Logo of the Romanian Government

Logo of 100th anniversary of the Romanian State

MINISTRY OF ENERGY

Romanian Energy Strategy for 2019-2030 in view of 2050

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FOREWORD

„The development and the growth of the economic competitiveness of Romania, the growth in the quality of life and the care for the environment are inseparably bonded with the development and the modernisation of the energy system." This is the phrase that the project for the Energy Strategy of Romania begins with, this is the concept that this pragmatic document is built on, and the main beneficiary of implementing the Energy Strategy shall be the consumer.

Romania urgently needs development benchmarks, and the view of the Energy Strategy is to grow the Romanian energy sector. The development of the energy sector requires, on one hand, coherent and clear energy policies, and on the other hand – investments. The growth of the Romanian economy means, from the energy sector's perspective, building of new energy production capacities; rehabilitation and modernisation of the production, transport and energy distribution capacities; supporting the internal consumption growth while being energy efficient; export.

The Energy Strategy is neither a speculative document nor an exclusively theoretical one. The Energy Strategy proposes real target, sets clear directions and defines the milestones by which Romania shall maintain its leader position regarding the energy production in the area and the one as an active and important player in managing the stress situations on a regional level.

The development of the energy sector is directly proportional with the accomplishment of some strategic investment projects that are of a national importance. These investments, which shall produce changes on a substance level and shall make the entire sector more dynamic, are fixed and mandatory benchmarks in the strategic programming. In the Energy Strategy of Romania, there are considered as strategic investments of national interest, the following objectives:

1. The completion of the Power Units No. 3 and No. 4 from Cernavoda Nuclear Power Plant;
2. The construction of Tarnita-Lapustesti pumped-storage hydroelectric power station
3. The construction of the 600 MW Power Unit from Rovinari
4. The construction of the Turnu-Magurele – Nicopole Hydrotechnic Complex

Also, the Energy Strategy states the position of Romania regarding the reformatory proposals for the European energy market, and an important place is kept for the assessment of the European context and policies that shall be on the base of the European Union that we shall be part of.

By implementing the objectives from the Energy Strategy, the national energy system shall be stronger, safer and stable. We have the necessary energy sources, we have a diversified and balanced energy mix and we have the determination for making Romania an energy security provider within the region.

Anton Anton,
Minister of Energy

INTRODUCTION

The development and the growth of the Romania`s economy competitiveness, the growth of the life quality and the care for the environment are inseparably bonded with the rehabilitation and the modernisation of the energy system.

Romania has the resources necessary for the growth of the energy system, and this must be prepared to sustain the development of the industry and agriculture, of the economy as a whole, as well as the improvement of the quality of life both in urban and rural environment. These resources must be valued in order to move from a waiting state to a proactive and courageous development state, complying, of course, with the durability principle.

The **"Romanian Energy Strategy for 2019-2030 in view of 2050"** is a programmatic document which defines the view and sets the fundamental objectives of the development process for the energy sector. Also, the documents indicate that the national, European and global benchmarks that influence and determine the policies and the decisions within the energy field.

The view of the Romanian Energy Strategy (*Chapter I*) is to grow the energy sector on a sustainability basis. The development of the energy sector is part of the Romania`s development process. The growth of the energy system means: building new capacities; rehabilitation and modernization of the production, transport and energy distribution capacities; encouraging the growth of the internal consumption while being energy efficient; export. By these, the national energy system shall be stronger, safer and more stable.

The Energy Strategy has **eight fundamental and strategic objectives (*Chapter II*)** which are structuring the entire assessment and planning process for the period between 2019 and 2030 and in view of 2050. The achieving of these objectives imposes a balanced approach regarding the development of the national energy system both from the perspective of the national and European regulations, as well as from the perspective of the investments expenses.

The objectives of the Energy Strategy:

1. **Clean energy and energy efficiency;**
2. **Ensuring access on electric and thermal energy for all of the consumers;**
3. **The protection of the vulnerable consumer and reduction of energy poverty;**
4. **Competitive energy markets, the base of a competitive economy;**
5. **The modernization of the energy governance system;**
6. **The growth in the quality of the education in the energy field and the continuous training for the human resource;**
7. **Romania, a regional provider for energy security;**
8. **Growth in the energy input of Romania on the regional and European markets by valuing the national primary energy resources.**

The strategic objectives shall be achieved simultaneously trough a set of operational objectives which have subsumed a series of practical priority actions. (*Chapter V*).

According to the view of the eight fundamental objectives of the Energy Strategy, the development of the energy sector is directly proportional with the achievement of some strategic investment projects that are of national interest ***(Chapter III)***.

These investments shall produce substance changes and shall make the entire sector more dynamic. Strategic investments of national interest are fixed and mandatory benchmarks related to the strategic programming; all the other necessary measures in order to achieve the strategic objectives shall be implemented on the premises of achieving the strategic investments of national interest.

In the Romanian Energy Strategy, there are considered as strategic investments of national interest, the following objectives:

1. The completion of the Power Units No. 3 and No. 4 from Cernavoda Nuclear Power Plant;
2. The construction of Tarnita-Lapustesti pumped storage hydroelectric power station;
3. The construction of the 600 MW Power Unit from Rovinari;
4. The construction of the Turnu-Magurele – Nicopole Hydrotechnic Complex.

The achievement of the strategic objectives imposes a rigorously transposition into the reality of the energy sector, together with a good understanding of the international context and of the technological, economic and geopolitical trends. ***(Chapter IV)***.

In the Energy Strategy, an important place is kept for the assessment of the European context and of the policies

that are on the base of the Energy Union (***Chapter IV.2***). The Strategy orientates and substantiates Romania`s position in relation with the reforming proposals for the European energy market and presents, through the operational objectives and the priority actions, the strategic options for the interference of the Romanian state in the energy sector.

In the same time, from the perspective of the regional energy policies, the Strategy reiterates the importance of the inter-connections that are being constructed in Central and Eastern Europe. These contribute to the development of the energy markets and of the regional mechanisms for energy security which shall operate according to the joint regulations of EU (***Chapter IV.3.1***). On this chapter, it must be mentioned that the inter-connection of the Romania`s transport systems for natural gases and electric energy with the ones from the Republic of Moldova represents a strategic objective for the governments of the two countries. Also, it is important to mention that, in this context, Romania can be highlighted as a regional provider for energetic security (***Chapter IV.3.2***).

The defining of the view and of the fundamental objectives, as well as the set out of the strategic investments that are of national interest have taken into consideration **the energy resources of the country**, as well as the fact that Romania has an **balanced and diversified energy mix (*Chapter IV.4*).**

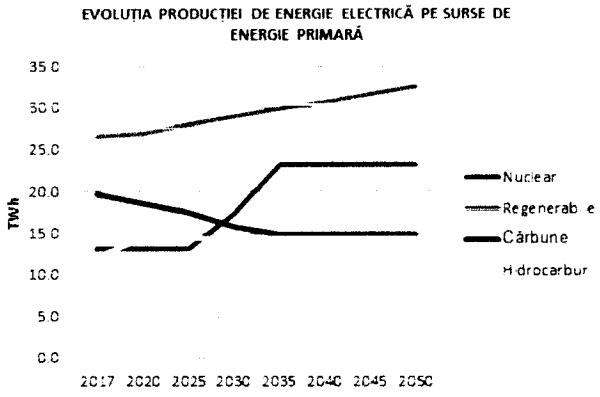
PRIMARY ENERGY RESOURCES	RESOURCES		RESERVES		ESTIMATED ANNUAL PRODUCTION		ASSURANCE PERIOD WITH RESOURCES AND RESERVES	
							RESOURCES	RESERVES
	Million Tons[1)]	Million Toe	Million Tons[1)]	Million Toe	Million Tons[1)]	Million Toe	YEARS	YEARS
LIGNITITE	690	124	290	52	25	4,5	28	12
HARD COAL	232	85	83	30	0,8	0,3	290	104
OIL	229,2		52,6		3,4		67,4	15,5
NATURAL GAS	726,8		153		10,5		69,2	14,6
URANIUM[2)]								

[1)]excluded natural gas espressed in Billion m^3

[2)]data with special requirements available in the classified annex

The Energy Strategy establishes that **Romania shall maintain its leader position in the region, in energy production and shall have an active and important role in managing the stress situations on regional level.**

In 2016, there has been carried out a complex study for macro-economic modelling, simulating and comparing a number of development scenarios. For the year 2030 **(Chapter VI)**, the results of the modelling in the Optimum Scenario that has been selected (corroborating the data of 2017, the objectives of the Energy Strategy and the objectives for strategic investments) show a growth of the energy production on nuclear sources from 17.4 TWh in 2030, to 23.2 TWh in 2035. A growth to 29 TWh shall be registered on the total amount of renewable sources, representing a share of 37.6% from the total of the primary energy sources that shall be at the base of the energy mix in 2030. The energy obtained from coal shall be 15.8 TWh and shall have a share of 20.6%. A growth of 1.9% shall be registered for the production of electric energy on hydrocarbs, of approximately 14.5 TWh.



EVOLUTIA PRODUCTIEI DE *ENERGIE ELECTRICA PE SURSE*

DE ENERGIE PRIMARA – EVOLUTION OF THE ELECTRICITY PRODUCTION BY PRIMARY ENERGY SOURCES
Nuclear – Nuclear power
Regenerabile – Renewable energy
Carbune – Coal
Hidrocarburi - Hydrocarbons

The Strategy takes into consideration the perspective of year 2050, also (***Chapter VII***). The projections for year 2050, even with a great degree of incertitude, are relevant for the view and for the fundamental objectives for system development of the energy system undertook by the Strategy.

I. THE VIEW OF THE ENERGY STRATEGY

Due to the intense development of the national industry before 1990, highly energy consuming, the Romanian energy sector has been subject to a great development pressure. The view of developing the energy sector was based on the concept of energetic independence and it was prioritized the discovering and the valuing of the energy resources that were on national territory. Also, there were an urge on developing own technologies for the exploitation the resources and there was a continuous development of the production capacities.

