogen	-	-	-	-	-215,2	-	-	-	-	-	-	-	-	150,6	-	-64,6
Consumption in the energy sector	-2,3	-	-	-138,5	-301,4	-	-	-	-	-	-	-	-	-	-51,5	-493,7
Losses	0,9	-	-112,2	-20,2	-411,5	-	-	-	-	-	-	-	-	-	-77,7	-620,7
Transformation output	**-4.097,6**	**-2.726,3**	**2.643,6**	**-1.382,2**	**3.393,1**	**-1.085,7**	**-**	**-256,6**	**-**	**-8,5**	**-867,7**	**-947,7**	**-79,2**	**150,6**	**772,6**	**-4.491,5**
Households	-	-	55,2	134,7	1.120,7	-	23,4	1.304,8	-	-	-	30,3	-	-	521,3	3.190,4
Public and commercial sector, other users	-	-	94,1	202,1	545,3	-	12,4	20,3	-	6,9	-	12,9	-	-	61,4	955,4
Transport	-	-	1.847,7	5,5	323,3	-	-	-	52,3	-	-	-	-	230,5	-	2459,3
Industry	188,2	-	435,4	776,0	1.257,9	-	-	92,4	-	-	-	-	-	35,6	189,9	2.975,5
Agriculture	-	-	99,6	17,2	37,7	-	7,9	1,2	-	4,5	-	-	-	-	-	168,1
Final Non-Energy consumption	12,2	-	812,1	310,5	-	-	-	-	-	-	-	-	-	-	-	1.134,7
Energy available for final consumption	**200,4**	**-**	**3.344,1**	**1.445,9**	**3.284,9**	**-**	**43,7**	**1.418,7**	**52,3**	**11,5**	**-**	**43,2**	**-**	**266,1**	**772,6**	**10.883,4**

* Includes forest and agricultural biomass

Table A11: Total Energy Balance in 2045, Scenario S

Total Energy Balance in 2045 Scenario S [1000 toe]	**Coal and Coal products**	**Oil**	**Oil products**	**Natural gas**	**Electricity**	**Hidro Energy**	**Geothermal Energy**	**Biomass***	**Biofuels**	**Biogas**	**Wind Energy**	**Solar Energy**	**Municipal solid waste**	**Hydrogen**	**Heat**	**Total**
Primary production	3.094,6	148,0	-	188,2	-	1.087,5	79,3	1.274,4	44,4	18,3	1.316,0	1.403,1	78,4	-	-	8.732,2
Import	170,1	2.334,9	726,8	2.865,1	-	-	-	-	-	-	-	-	-	223,0	-	6.319,8
Export	-	-	-135,0	-	-74,6	-	-	-	-	-	-	-	-	-	-	-209,6
Gross inland consumption	**3.264,7**	**2.482,9**	**591,8**	**3.053,2**	**-74,6**	**1.087,5**	**79,3**	**1.274,4**	**44,4**	**18,3**	**1.316,0**	**1.403,1**	**78,4**	**223,0**	**-**	**14.842,4**
Refineries	-	-2.482,9	2.533,7	-85,4	-	-	-	-	-	-	-	-	-	-	-	-34,6
CHP and Autoproducers	-37,7	-	-17,7	-39,4	10,8	-	-	-12,2	-	-7,1	-	-	-	-	65,5	-37,8
Facilities for electricity generation	-2.840,5	-	-	-892,2	4.774,2	-1.087,5	-	-267,6	-	-	-1.316,0	-1.321,9	-54,9	-	316,5	-2.689,9
District heating plants	-	-	-	-387,3	-12,8	-	-	-71,1	-	-	-	-29,2	-23,5	-	489,4	-34,5
Blast furnace plants	-166,2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-166,2
Production of hydrogen		-	-	-	-269,1	-	-	-	-	-	-	-	-	188,3	-	-80,8
Consumption in the energy sector	-2,2	-	-	-133,4	-292,2	-	-	-	-	-	-	-	-	-	-49,8	-477,6
Losses	-0,9	-	-98,0	-21,1	-437,1	-	-	-	-	-	-	-	-	-	-75,1	-632,1
Transformation output	**-3.047,4**	**-2.482,9**	**2.418,0**	**-1.558,9**	**3.773,9**	**-1.087,5**	**-**	**-350,9**	**-**	**-7,1**	**-1.316,0**	**-1.351,1**	**-78,4**	**188,3**	**746,6**	**-4.153,4**
Households	-	-	48,2	168,8	1.217,4	-	39,6	824,3	-	-	-	38,7	-	-	487,6	2.824,8
Public and commercial sector, other users	-	-	106,5	207,6	605,5	-	31,5	5,3	-	6,7	-	12,9	-	-	69,0	1.045,0
Transport	-	-	1.474,2	5,5	472,7	-	-	-	44,4	-	-	-		355,4	-	2.352,2
Industry	204,7	-	445,4	784,8	1.363,7	-	-	92,7	-	-	-	-		55,7	189,9	3.137,0
Agriculture	-	-	100,3	17,4	40,1	-	8,1	1,2	-	4,5	-	-	-	-	-	171,6
Final Non-Energy consumption	12,9	-	835,1	310,5	-	-	-	-	-	-	-	-	-	-	-	1.158,4
Energy available for final consumption	**217,5**	**-**	**3.009,8**	**1.494,7**	**3.699,3**	**-**	**79,3**	**923,5**	**44,4**	**11,2**	**-**	**51,6**	**-**	**411,1**	**746,6**	**10.688,9**