A significant part of the energetic capacities have been developed integrated with other industrial objectives. The industrial sites have been developed having their own power plants that produced both a part of the electric energy necessary on the industrial site and also the thermal agent; these were integrated even with the systems for supplying the thermal agent for household consumers.

Also, in that period, as a result of the growing energy demand, there have been intensively developed the exploitations for primary energy resources: coal mining, extraction sites, hydroelectric facilities.

The energy transport infrastructure has been developed according to the same principles. The power lines and the electric stations, the transport pipelines, the terminal points of these and their respective stations, as well as a part of the railroads have been developed in order to ensure the proper delivery for the industrial objectives.

In the 28 years that have passed since 1990, the Romanian energy sector had to deal with the major economic changes from Romania, most of them referring to general reduction of the economic activities within the energy consuming sectors.

Presently, the primary energy resources, their derivates and the most valuable end products – electric energy, thermal energy or fuels – are considered assets with merchandise value which are transacted both on the national market, as well as on the regional, European or global markets.

By the accession of Romania to the European Union, the concept of the energy independence was upgraded, and gradually, replaced by the concept of energy security. The entire Romanian energy sector was subject to the transition from the energy independence to the free markets conditions.

Therefore, the main challenge for the energy sector is reconfiguring the activities in order to deal with the market competition.

Since 1990 until present date, gradually, multiple primary resources exploitation capacities have been closed, as well as production capacities for electric energy and thermal agent. The main reasons for this fact are related to the general reduction of the economic activity, the low profitability or the failure to comply with the environmental requirements.

Although a part of the activities from this field were privatized or leased to private investors, a significant part is still under the management of the state.

From this perspective, without an unitary planning of the entire development of the country, it is possible that at the end of 2030's the Romanian energy sector shall follow the downward trend that has been present in the past 28 years.

The view of the Romanian Energy Strategy is to grow the energy sector on a sustainability basis. The development of the energy sector must be taken as a part of the Romania's development process.

The growth means: building new production capacities based on high end green technologies; rehabilitation and modernization of the existing production capacities in order to make them to comply with the environmental requirements, energy transport and distribution;

encouraging the increase within the internal consumption while being energy efficient; export. The national energy system shall thus be safer and more stable.

Romania has the necessary resources for the growth of the energy system, and this must be prepared to sustain the development of the industry and agriculture, of the economy as a whole, as well as the increase of the life quality both in urban and rural environment.

The view of the Romanian Energy Strategy is based on the achievement of eight strategic objectives and the implementation of a strategic investment program that is of national interest.

II. FUNDAMENTAL STRATEGIC OBJECTIVES

The Energy Strategy has eight fundamental strategic objectives that divide the entire assessment and planning process for 2019-2030 with the premises of 2050. The achievement of these objectives imposes a balanced approach towards the development of the national energy sector, correlated with the value of the investments costs.

The strategic objectives shall be fulfilled simultaneously through a set of operational objectives that have priority actions divided in time, with an implementation schedule for short, medium and long period.

II.1. Clean energy and energy efficiency

During the evolution process of the energy sector, Romania shall follow the best practices regarding the environmental protection, complying with the national benchmarks undertaken as a Member State.

In the same time, the development of the energy system shall ensure the energy efficiency, as defined in the EU instructions and in the national laws.

II.2. Providing access to electrical and thermal energy for all consumers

This objective aims to continue the electrification program as well as the development and the profitability of the system ensuring the thermal agent.

This objective sets as a priority the completion of the electrification process in Romania and the maintenance of the electric energy transmission systems in close relation with the social-economic development.

Also, the objective refers to the necessity of setting out the principles that shall be on the base of the way by which the heating agent shall be provided in the urban environment, but also the implementing of some policies that shall find alternative solutions for rural environment.

II.3. Vulnerable consumer protection and reduction of energy poverty

Price accessibility is one of the main challenges for the energy system and represents a strategic responsibility.

Development policies and the fair adjustment of the social assistance in the energy field, especially in the areas with high poverty, shall ensure a real protection for the vulnerable consumers.

II.4. Competitive energy markets, the grounds for a competitive economy

The energy system should operate based on the free market mechanisms, the main role of the State being to issue policies, being regulator, keeper of the stability of the energy system, investor.

II.5. Energy governance system modernization

The State has a double role in the energy sector: on one hand, it is a law maker, regulator and energy policies implementer, and on the other hand is the keeper and administrator of assets or significant shareholder both in the natural (electric energy and natural gas transmission and distribution), and production, also.

In a market based system, the State has the essential role as arbitrator and regulator of the markets. In this purpose, it is necessary a legal and regulation framework that is transparent, coherent, fair and stable.

As an assets owner, the State must improve the management of the companies that it has shares on. The energy companies that have state-owned capital must become more efficient, more professional and must be modernized. Making management more professional and depoliticizing the management in the companies that are controlled by the state, along with the supervision without interferences of the administrative process represents, especially within the energy sector, strategic benchmarks.

II.6. Increasing the quality of education and innovation in the energy field and the ongoing training of the human resources

The energy sector faces a great lack of professionals. The qualified personnel is mainly aged, and a part of the active qualified personnel chose to leave Romania.

The training and the ongoing improvement of an energy specialist, regardless of his position or the level of his studies, is a complex one. The increase of the number of professionals in the energy field implies the improvement in the quality and the attractiveness of the specialized education.

Developing the skills and abilities of the energy specialists means developing specific educational packages at all levels: high schools and public and dual-level vocational schools, in-service training, modern bachelor and master programs as well as doctoral schools in this field.

The innovation based on scientific research and the technological development requires the encouragement and development of excellence centers in the energy field, in particular regarding renewable energies, that are capable of carrying out complex projects on a theme that is defined by the projected developments of the energy sector, thus providing a good know-how to ensure optimal performance for the new investments, respectively for the operation and retechnologization of existing equipment.

The success on implementing the view and the objectives of the Romanian Energy Strategy is directly proportional with the investment in the quality of the education and training in the energy field, as well as the innovation based on scientific research and technological development.

II.7. Romania, the energy security regional provider

Romania has a higher score for energy security that is higher than the OECD average and better than its neighbors. The present international context on the energy markets is characterized by volatility, and the evolution of technologies can have disruptive effects on the energy markets.

In this context, there are the premises that, by developing the energy sector, keeping in mind the availability of the resources and the stability offered by the maturity of traditional technologies, Romania shall consolidate its position as energy security regional provider.

II.8. The increase of Romania's energy contribution on regional and European markets by valuing the national primary energy resources

This objective expresses the development view of Romania in regional and European context and the will to become a main player of EU in this field.

Romania takes part on a large process for integrating the EU energy markets, the effect being a wider competition on the energy markets.

Romania has the necessary primary energy resources, this must be coherently valued, in terms profitability, accompanied by the increase of the inter-connectivity level.

This objective shall be reached through a development program for the strategic objectives that are of national interest.

III. THE PROGRAM FOR THE NATIONAL INTEREST STRATEGIC INVESTMENTS

According to the view and to the eight fundamental objectives from the Energy Strategy, the development of the energy sector is directly proportional with the achievement of some investment projects of national interest.

These investments shall produce substance changes and shall make the entire sector more dynamic. The national interest strategic investments are fixed and mandatory benchmarks in what concerns the strategic programming; all the other measures necessary for achieving the strategic objectives shall be implemented on the premises that the national interest strategic investment projects shall be achieved.

In the Romanian Energy Strategy, there are considered as strategic investments of national interest, the following objectives:

1. The completion of the Power Units no. 3 and no. 4 from the Cernavoda Nuclear Power Plant;
2. The construction of Tarnita-Lapustesti pumped storage hydroelectric power station;
3. The construction of the 600 MW Power Unit from Rovinari;
4. The construction of the Turnu-Magurele – Nicopole Hydrotechnic Complex.

III.1. Completion of Power Units No. 3 and No. 4 from the Cernavoda Nuclear Power Plant

The nuclear energy, a low carbon emissions energy source, has a significant share in the national electrical energy production – approximately 18% -, and represents a basic component for the Romania`s energy mix. The nuclear energy in Romania is based on internal resources and infrastructure covering the entire open cycle for nuclear fuel; practically, Romania has a high level of independency in what concerns the production of nuclear energy.

The assessments regarding the achieving of the environmental objectives and benchmarks and the energy security, the safety in supplying and the diversification of the sources in order to obtain a balanced energy mix, which could offer a bearable price for the consumers, indicate that the Project for the Power Units No. 3 and No.4 from Cernavoda Nuclear Power Plant represents one of the optimal solutions for covering the deficiency regarding the production capacities for electric energy, predicted for 2028-2035, following the reaching the operating lifetime on multiple existing capacities.

The project for Power Units no. 3 and 4 at Cernavoda Nuclear Power Plant foresees the completion and commissioning of two CANDU 6 nuclear units, each with an installed capacity of 720 MW, a power unit being predicted to be put into operation by 2030.

Increasing the production capacity on Cernavoda Nuclear Power Plant is, also an investment measure sustained by the Romania`s energy security objective. The achieving of the investment objective shall ensure an additional energy contribution on the energy system of about 11 TWh, as well as an increase on the installed capacity of 1,440 MW.

Taking into account the operational feature of Cernavoda Nuclear Power Plant, this capacity shall have a high availability level and shall ensure the coverage of the production and consumption curves from NES. The systemic effects that shall arise after the commissioning of these two new power units shall be the following:

- increasing the production capacity of NES with positive effects on the energy security by ensuring the energy contribution of Romania on the regional markets;
- installing of new power units with high efficiency and reliability, which shall increase the global efficiency and reliability indicators for the production system;
- the power and energy excess from the system shall allow to temporarily withdraw from operation other capacities in order to modernize and rehabilitate them or retiring those capacities on which these actions are not justified;
- the transition to an energy sector with low emissions of green house gases;
- maintaining the production capacities from the national territory including the cost efficient activities in the field of uranium exploitation, nuclear fuel processing and production with positive effects also on the management of social issues in the mining field;
- recovery of the investments from the construction of Power Units 3 and 4 from Cernavoda Nuclear Power Plant;
- valuing the reserves of heavy water constituted in the previous years for the operation of Cernavoda Nuclear Power Plant with 4 operational power units;
- ensuring a transparent participation of the horizontal nuclear industry from Romania

(engineering, designing, manufacturing of equipments, etc.) and the increase of the number of jobs (approximately 19.000).

III.2. Construction of a new power unit of 600 MW at Rovinari

Presently, the net installed and available capacity (including the one that is in reserve for ancillary services) on lignite and hard coal fired thermal power plants is about 3300 MW.

The competitiveness of the coal in the electric energy mix depends on:

1. the performance of each power unit, which is relatively low for the existing capacities;
2. the cost of the delivered coal, which is on a relatively high level;
3. the price of the EU-ETS allowances.

In order to maintain its place in the energy mix, the cost of the lignite must be as low as possible, and the self technological consumption of the power units must be reduced. The new lignite powered capacities must have ultra-critic parameters, high efficiency, operational flexibility and low emissions of green house gases.

The price predictions for the electric energy and for the ETS allowances indicate the need to maintain the lignite competitiveness in the energy mix, on a level that is similar to the present one, at least until 2025.

The lignite shall have a great importance in ensuring the adequacy during the stressful situations of NES, as wll as during the extended drought periods of high frost.

The lifetime of the existing power units shall depend on whether they shall manage to remain competitive in the electric energy mix and to fulfill their environmental obligations.

On long term, the lignite`s place in the energy mix can be maintained by developing new capacities, that are equiped with technology for the capture, transport and geological storage of CO2 (CSC).

The results of the modelling indicates the feasibility, starting with 2020, of the projects for new lignite fired thermal power plants with super-critical parameters, and from 2015 with the condition that these shall have the technology for capture, transport and geological storage of CO2 (CSC). The modelling indicates that a lignite fired power plant with CSC could be built, with a capacity between 600MW- 1000 MW.

Thus, the construction of a super-critical 600 MW capacity, on lignite, that could start the production after 2020, and on which it could be added an installation for the capture, transport and geological storage for CO2 starting with 2035, is not only necessary, but is mandatory in order to ensure the energy mix with an optimal cost on a systemic level.

The power unit shall use lignite from the open pits that are placed near by the investment objective.

Macroeconomics advantages:

- access to modern technologies in an energy investment of about one billion Euros, taking into consideration that in the last 25 years there have not been made any investments in the Romanian thermal energy sector;
- access on modern and viable management regarding the environmental protection;
- the consolidation of the national energy market and of the diversified energy mix by valuing the primary energy resources;
- incentivizing the internal investments by using a part of the equipments and materials from Romania;
- creating jobs during the project implementation period (approx. 4000).

iii.3. Construction of Tarnita Lapustesti Pumped-Storage Hydroelectric Power Station

Taking into consideration that, in view of 2030, in the technological mix of the electric energy production system in Romania the share of the nuclear and of the renewable sources share and shall increase, there are necessary capacities that could ensure the flexibility of the electro energy system.

By constructing the two new nuclear power units and by maintaining a growing level of the production capacities on intermittent renewable sources, the construction of a pumped storage hydroelectric capacity is mandatory for the stability of the electricity system.

In 2030, there also is the perspective of other energy storage technologies, but these, at the moment, do not have sufficient technological maturity in order to be implemented. Thus, it is mandatory the construction of a storage facility with a capacity of approximately 1,000 MW on Tarnita-Lapustesti pumped-storage hydroelectric power station, that could intervene in system balancing on periods between 4 to 6 hours.

III.4. The construction of the Turnu-Magurele - Nicopole Hydrotechnic Complex

The water flow arrangement is not done only from the perspective of obtaining the electric energy. Once with the use for energy purposes, the arrangement must allow other uses as well: protection against floods and their safely passing, ensuring water for agriculture and industry, navigation and development of marine infrastructure, development of roads and railroads passes across the water flows, drainage and restoration of some lands to their agricultural condition, etc.

One of the hydrotechnical projects with complex uses and with a high potential for regional economic development is Turnu-Magurele – Nicopole Hydrotechnic Complex. The project shall be achieved by arranging the Danube River on the downstream sector from Portile de Fier I and II up to downstream of the confluence with Olt River, within the cooperation agreement with the governments of Romania, Bulgaria and Serbia.

The hydrotechnical complex shall produce, in average, an amount of about 2,200 GWh/year, significantly contributing to the increase of Romania`s status as an energy security within the region.

By achieving this investment objective, there shall be created better navigation conditions on the Danube by reducing the cost for dredging, shortening the navigational canal, improvement of the harbors exploitation and eliminating the inconveniences created by the navigation during the periods with low water debits.

Also, it shall be ensured the water supply of the riverside settlements, without the condition of Danube`s water debit. Following the continuous and controlled operation of the drainage system the underground water in the Danube`s meadow shall be settled, making possible the construction of gravitational irrigation systems which shall lead to a significant increase of the agricultural production.

Furthermore, the project includes the achieving of a new road and railroad passage between Romania and Bulgaria, across the dam being designed a four-lane road and a double railroad.

The project is addressing to the authorities that administrate the fields of transport, electric energy generation, water management, but also to the local communities that are river side to the Danube, and from this reason, the way this investment shall be implemented required a government decision. The Government of Romania has approved by the Decision no. 643/23.08.2018 the inclusion of the Turnu-Magurele – Nicopole Hydrotechnic Complex project on the list of strategic investment projects that are to be prepared and assigned in a public-private agreement by the National Commission for Strategy and Prognosis.

IV. THE PRESENT CONTEXT

IV.1. Global context

The international energy markets are in a dynamic and complex change on multiple dimensions: technological, climatic, geopolitical and economical. Romania must anticipate and must take position towards the trends of the international markets, as well as towards the geopolitical changes which influence the strategic partnerships.

Technological transformations

Multiple technological developments, sustained by the relatively high prices on energy after year 2000 and by the subsidies from the public budgets, have lead in the last years to an increased energy production. On the European markets, influenced by the energy efficiency policies, it can be observed a slight decrease on energy demand, but also a diversified offer.

The extraction technology for the "shale" hydrocarbs lead to a change in the global hierarchy of the oil and natural gas producers. The spectacular drop of the energy production costs on renewable energy sources, the provisions to storage the energy on commercial scale in the following years, the emergence of the electromobility, the progress of the management systems for the energy consumption and the digitalization represent real challenges regarding the paradigm for conventional production, transport and consumption of energy.

The energy policies planners and the decision makers from the companies in this sector, operate in an environment with new opportunities and which is extremely dynamic.

The transformation of the energy sector is happening in an alert rhythm, due to the expansion of RES share and due to digital "revolution", consisting in the development of intelligent networks with real time coordination and wit dual-way communication, sustained by the increase of the capacity for assessment and transmission of large volume data, with energy consumption optimization. The increasing share or wind and solar energy production arises the issue of NES adequancy and of the operating regulations of the energy markets. On long term, the increase of the decentralized electric energy production can lead to a high resilience level, by reorganizing the entire transport and distribution system, taking into account the emerging of the active consumers (prosumers) and the increasing of the electric energy storage units.

Climate change mitigation

The climate and environmental policies, focused on the reduction of the greenhouse gases and on the change of social attitude towards the "clean energies" represent the second determinant factor, which models the investment behavior and the consumption charts within the energy sector.

The Paris Agreement in 2015 and the European policies for prevention of climate changes contribute to the achievement of sustainable energy system. According to IEA, in 2014, the most of the RES shall be competitive without any aid schemes; the photovoltaic technology shall have an average cost reduction of 40-70% by 2040, and the offshore wind technology shall have average costs by at least 10-25% lower (IEA 2016b, 24).

The report Energy, climate changes and environment of IEA, from November 2016 (IEA 2016a) represents a list of measures for the reduction of greenhouse gases emissions in the energy sector, with the purpose of limiting the global warming with at least 2°C above the pre-industrial level, from which: increase of energy efficiency; introducing a global price for pollution (CO2); setting a global list of indicators for decarbonization; increase of the governments capacity for implementing the energy transition process.

Economical changes

The evolution of oil price influences the global energy consumption and commercial and investment flows on a global level. The reduction of oil price, two years before resulted in a drop in natural gases and electricity prices, which was favorable for the consumers, but which affected the energy producers ability to invest in strategic importance projects. By a domino effect, the price lowering also affects the profitability of RES investments and in energy efficiency investments, as well as the increase of the level for electric propulsion vehicles usage. Still, the attractiveness for RES remains relatively high, as long as the cost for RES technologies continues to drop.

The natural gas international commerce is more and more intensive, by increasing the share of liquefied natural gases (LNG); by the year 2020, the capacity of liquefying terminals shall be substantially developed, especially in Australia and USA. The price for natural gas is set more and more on a global level, with small regional differences, and an increasingly share is given by the spot markets, to the detriment of indexing at the price of oil, the regulated prices, etc.

As the nuclear energy production plants that were commissioned in 1970-80 are reaching the end of their lifetime in 2030-40, in many states it appears the problem of rehabilitation/extension of their lifetime or of replacing those capacities with other technologies. The pressure to limit the climate changes shall encourage all energy forms that have no greenhouse emissions.

IV.2. European context – Energy Union

Legislation reform package "Clean Energy for All"

During 2016, EC presented two reformative legislation packages for the European policies in the energy field that were anticipated in 2015 by the Energy Union Framework-Strategy. These packages are defining for the European energy sector and for the Romanian one as well, during 2020-2030, the energy transition in EU being scheduled to speed up.

In July 2016, there was published the first package of proposals, regarding: reduction of non-ETS emissions in each Member State for the period 2021-2030 (Romania has a set target of a reduction with 2%), accountability of the greenhouse gases resulted from the land use, changing the destination of land and forestry, as well as communication regarding an European strategy for decarbonization in the transport sector.