* Includes forest and agricultural biomass

Table A12: Total Energy Balance in 2050, Scenario S

Total Energy Balance in 2050 Scenario S [1000 toe]	Coal and Coal products	Oil	Oil products	Natural gas	Electricity	Hidro Energy	Geothermal Energy	Biomass*	Biofuels	Biogas	Wind Energy	Solar Energy	Municipal solid waste	Hydrogen	Heat	Total
Primary production	113,2	98,0	-	136,6	-	1.089,3	133,3	1.009,5	39,9	32,8	1.928,3	1.973,4	78,6	-	-	6.632,9
Import	376,7	2.510,6	1142,4	2.742,8	-	-	-	-	-	-	-	-	-	303,0	-	7.075,5
Export	-	-	-434,8	-	-71,3	-	-	-	-	-	-	-	-	-	-	-506,1
Gross inland consumption	**489,9**	**2.608,6**	**707,6**	**2.879,5**	**-71,3**	**1.089,3**	**133,3**	**1.009,5**	**39,9**	**32,8**	**1.928,3**	**1.973,4**	**78,6**	**303,0**	**-**	**13.202,4**
Refineries	-	-2.608,6	2.144,2	-76,9	-	-	-	-	-	-	-	-	-	-	-	-541,3
CHP and Autoproducers	-90,3	-	-44,8	-99,7	27,4	-	-	-13,5	-	-21,6	-	-	-	-	165,7	-76,8
Facilities for electricity generation	-	-	-	-606,8	5.297,1	-1.089,3	-	-365,7	-	-	-1.928,3	-1.882,3	-54,9	-	80,0	-550,2
District heating plants	-	-	-	-390,7	-20,2	-	-	-71,3	-	-	-	-29,5	-23,8	-	634,7	99,3
Blast furnace plants	-167,8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-167,8
Production of hydrogen	-	-	-	-	-322,8	-	-	-	-	-	-	-	-	226,1	-	-96,7
Consumption in the energy sector	-2,1	-	-	-126,7	-277,7	-	-	-	-	-	-	-	-	-	-50,3	-456,7
Losses	-0,8	-	-91,3	-21,8	-463,3	-	-	-	-	-	-	-	-	-	-75,8	-653,1
Transformation output	**-261,0**	**-2.608,6**	**2.008,1**	**-1.322,6**	**4.240,5**	**-1.089,3**	**-**	**-450,5**	**-**	**-21,6**	**-1.928,3**	**-1.911,8**	**-78,6**	**226,1**	**754,2**	**-2.443,4**
Households	-	-	11,0	150,0	1.328,0	-	43,5	458,7	-	-	-	47,3	-	-	477,1	2.515,5
Public and commercial sector, other users	-	-	115,6	212,6	676,9	-	81,7	5,0	-	6,7	-	13,9	-	-	87,2	1.199,5
Transport	-	-	1.185,4	5,3	627,6	-	-	-	39,9	-	-	-	-	464,3	-	2.322,5
Industry	215,2	-	443,5	837,6	1.494,6	-	-	93,9	-	-	-	-	-	64,7	189,9	3.339,5
Agriculture	-	-	100,3	17,4	42,6	-	8,1	1,2	-	4,5	-	-	-	-	-	174,1
Final Non-Energy consumption	13,6	-	859,8	334,4	-	-	-	-	-	-	-	-	-	-	-	1.207,8
Energy available for final consumption	**228,8**	**-**	**2.715,7**	**1.557,2**	**4.169,6**	**-**	**133,3**	**558,8**	**39,9**	**11,2**	**-**	**61,1**	**-**	**529,0**	**754,2**	**10.759,0**

* Includes forest and agricultural biomass

Table A13: Indicators – BAU scenario

Year	2025.	2030.	2035.	2040.	2045.	2050.
Net import dependency	33.7%	35.8%	37.0%	39.5%	41.1%	44.8%
Share of RES in gross final energy consumption	29.1%	27.4%	26.3%	25.0%	24.1%	26.6%
Share of RES in electricity generation	30.9%	28.8%	28.6%	29.9%	29.4%	38.6%
Share of RES in heating/cooling	41.7%	37.9%	35.6%	32.3%	31.2%	30.3%
Share of RES in transport	1.4%	3.7%	4.0%	4.1%	4.2%	4.9%

Table A14: Indicators – Scenario S

Year	2025.	2030.	2035.	2040.	2045.	2050.
Net import dependency	35.6%	41.9%	36.7%	38.3%	41.1%	49.8%
Share of RES in gross final energy consumption	29.5%	33.6%	40.3%	44.8%	52.7%	62.9%
Share of RES in electricity generation	*35.5%*	*45.3%*	*57.8%*	*73.3%*	*80.4%*	*97.6%*
Share of RES in heating/cooling	*39.8%*	*41.4%*	*43.9%*	*44.5%*	*41.0%*	*39.1%*
Share of RES in transport	*1.8%*	*3.0%*	*5.3%*	*9.9%*	*23.9%*	*44.8%*