On 30 November 2016, EC presented the second reformal package, named "Clean Energy for all", which includes a series of legislative proposals of great importance:

- updating the directives regarding the RES (EC 2016b), the directive regarding the energy efficiency (EC 2016c) and the directive regarding the energy performance of the buildings (EC 2016d);
- a new design of the single energy market (EC 2016e), which imposes the updating of the directive and the regulation regarding the operating rules of the market, of the regulation regarding the Cooperation Agency on European level for the Regulatory authorities in energy field (ACER), as well as the regulation for risk management in electric energy field;
- a new regulation regarding the Energy Union Governance (EC 2016f), intended to integrate, simplify and coordinate much better the dialogue between the Member States and EC and the actions of the Member States in order to achieve the objectives of the Energy Union;
- new regulations and decisions of EC, as well as a series of recommendations regarding the eco-design (EC 2016g), which mainly aims the energy efficiency and the labeling of the equipments for heating and cooling, as well as rules for general procedures regarding the compliance with the eco-design standards by the producers.

The Strategy orientates and fundaments the Romania's position towards these reforming proposals for the European energy market. The Strategy presents, by its operational objectives and priority actions, the strategic intervention options of the Romanian State in the energy sector.

The grounds for achieving the Energy Union

Energy security and diplomacy within the EU

Since 2000, EC has related the energy security of EU with the ensuring of uninterrupted physical availability of the energy products, at an accessible price and pursuing the durable development.

Among the priority actions proposed by the European Strategy for energy security, we find:

- building a new internal energy market that is completely integrated;
- diversifying the external supplying resources and the related infrastructure;
- reduction of energy demand and increase of energy production from EU;
- consolidating the growth mechanisms for the level of security, solidarity and trust between states as well as protecting the strategic/critical infrastructure;
- coordinating the national energy policies and transmitting of an unitary message towards the external energy diplomacy.

Released in February 2015, the project of Energy Union aims to increase the level of integration within the energy sector by coordinating the Member States in five independent domains, also called "pillars" of the Energy Union: energy security, solidarity and trust; fully integrated European energy market; energy efficiency contribution to the reduction of energy demand; economy decarbonization; research, innovation and competitiveness.

EU is an important financer for the energy projects, mainly for those that aim to produce "clean energy" and to interconnect the energy markets.

Romania has European funds for BRUA project, natural gas pipeline with a length of 528 km via Bulgaria – Romania – Hungary – Austria. Due to its importance for the energy security in Central and South-East Europe, BRUA has an European level priority and is financed, for starting, with 179 mil €, through the Connecting Europe Facility (EC 2016h).

European policies for the reduction of greenhouse gases emissions

EU assumes a leadership role in combating the climate changes both by supporting the global agreements in climate change field, as well as through its climate policies.

A part of the European energy diplomacy is the environmental diplomacy, especially in the context of forming of an international regime for climate policies based on the Paris Agreement. The global objective on long term set up in Paris in 2015 is limiting the growth of the average global temperature to 2°C, comparatively with the preindustrial level.

EU proved its leadership by assuming some ambitious targets for the reduction of greenhouse gases emissions, for increasing the RES share in the energy consumption structure and for energy efficiency. The so called EU's determined nationally indicative contribution within the Paris Agreement is the same with the targets 40/27/27 set up by the European framework for climate and energy policies for 2020-2030, with the option for increasing the strictness regarding the energy efficiency from 27% to 30%. EU has set the aim that until 2050, the greenhouse gases emissions shall be reduced by 80-95% compared with the level of 1990, its targets being 40% for 2030 and 60% for 2040.

For the non ETS part, the proposed reduction is 30% until 2030 compared to 2005, objective that shall be achieved by the Member States collectively.

Energy efficiency, the main priority of the new reforming package

The EC proposal for updating the directive regarding the energy efficiency (CE 2016c) is to increase the target for the primary energy demand reduction to 32.5%. The provisions of article 7 from the directive are extended up to year 2030, but they leave full flexibility for each Member State to chose the measures by which are fulfilled the obligations regarding the energy demand reduction.

The EC proposal for reviewing the directive regarding the energy efficiency for buildings (EC 2016d) aims the decarbonisation of the buildings sector until 2050, by creating a long term perspective for investments and the increase of the rehabilitation rhythm. The Directive provides for the use of the new technologies with respect to the "intelligent buildings" in order to increase their energy management.

By promoting the construction of recharging power stations for electrical vehicles within certain types of new buildings the directive contributes to the development of the electromobility. The Energy Efficiency Agreements shall became a more efficient instrument for promoting the building's electric efficiency by increasing the transparency and the access to the know-how.

EC launched, as well, the work plan for 2016-2019 for eco-design (EC 2016g), which shall introduce the energy efficiency standards for new product categories and shall move the aim from the energy efficiency to the design in the spirit of circular economy.

Concerning the financing of the energy efficiency investments, with high initial cost and long term return of the investment, EC introduces the initiative "Intelligent financing for smart buildings", which starts from the main European financing instruments, with specific measures that can unlock 10 billion Euros in additional financing for the energy efficiency projects.

Promoting the energy from renewable sources

The EC proposal for the updating of the directive regarding the promotion of RES (EC 206b) provides six directions for future actions. The first one proposes general principles for when the Member States define aid policies for RES, complying with the transparency and economic efficiency principles, based as much as they can on the competitive market mechanisms. These elements are combined within the Strategy, under the principle of technological neutrality.

The second direction brings in the foreground the RES within the regarding the requests for heating and cooling (RES-HC), presenting to the Member States options for reaching, on national level, a growth rhythm of the RES share in the total amount for energy demand for heating and cooling with 1.3% per year until 2030. Also, the directive intends to ensure the access of the third parties to the SACET networks for the new producers that use RES (mainly biomass, biogas and geothermal energy, but it could be taken into consideration the heat pumps as well).

The third direction aims to increase the share of the RES and of the low carbon fuels in the transport sector – including advanced bio-fuels, hydrogen, fuels produced by waste and RES - E.

The forth direction promotes a better informing of the consumers regarding the RES. Also, the Directive guarantees the individual consumer rights and the rights of the local communities to become prosumers and to be paid for the energy delivered in the network.

The fifth direction provides the strengthening of the sustainability standards for the energy produced on biomass – including the guarantee of avoiding deforestations and the degradation of the habitats, as well as the requirement that the emissions related to RES to be rigorously accounted.

The sixth direction aims ensuring that the collective target of 32% for the share of RES in the final brut energy consumption on European level, in 2030, shall be achieved, keeping in mind the cost efficiency.

The new model for electric energy market

The EC proposal regarding the common rules for the functioning of the electric energy internal market (EC 2016e) brings the most substantial changes within the "Clean energy for all" package. By this opportunity, EC defines the general principles and the technical details for organizing the electric energy market, specifying the rights and the responsibilities for all types of market participants.

Regarding the electric energy wholesale market, the new model provides, mainly, the removal of the price caps, harmonization of the dispatching rules for all types of capacities, including intermittent RES, reduction congestion situations in the cross-border interconnection infrastructure for the electric networks in the Member States through a better coordination between the transmission and system operators, respectively through investments in projects that shall improve the flows, a better payment for the participation of electric energy consumers on the balancing market by managing the demand.

For the retail markets, the new model provides a better informing and an increase in what concerns the consumers rights, inclusively by loosening the participation conditions as prosumer on the electric energy market, the guarantee of the right to participate on the balancing market, individually or through centralized platforms, thus encouraging the active management for self consumption. The needs of vulnerable consumers shall be covered by keeping the social pricing or by alternative measures that are adequate for social protection and for increasing the energy efficiency.

The new market model provides the establishment of an entity for coordinating the activity of European level network operators (similar to ENTSO-E), with attributions related to the integration of RES, the production of distributed electric energy, the electric energy storage, the intelligent systems for consumption measuring and control, etc.

Also, the new market model takes into consideration the capacity for managing the risks on regional level, mainly by developing a new common methodology for the assessment of the risks and the ways to prevent and prepare the crisis situations, respectively for managing these situations when they occur.

A challenge is that the implementation of the Regulation (EU) 2015/1222 of the Commission for setting directive lines regarding the allocation of the capacities and management of the congestions, which provides detailed directive lines regarding the allocation of the interregional capacities and the management of the congestions, aiming the single couplings of the following day energy markets and of the intraday markets, on European level.

The governance of the Energy Union

For the efficient management of all aspects regarding the five dimensions of the Energy Union and the correlation of these with other fields, the EC proposal for a new regulation regarding the governance of the Energy Union (EC 2016f) takes into account a coherent, simplified and integrated framework for regulating and dialog between EC and the interested parts.

The main instrument introduced by this regulation shall be the Integrated National Energy and Climate Plan (NECP), which replaces a number of obligations, sometimes redundant, for reporting on a national level – there are integrated 31 reporting obligations and are canceled 23 other. The Member States shall submit the first draft of their own NECP in 2018, based on a detailed indication for the content, defined by the regulation.

IV.3. Regional context: Central and Eastern Europe and Black Sea Area

IV.3.1. Interconnecting the energy transmission networks

The interconnections that are under construction in Central and Eastern Europe shall contribute to the development of the energy markets and of some regional mechanisms for energy security which shall operate according to the common rules of EU. Regional cooperation is an efficient solution to the energy supply crisis.

In the region, compared to Western Europe, the interconnections, the modern capacities for natural gas storage, the institutions, the rules for market operation and the infrastructure quality are still in the process of development.

EU defined as objectives the completion and functionality of the internal market for electric energy and the functionality of the cross-border commerce, as well as the ensuring of an optimal management, of a coordinated exploitation and of a healthy technical evolution for the electric energy European transport network.

The European network of transmission system operators (ENTSO-E) elaborates a development plan of for the next ten years for the electric network and comprises an assessment regarding the pan-European electro-energy

system adequacy, every two years. This plan takes into consideration the integrated model of the European electric network, the elaboration of scenarios and the assessing of the resilience of the system.

Within the ENTSO-E there have been created six regional groups which assess and complete the European development plan for the network.

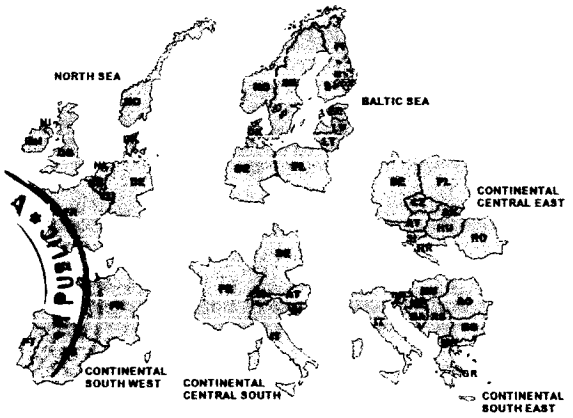


Fig. 1 – ENTSO-E regions (source: ENTSO-E)

The regulation (EU) no. 347/2013 of the European Parliament and Counsel regarding the directing lines for the trans-European energy infrastructure, proposes a set of measures for the achievement of the EU objectives in the field, like: integration and operation of the energy internal market, ensuring the energy security of EU, promoting and developing the energy efficiency and the renewable sources energy and promoting the interconnection of the energy networks.

The (EU) regulation no. 347/2013 identified, for the period of 2020 and after, a number of 12 (twelve) high priority corridors and cross-European fields, which comprise the electric energy and natural gas networks, as well as the oil and carbon dioxide transport infrastructure.

Romania is part of the priority corridor no. 3 regarding the electric energy: "North-south interconnections regarding the electric energy in Central and South-East Europe" ("NSI East Electricity"): interconnections and internal lines on north-south and east-west directions for the implementation of the internal market and for the integration of the production from renewable sources. Member States that are involved: Bulgaria, Czech Republic, Germany, Greece, Croatia, Italy, Cyprus, Hungary, Austria, Poland, Romania, Slovenia, Slovakia.

Transelectrica SA is involved in multiple projects that are included on the list of projects which are of common interest on European level, that are mentioned below.

Project 138 "Black Sea Corridor"

The "Black Sea Corridor" is part of the priority corridor for electric energy: "North-South interconnections regarding the electric energy in Central and South-East Europe ("NSI East Electricity) and its role is to consolidate the electric energy transmission across the Black Sea coast line (Romania – Bulgaria) and between the coast line and the rest of Europe.

This project contributes significantly, by increasing the interconnection capacity between Romania and Bulgaria and by enforcing the infrastructure which shall sustain the transmission of the power flows between the Black Sea coast line and the North Sea/Atlantic Ocean coast line, to the implementation of the European Union's strategic priorities regarding the cross-European energy infrastructure, a mandatory requirement for achieving the objective within the energy and climate policies.

Also, by implementing this project it shall be achieved the consolidation of regional and European energy market integration, which shall allow the trades in the area to be increased. The development of the renewable energy sources with intermittent character shall be possible due to the capacity of the transmission network to transmit the energy produced from renewable sources from South-East Europe to the main consumption centers and to the storage units located in the center of Europe and respectively in the north of Europe. The components of the project are the following:

- a new AEL of 400kV d.c. between the existing power stations Cernavoda and Stalpu, with an input/output circuit on the power station 400kV Gura Ialomitei;
- a new AEL of 400kV d.c. (with an equipped circuit) between the existing power stations Smardan and Gutinas;
- the expansion of the Stalpu power station 220/110 kV by building the 400/110 kV power station.

Project 144 "Mid Continental East Corridor"

The project "Mid Continental East Corridor" is part of the priority corridor regarding the electric energy: "North-south interconnections regarding the electric energy in Central and South-East Europe" ("NSI East Electricity") and shall lead to an increase of the exchange capacity on the borders: Romania – Hungary – Republic of Serbia; it shall enforce the north-south European corridor from the north-eastern Europe to the south-eastern Europe through Romania, allowing a stronger integration of the markets and the increase of the supply security in Europe's South-East area.

The components of the project are the following:

- a new AEL of 400 kV d.c. between the existing power stations Resita (Romania) and Pancevo (Serbia);
- a new 400 kV d.c. between the existing station Portile de Fier and the new station of 400 kV from Resita;
- upgrading the AEL of 200 kV d.c. to 400kV Resita-Timisoara-Sacalaz-Arad;
- expansion of the power station of 220/110 kV from Resita by constructing a new one of 400/220/110 kV Resita;
- replacing the power station 220/110 kV from Timisoara with a new one of 400/220/110 kV.

The real interconnection capacity depends both on the internal and interconnection electric network, as well as on the status of the transmission networks from the neighbor states.

Presently, Romania has an interconnection capacity of 7%, and for year 2020 it is foreseen an increase to 9%, which is close to the objective of 10%.

In what concerns the achieving of the interconnection objective of 15% in 2030, it is estimated that this objective shall be accomplished mainly by implementing the CIPs (Common Interest Projects) and respectively by achieving the other development projects for the electricity transmission network included in the Development Plan of the ETN (Electricity Transmission Network) for 2018-2027.

There must be developed coordinating mechanisms for planning and financing the regional projects for energy infrastructure. Romania must have an active presence in the intra-community diplomacy, coordinating with the countries from Central and East Europe, with similar energy system structure.

Besides the interconnections with Hungary, Bulgaria and Republic of Serbia, Romania has to develop interconnections with the neighbor states that are not part of EU as well (Republic of Moldova, Ukraine).

The interconnections of the transport systems for natural gas and electric energy of Romania with the ones of Republic of Moldova represent a strategic objective of governments from both countries.

IV.3.2. Regional geopolitics

As an EU borderline country, Romania is directly exposed to the increasing geopolitics tensions in the Black Sea Basin.

In the same time, Romania can prove itself as a regional energy security provider.

The natural gas flow from Romania would help countries like the Republic of Moldova and Bulgaria to reduce their excessively dependence on a single source, and the producers from Romania would receive a stimulus to invest in the ongoing of the lifetime of the existing deposits and the discovery of new deposits.

By modernizing the natural gas storage capacities and by implementing balancing and backup systems for electric energy, Romania can have an important and profitable contribution on the regional market of technological ancillary services.

IV.4. The national energy system current status

IV.4.1. Primary energy sources

Romania has a balanced and diversified energy mix.

The main primary energy sources were, in 2017, 43,291.4* thousand toe, of which 21,303.5 thousand toe from the internal production and 12,987.9 thousand toe from impost, with the following structure:

- coal: 5,164.7 thousands toe (4,654.6 thousands toe internal production and 510.1 thousands toe import) – 15% from the energy mix;
- oil: 11,175.9 thousands toe (3,421.7 thousands toe internal production and 7,754.2 thousands toe from import) – 32.6% from the energy mix;
- natural gas: 9,282.1 thousands toe (8,337.7 thousands toe internal production and 944.4 thousands toe from import) – 27% from the energy mix;
- hydroelectric energy, nuclear-electric energy, solar energy and import energy: 5,203.8 thousands toe (4,889.5 thousands toe internal production and 314.3 thousands toe from import) – 15,2% from the energy mix;
- imported petroleum products: 2,985.8 thousands toe – 8.7% from the energy mix.

Source: National Institute of Statistics

Oil and natural gas

Presently, in Romania, there are under exploitation approximately 400 deposits of oil and natural gas, of which:

- OMV Petrom extracts from more than 200 commercial deposits of oil and natural gas in Romania. In the Black Sea, OMV Petrom extracts from seven fixed platforms;
- Romgaz operates as sole owner of oil extraction agreement, in 8 exploration, development and exploitation perimeters.

For other 39 deposits, there have been concluded petroleum agreements for development-exploitation and

petroleum exploitation with different companies. The majority of these deposits are mature, having an exploitation period of 25-30 years.

On short and medium term, the exact reserves of oil and gas can be increased by implementing new technologies that shall lead to an increase in the extraction rate and by implementing the projects for high depth exploration and for off shore areas exploration on the Black Sea's continental platform.

Crude Oil

In 2017, the internal crude oil production covered approximately 32% from the demand. The decline of the annual average production was 2% in the last five years, being limited by the investments boring new wells, recommencement of production, secondary extraction, etc. The proved oil reserves of Romania shall depleted in approximately 16 years at a consumption rate of 3.4 million t/year.

Natural gas

The natural gas has a share of approximately 30% from the internal primary energy consumption. Their important share is explained by the relatively high availability of the internal resources, by the low impact on the environment and by the capacity to balance the electric energy produced by intermittent RES. The existing infrastructure for extraction, transport, underground storage and distribution is expanded on the entire territory of the country.

The natural gas market is advantaged by the favorable position of Romania related to the transport capacities in the region and by the possibility to interconnect the NTS with the central European transport systems and with the gas resources from the Caspian Basin, from the east of Mediterranean Sea and from the Middle Orient, through the Southern corridor.

In 2017, the total natural gas consumption was 129.7 TWh, from which the internal production covered 89.4%, and the imports 10.6%. The structure of the consumption: household consumption – approximately 33.4 TWh (25,73%), electrical and thermal power producers – approximately 35.4 TWh (27.27%), chemical industry – approximately 12.9 TWh (9.93%), commercial sector – approximately 8,5 TWh (6.59%).

Coal

The coal is the primary energy resource in the energy mix, being a strategic fuel in the maintaining of the national and regional energy security. In the extreme meteorological period, the coal is at the base of the energy supply resilience and of the operation of the National Energy System (NES), covering a third part from the electric energy demand.

The lignite resources of Romania are estimated at 690 million tons [124 millions toe], from which, there are 290 million tons [52 million toe] exploitable in sublicensed perimeters. On an average medium consumption of 4.5 million toe/year, the assurance rate is 28 years, with the condition that the consumption in the following 25 years remains constant and there shall not be valued any other lignite deposits.

The medium calorific value of the Romanian lignite is 1800 kcal/kg. Because the lignite deposit from Oltenia area is composed from 1-8 exploitable coal layers, the high extraction rate imposes the urgent implementation of some regulations that shall ensure the reasonable exploitation under safety and efficiency conditions, with minimal losses.

The known hard coal resources in Romania are in an amount of 232 million tons [85 million toe] from which, there are 83 million tons [30 million toe] exploitable in sublicensed perimeters. On a medium consumption of the reserves of 0.3 million toe/year the assurance rate of the hard coal resources is 104 years, but the exploitation of this primary energy resource depends on the economical feasibility of the exploitation works. The average calorific value of the hard coal extracted in Romania is 3,650 kcal/kg.

Primary energy national resources (source: ANRM)

PRIMARY ENERGY RESOURCES	RESOURCES		RESERVES		ESTIMATED ANNUAL PRODUCTION		ASSURANCE PERIOD WITH RESOURCES AND RESERVES	
							RESOURCES	RESERVES
	Million Tons[1)]	Million Toe	Million Tons[1)]	Million Toe	Million Tons[1)]	Million Toe	YEARS	YEARS
LIGNITE	690	124	290	52	25	4,5	28	12
HARD COAL	232	85	83	30	0,8	0,3	290	104
OIL	229,2		52,6		3,4		67,4	15,5
NATURAL GAS	726,8		153		10,5		69,2	14,6
URANIUM[2)]								

[1)]excluded natural gas expressed in Billion m^3

[2)]data with special requirements available in the classified annex

Uranium

Romania has a full open cycle of nuclear fuel, developed on the basis of CANDU Canadian technology. Uranium dioxide (UO2), used to produce the nuclear fuel required for Cernavoda reactors 1 and 2, is the by-product resulted from processing and refining of uranium extracted from the indigenous production.

Compania Nationala a Uraniului has entered a restructuring process and it follows that, in parallel with the closure of the Crucea mine (Suceava County), to exploit new deposits in terms of efficiency. Until the opening and operation of new indigenous uranium deposits, the nuclear power plant operator, Nuclearelectrica SA, acquires raw material both from domestic market and from external market for the production of nuclear fuel.

The existing and exploitable ore reserves ensure the demand for natural uranium for the operation of two nuclear-electric units throughout their entire lifetime.

Renewable energy sources

Romania owns rich and varied renewable energy resources: biomass, hydropower, geothermal potential, respectively for wind and photovoltaic energy. They are distributed throughout the entire country and can be exploited on a wider scale as the performance-price ratio of technologies improves by maturing the new generations of equipment and related facilities.

The hydropower potential is largely used, although there is the possibility to continue the hydropower development of the main water courses, with observing the good practices for the biodiversity and ecosystems protection.

In the last six years, Romania has advanced in the use of a large part of the wind and solar energy potential.

Hydropower

Romania benefits from a high potential of hydropower resources. From a linear theoretical potential of about 70.0TWh/year, the theoretical linear potential of the inland water courses is about 51.6 TWh/year, and the Danube (only the Romanian part) is estimated at about 18.4TWh/year.

The complex arrangements of the interior rivers and the Danube River have been developed since the interwar period and most of them were completed by 1990. They were designed to allow complex uses: hydropower, navigation, multiannual or seasonal regulation of water supplies to enable water or irrigation, industry and population, as well as to mitigate floods and transit them safely to the riverbeds. The arrangement schemes were partially put into operation according to these complex uses until 1990, but a significant part is still in the project stage or the works have started and are unfinished.

According to the complex arrangement schemes designed before 1990, the technically arrangeable hydropower potential is approx. 40.5 TWh/year, of which approx. 11.6TWh/year belong to the Danube, and on the inner rivers a potential of approx. 24.9 TWh/year through power plants with installed powers of more than 3.6 MW and the remaining 4.0 TWh/year in smaller power plants. These arrangement schemes have been designed to harness the high-potential hydropower potential, based on falls and flow concentrations, achievable through water supply derivation works and installation in the power plants of the flows exceeding 3-4 times the flows of the arranged sections, even in case of schemes with small accumulation lakes, with a regularity degree at most daily-weekly.

After 1990, but especially after Romania's accession to European Union, the use of water resources had to take into account the policies promoted for the environmental protection. In the hydro-energetic field, these environmental policies had an impact on how the natural potential can be exploited, mainly by combining two measures: adopting higher levels for servitude/ecological flows and establishing sites included in the Natura 2000 network. Practically, in 2018 compared to 1990, annual useful water supplies decreased by about 20% and the most feasible sites for new projects were blocked as a result of the establishment of Natura 2000 sites, which account about 22.5% of all river basins area.

The current estimates of the technically and economically feasible potential, diminished by these regulations for environmental protection, show that compared to the 40.5 TWh / year energy estimated in 1990, in 2018, the technically and economically feasible potential was reduced to about 27.10 TWh.

S.P.E.E.H. Hidroelectrica S.A., it is a company to which the state has concessioned the public property in the field of electricity production in hydropower plants, for the purpose of exploitation, rehabilitation, modernization, rehabilitation and construction of new hydropower facilities, which operates plants that according to the technical documentation amount to 17.46 TWh/year.

Approximately 0.80 TWh/year is the designed power of all micro-hydropower plants owned by other operators, mostly private. They have invested in small-scale hydropower projects, especially during 2010-2016, being stimulated by the support scheme of Law 220/2008.

At the level of 2018, the rest of the technical hydropower potential that still can be arranged in Romania is estimated to be approx. 10.30 TWh/year.

An extremely important aspect of the hydropower investment activity lies in the fact that large hydropower projects started before 1990 and not completed by 2018 have complex utilizations. In order to complete these, complex technical and economic analyzes shall be required, which shall be the basis of the decisions for their achievement.

Wind energy

By its geographic position, Romania is at the Eastern limit of the atmospheric circulation generated in the North Atlantic basin, which manifests itself with a sufficiently high intensity to allow energy capitalization only at high altitudes on the Carpathian ridges. The atmospheric circulation generated in the Black Sea and the Russian Plain, in conjunction with the North Atlantic one, offers opportunities for energy capitalization in the area of Dobrogea, Baragan and Moldavia. Also, on small areas there are local atmospheric circulations that allow economic capitalization through projects of small wind farms.

A systematic study of the theoretical wind potential for the entire national territory elaborated by ICEMENERG in 2006 and provided a potential value of approximately 23TWh/year by installing capacities with a total power of approx. 14,000 MW. The wind potential, determined in 2006, needs to be adjusted taking into account the subsequent establishment of Natura 2000 protected areas as well as flight paths for wild bird populations, which diminish the options for developing new projects in the Dobrogea region.

For a better assessment of the arrangeable wind technical potential, the studied variants of the wind farm projects developed between 2009 and 2016 can be taken into consideration, through which practically all the niches available for such developments were investigated considering the current environmental limitations. The projects analyzed during the mentioned period amount to a total power of about 5,280 MW with a project power of 10.23 TWh/year. Of all these projects, at the end of 2016, projects amounting to 2,953 MW and total project power of about 6.21 TWh/year were completed. In 2016, taking into account the specific conditions of that year, the wind power plants from Romania generated 6.52 TWh, a value that is around the value of project power. Investments for wind farms development in Romania have been encouraged between 2009 and 2016, through a support scheme using green certificates, according to Law 220/2008.

The main reason why from the technical potential of about 10.23 TWh/year is currently being used in only 60.7% is the adequacy of the national energy system that can not take over the production sources with an unpredictable and discontinuously character. For this reason, any eventual development of wind capacities must be done in parallel with other developments in order to provide balancing services in the system. After closing access to the support scheme of Law 220/2008, at the end of 2016, no new investments were made in wind farms. This indicates that without a support scheme, the current technological level of turbines does not allow cost-efficient capitalization of wind potential in most locations, also taking into account the prices recorded between 2017 and 2018.

Solar energy

Solar energy can be used for energy purposes either in the form of heat, which can be used for the preparation of domestic hot water and heating of buildings or for the production of electricity in photovoltaic systems. The distribution of solar energy on the national territory is relatively uniform with values between 1,100 and 1,450 kWh/m²/year. Minimum values are recorded in low lands areas and maximum values in Dobrogea, east side of Baragan and south side of Oltenia.

Correlated with the development way of households or other buildings within the localities, according to the ICEMENERG 2006 study, the solar collectors with an area of 34,000 sqm could be used to produce an amount of energy of 61,200TJ/year. The maturation of capture technologies and the experience of current users from Romania, now lead to the idea that this utilization can be widely extended in Romania over the whole year, at least for the preparation of domestic hot water.

The improved use of solar potential to produce electricity through the use of photovoltaic panels allows the installation of a total capacity of 4,000 MWp and the production of an annual energy of 4.8 TWh, according to the same study. At the end of 2016, solar parks with a total power of 1,360 MW were installed in Romania, which, according to project power, produced 1.91 TWh/year. In 2016, photovoltaic parks from Romania produced 1.67TWh. The construction of photovoltaic parks has benefited from a support scheme in 2009-2016, according to Law 220/2008.

The establishment of Natura 2000 protected areas, as well as the restriction of photovoltaic parks development on agricultural land, limits the options for the installation of new large photovoltaic parks only on degraded or unproductive land.

The main reason why the solar potential is not capitalised to a higher degree is because the national energy system

can not take over the large variations of power injection generated by photovoltaic sources in the absence of properly sized balancing and storage systems.

On the other hand, after closing access to the support scheme of Law 220 at the end of 2016, it was found that no new investments were made in such production capacities due to the fact that the current technology did not achieve the necessary performance to be cost-effective without a support scheme.

Biomass, bio-liquids, biogas, waste, and waste and sludge fermentation gas

The biomass energy potential is estimated at a total of 318,000 TJ/year, equivalent to 7.6 million toe.

The data related to solid biomass production presents a high degree of uncertainty (about 20%), with a central estimate of 42 TWh in 2015.

The main form of the biomass with energetically destination produced in Romania is firewood, burned in low-efficiency stoves. The consumption of firewood used in households is estimated at 36 TWh/year. In 2015, the production of bio fuels was about 1.5 TWh and the biogas of 0.45 TWh.

In 2015, only 0.7 TWh of the electricity produced nationwide was obtained from biomass, bio liquids, biogas, waste and fermentation gas of waste and sludges, in installed power capacity totaling 126 MW.

Geothermal energy

In Romania, there were identified several areas where geothermal potential is estimated to allow economic applications over a wide area on west side of Transylvania and smaller areas on the north side Bucharest, north side of Rm. Valcea and around Tandarei. The research before 1990 revealed that the potential of the known geothermal resources in Romania is about 7 PJ/year (about 1.67 million Gcal/year). The records for the period 2014-2016 indicate that from all of this potential is capitalized annually as heat or hot water between 155 thousands and 200 thousands Gcal.

Most of the wells by which the geothermal energy is better used were executed before 1990, and were financed from the state budget for geological research.

Current costs for digging a geothermal water well are similar to the cost of digging hydrocarbons well. Under these circumstances, for the depths of over 3,000 meters that characterize most of the geothermal resources from Romania, the investment amortization for the use of geothermal energy exceeds 55 years; such projects are considered unprofitable. Therefore, the wells park for geothermal water production did not increase.

IV.4.2. Refining and petroleum products

Romania has a crude oil processing capacity higher than the domestic demand for petroleum products. The Romanian refineries, which acquire national crude oil production and import about two thirds of the necessary oil, have currently an operational capacity of 12 million t/year. In recent years there has been a decline of indigenous refining activity, both on the background of the relatively high energy price in the EU compared to non-EU competing countries and the costs generated by European regulations on CO2 and NOx reduction.

The refining sector in Romania consists of four operational refineries: Petrobrazi (owned by OMV Petrom), Petromidia and Vega (owned by Rompetrol), Petrotel (owned by Lukoil) with a total operating capacity of about 12 million tons per year.

In 2017, the refineries from Romania processed 11.2 million tons of crude oil and additives (domestic gross deliveries were 11.17 million tons of crude oil and additives, of which 3.52 million tons of domestic production), resulting 5.47million tons of diesel; 1.55 million tons of gasoline and kerosene; 0.56 million tons of oil coke; 0.7 million tons LPG; 0.38 million tons of heavy oil; 0.2 million tons of naphta; 0.5 million tons of refinery gas and 0.81 million tons of other refinery products. Total oil consumption was 9.45 million tons.

In 2017 net crude oil imports were 7.75 million tons, mainly from Kazakhstan and the Russian Federation, but also from Azerbaijan, Iraq, Libya and Turkmenistan, and imports of petroleum products were of about 2.98 million tons. Romania is an exporter of petroleum products - according to statistical data, in 2017 Romania exported oil fuels and lubricants worth 2,285.3 million Euro (out of which 943.4 million Euro for engine fuels). (Source: INS)

The demand for petroleum products depends in particular on the evolution of the transport sector. Over the last decade, as a result of ever-stricter regulations, technology has evolved towards high efficiency internal combustion engines. At the same time, there is a diversification of vehicle propulsion, using bio fuels, natural gas and biogas, as well as electric and marginal hydrogen.

IV.4.3. Domestic natural gas market, transport, storage and distribution

Domestic natural gas market

Natural gas market consists of the regulated market and competitive market and natural gas transactions are made either wholesale or retail.

The natural gas market comprises, in terms of natural gas supply:

- the supply of natural gas to household customers - supply on the regulated market - by June 30, 2021 (according to the Law on Electricity and Natural Gas No. 123/2012, as subsequently amended and supplemented);
- the supply of natural gas to non - household customers - supply which has been fully liberalized since January 1, 2015.

Transport, storage, distribution and natural gas market

The National Transport System (NTS) was designed as an interconnected radial-ring system, being developed around and having as its starting points the large natural gas deposits from the Transylvania Basin (central part of the country), Oltenia and later East Muntenia (south of the country). The destination were the great consumers from the Ploiesti - Bucharest, Moldova, Oltenia areas, as well as from the central (Transylvania) and northern parts of the country.

Subsequently, natural gas flows have undergone important changes due to the decline of sources from the Transylvanian Basin, Moldova, Oltenia and the occurrence of other sources (import, OMV-Petrom, concessions made by third parties, etc.), given that the natural gas transport infrastructure remained the same.

The National Transport System is represented by the main pipeline system, as well as the installations, their equipment and accessories, used at pressures ranging from 6 bar to 40 bar, with the exception of the international transport (63 bar), which ensures the take-over of extracted natural gas from production perimeters or from import and their transport.

The total technical capacity of the entry/exit points in/from the NTS is 149,034 thousand cm/day (54.39 billion cm/year) at entry and 243.225 thousand cm/day (88.77 billion cm/year) at the exit.

The total technical capacity of the interconnection points located on the international transport pipelines is about 70,000 thousand cubic meters/day (25.55 billion cm/year), both at the entrance and the exit from the country.

Transport of natural gas is performed by Transgaz - the transport and system operator.

Natural gas transport is ensured through more than 13,300 km of gas pipelines and gas connections with diameters between 50 mm and 1,200 mm at nominal pressures of 40 bar.

The international gas transmission activity is performed by Transgaz on the basis of the operating license for the gas transport system. At present, the international natural gas transport activity is taking place in the South-Eastern part of the country (Dobrogea) where the Romanian pipeline sector between Isaccea and Negru Voda is included in the Balkan natural gas transport route from the Russian Federation to Bulgaria, Turkey, Greece and Macedonia.

The NTS is connected with neighbouring countries, namely Ukraine, Hungary, Moldova and Bulgaria, through five cross-border interconnection points.

Storage of natural gas

The underground storage of natural gas has a major role to play in securing natural gas supply, facilitating the balancing of domestic consumption - domestic production - natural gas imports by covering the consumption peak that is mainly due to temperature variations as well as by maintaining the optimal operating characteristics of the national gas transport system during the cold season.

The underground storage of natural gas is a charged and regulated activity and can only be performed by operators licensed by Romanian Energy Regulatory Authority for this purpose.

The total storage capacity of Romania is currently about. 4.5 billion cm/cycle, of which the useful capacity is of 3.1 billion cm/cycle (only in depleted deposits); seven storage facilities are operated, of which six by Romgaz, with a useful capacity of 2.8 billion cm, and one, with a total capacity of 0.3 billion cm is operated by Engie.

To ensure security of supply, current national legislation regulates the level of minimum natural gas stock to be set by each supplier and for each segment of the market.

The underground storage is predominantly used for:

- coverage of consumption peaks and fluctuating regime of demand;
- operative recovery of the functional parameters of the transport system (pressures, flow);
- control of deliveries in extreme situations (sources stops, accidents, etc.).

Due to the changes occurred on the European natural gas market, to the liberalization of the gas market, the underground storage of natural gas shall acquire new

valences. In the new context, storage facilities shall also be used to optimize the price of natural gas.

The European Commission adopted in November 2017 the third list of key energy infrastructure projects that shall contribute to Europe's energy and climate goals and which are essential elements of the EU's energy union.

Among the projects of interest promoted by Romania, included in the list, in the field of natural gas, there are also investment projects for the purpose of increasing the natural gas underground storage capacities, namely the projects promoted by ROMGAZ and Depomures:

- increasing the underground natural gas storage capacity of the Sarmasel storage facilities;
- natural gas storage facilities Depomures.

Underground storage of natural gas is a tool for ensuring national energy security.

The increasing of the daily extraction capacity through investments in order to reduce the dependence of daily extraction capacity on the reservoir pressure is a stringent need for storage.

Distribution of natural gas

The natural gas distribution system consists of about 43,000 km of pipelines - of which 39,000 km are operated by the two major distributors, Delgaz Grid (20,000 km) and Distrigaz Sud Networks (19,000 km) - supplying about 3,5 million consumers. On the natural gas market of Romania, there are active another 35 local distribution system operators, that are operating approximately 4,000 km of network.

IV.4.4. Electricity

Electricity consumption

Total electricity consumption registered a substantially decline from 60 TWh in 1990 to 40 TWh in 1999 (Eurostat 2016), mainly due to the diminishing of industrial activity, after which it increased to 48 TWh in 2008.

The economic crisis of 2008-2009 has caused a further drop in consumption, followed by a gradual recovery to 63 TWh in 2017.

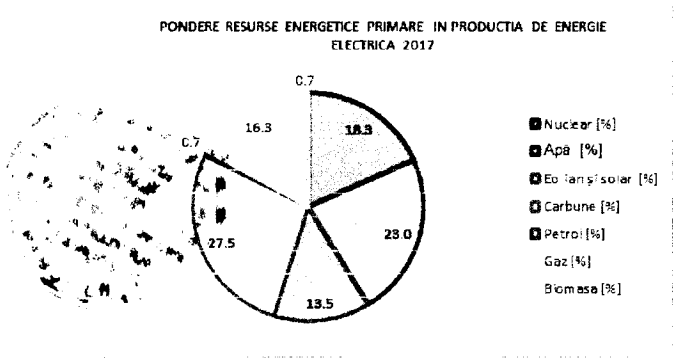
According to Eurostat data released in July 2016, Romania had the sixth lowest average EU electricity price for household consumers in 2015. However, given the relatively low purchasing power, price supportability is a first-rate problem that leads to a high level of energy poverty. Moreover, consumption is also affected by the fact that almost 100,000 housing from in Romania (of which some are not permanently inhabited) are not connected to the electricity grid; the most suitable for them being isolated power generation and distribution systems.

There is a significant improvement in the efficiency of gross electricity consumption due to transformation losses, namely those in the transmission and distribution networks. On the other hand, electricity consumption can be extended to new sectors.

The economic development of the country can increase the consumption of electricity, both in industry, transport and agriculture.

Electricity production

Romania has a diversified electricity mix, mostly based on indigenous energy resources.



PONDERE RESURSE ENERGETICE PRIMARE IN PRODUCTIA DE ENERGIE ELECTRICA 2017 – SHARE OF PRIMARY ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2017
Nuclear – Nuclear power
Apa – Water
Eolian si solar – Wind and photovoltaic
Carbune – Coal
Petrol – Oil
Gaz – Gas
Biomasa - Biomass

Most of the generating capacities are older than 30 years, with a relatively small number of remaining operating hours until the end of their service life. Older power units are often stopped for repair and maintenance, some of them being in conservation. There is a difference of almost 3,400 MW between the gross installed power and the available gross power, of which about 3,000 MW are capacities based upon coal and natural gas.

The diversity of the energy mix has allowed NSP resilience to be maintained, with extreme weather conditions being overcome. The extreme temperature situation is a specificity of the region when NES is subject to

vulnerabilities in ensuring full coverage of electricity demand for both domestic and export consumption, in situations when the neighbouring states are facing the same situation.

Under such conditions, Romania is among the 14 EU Member States that maintain their option of using nuclear energy. At present, the power produced by nuclear fission covers about 18% of the country's electricity production through the two Cernavoda power units; the percentage shall be of about 28% in 2035 by building the two new nuclear power units in Cernavoda.

The increasing price of ETS emission allowances shall put additional pressure on power producers based on fossil fuel. Efficient gas-based capacities have the perspective of a competitive positioning in the energy mix due to relatively low GHG and noxious emissions as well as their flexibility and capacity to quickly adjust. They are able to provide ancillary system services and backup for intermittent RES.

In the long term, the opportunity to install new generating capacities (of new technological generation) based on coal and natural gas shall be driven by the evolution of ETS emission allowances prices, by the need to set up a strategic reserve for NES safety, by the increasing demand for electricity, by the installed capacity performance, by the technology prices (including operating and maintenance costs) and the sustainability of indigenous fuels.

Hydropower is the main type of RES. Hydroelectric power plants have a high efficiency and the energy stored in storage lakes is available almost instantly, which gives them a basic role on the balancing market. Because most of the hydroelectric power plants were built between 1960 and 1990, investments are needed to increase efficiency. Hidroelectrica Company is in the process of achieving, by 2030, over 800 million € in total investments that include the completion of about 200 MW of new capacity.

The installed capacity of the wind power plants is of about 3,000 MW, which is considered close to the maximum level for the safe operation of the NES in its current configuration. The volatility of power generation in the wind power plant puts pressure on the entire NES, requiring a reassessment of the need for ancillary system services and proper investment in peak power plants, with fast-control and storage systems.

The power installed in photovoltaic power plants is approximately 1,500 MW. The balancing market is less influenced by production variations in photovoltaic plants, which have a more predictable operation than wind power.

Also in the RES category is the biomass, including biogas, which does not depend upon the variation of weather conditions. Given their economic potential, these energy sources can earn percentages in the electricity mix.

Infrastructure and electricity market

The transmission and system operator, Transelectrica SA, coordinates the power flows of the NES by controlling dispatchable production units. Although the dispatching involves additional costs for producers, it makes possible the balance of NES in extreme situations. Of the total gross power available of about 20,000 MW, 3,000 MW are undispatchable.

The development plan of the electricity transmission grid (ETG) (Transelectrica 2016b), according to the model developed by ENTSO-E in Europe, aims to evacuate power from the areas of RES concentration towards areas of consumption, the development of Romanian regions in which ETG is deficient (eg. the Northeast region), as well as increased cross-border interconnection capacity.

Against the background of a strong growth in intermittent RES investments in recent years, the market balancing has become essential, the more so since the coal-based power units can not respond rapidly to fluctuations of wind and solar radiation, with exception on the narrowband. The main categories of producers with rapid response to balancing requirements are the hydroelectric power plants and natural gas power units. The balancing on a regional market requires an increased interconnection capacity.

Starting November 2014, the Next Day Market (DAM) in Romania operates in a regime coupled with markets from the Czech Republic, Slovakia and Hungary (4M MC coupling), based on the region's price coupling solution.

Romania is actively involved in the regional and European projects dedicated to the creation of the single European electricity market.

Electricity import and export

Of the 35 ENTSO-E Member States, 12 of them, including Romania, have net electricity exports.

Romania has to maintain its position as energy producer in the region and strengthen its role as an energy security provider in the management of stressful situations at regional level.

As the balancing and reserve capacities are planned at national level, in many EU Member States there shall be a surplus of capacity, so the long-term export requires competitiveness on the European market. Therefore, for the Romanian electricity sector, the regulations should

avoid the imposing of additional costs on producers in comparison with external competitors.

IV.4.5. Energy efficiency, heat and cogeneration

Energy efficiency

Energy efficiency is one of the least expensive ways to reduce GHG emissions, to reduce energy poverty and to increase energy security. The EU 2020 energy efficiency target is to reduce primary energy consumption by 20% compared to the reference level established in 2007 (Ministry of Regional Development and Public Administration 2015). For Romania, the target is 19%, corresponding to a primary energy demand of 500 TWh in 2020. For 2030, the EU proposes a cumulated decreasing by at least 27% of energy consumption.

Energy efficiency in Romania has been steadily improving in recent years. Between 1990 and 2013, Romania recorded the highest average decrease of energy intensity in the EU of 7.4%, amid the restructuring of industrial activity (Romanian Energy Regulatory Authority 2016a). Between 2007 and 2014, the fall of energy intensity relative to GDP was 27%, Obtained also by the shutting down of some energy-intensive industrial units.

The increasing of energy efficiency by investing in technology is essential for the companies with high energy intensity that have to cope with international competition. The further rapid growth of energy efficiency in industry is more difficult, the high potential can be found at the present especially in the increasing of buildings energy efficiency (residential, offices and commercial spaces).

Efficient heating of buildings

- The segment of buildings and services represents 40% of total energy consumption in the EU and about 45% in Romania - especially heating and much less cooling. At EU level, the residential heating represents 78% of energy consumption, while cooling is only approximately 1%. By 2050, it is estimated that the production of cold in Europe shall see spectacular growth as a share of total heating / cooling consumption.

The demand of thermal energy is concentrated in the industrial, residential and service sectors. In the residential sector, the main factors are the atmospheric temperature and the level of thermal comfort of housing - which, in their turn, are depending upon the purchasing power of the population, but also upon cultural factors. Another factor is given by building thermal insulation standards.

As a result of the dramatic restructuring of the Romanian industry from 1992 to 2005, the demand for thermal energy in the industry has been substantially reduced.

Romania currently has a total of about 8.5 million housing, of which approximately 7.5 million are inhabited. Of these, approximately 4.2 million are individual housing, and about 2.7 million housing are apartments located in residential blocks of flats (condominiums). Only 5% of the apartments are energetically upgraded by thermal insulation. As wood is becoming better regulated and the prices of heating and fuels are liberalized, the heating costs shall start to increase, encouraging the investment in thermal rehabilitation measures of the housing.

Of the total housing, only approx. 1.2 million are connected to Centralised Heating Systems (about 600,000 apartments only in Bucharest). One third of Romania's housing (almost 2.5 million) is heated directly by natural gas, using apartment plants, as well as stoves with extremely low efficiency (at least 250,000 housing). Approximately 3.5 million housing (the vast majority in the countryside) use solid fuel - mostly wood, but also coal - burned in stoves with very low efficiency. The rest of the housing are heated with liquid fuels (heavy oil, diesel or LPG) or electricity. More than half of the Romanian homes are partially heated in winter.

Access to European funds (Energy Efficiency Directive, Energy Performance of Buildings Directive, RES Directive) needs to be stepped up. Elimination of heat losses in buildings shall contribute substantially to the decreasing of the heating bill, with the effect of lowering the need for funds allocated supplementary for housing.

IV.4.6. Thermal energy and cogeneration

Prior to 1989, the centralized heating supply (Centralised Heating Systems) of urban localities was practically generalized in Romania. More than 60 such systems were built during that period, in most of them being also installed units for the production of electricity in cogeneration.

After 1989, as a result of the restructuring and even the disappearance of the Romanian industry, the heat demand related to these Centralised Heating Systems decreased year after year and they became more and more inefficient from economical point of view.

In recent years, much of the Centralised Heating Systems cogeneration capacities have been withdrawn from operation and even decommissioned due to the financial impossibility of making the necessary environmental investments, but in some cases due to the constructive inconsistency of these groups (designed especially for

industrial cogeneration) to the current requirements of the thermal energy market.

For these reasons, District Heating Systems (DHS) have experienced over the past 20 years with massive consumer disconnections, who have chosen afterwards the individual heating solutions.

The EU's Heating and Cooling (HC) strategy promotes the development of cogeneration and trigeneration units (electricity, heating and cooling). For this reason, distributed production is encouraged, as far as it proves to be economically feasible.

2.4.7. Regional champions of the Romanian energy domain

Romania has a balanced and diversified energy mix. This fact is also illustrated by the performance of the main energy generating companies, concentrating each on the exploitation of one type of primary energy source, as well as by the electricity and natural gas transmission operators.

Large companies where the state is the majority shareholder are the backbone of the National Energy System. Taking into account the geographical and strategic positioning of Romania, as well as the vision of the development of the energy sector, these companies have the potential to become genuine regional champions.

The contribution of these regional champions to the energy security of the region has been clearly seen in the last few years when the energy systems of the countries in this part of Europe have been affected by extreme weather conditions. The size of these companies, the energy produced, delivered and transported, ensured the proper functioning of the National Energy System, as well as of the energy systems in the neighbouring countries. The status of Romania as an energy security provider in the region is sustained to a great extent by the activity of these companies.

All six companies have ambitious development plans - whether we are talking about new investment objectives, or whether we are talking about rehabilitation and modernization of some of the targets in operation. And the development is not limited to the territory of Romania; on 28 March 2018, EUROTRANSGAZ, established and owned by TRANSGAZ Romania in the Republic of Moldova, signed the sale / purchase contract of the Vest Moldtransgaz State Enterprise from the neighbouring country.

The Energy Strategy sets out the guidelines for the development of the energy sector; the development of companies is a natural consequence of the growth of the domain, both from the point of view of the balanced mix of resources that Romania benefits, as well as of the size of these regional champions from all points of view: energetically, economical, financial or social.

SPEEH HIDROELECTRICA SA

Hidroelectrica operates 208 hydro power plants with a total installed capacity of 6,444 MW. In 2017, the company produced over 14 TWh, registering a net profit of 1,360 million Lei. Hidroelectrica is a leader in power generation and the leading provider of ancillary system services in Romania.

SPEEH Hidroelectrica SA is owned by the Romanian state, through the Ministry of Energy (80.06% of the shares) and by Fondul Proprietatea (19.94% of the shares) and it is preparing for listing on the stock exchange.

Hidroelectrica SA had at the end of 2017 a number of 3,297 employees.

SN NUCLEARELECTRICA SA

SN Nuclearelectrica SA produces electric and thermal energy, and also nuclear fuel. In 2017, total electricity production was of 11.5 TWh, and the net profit of the company was over 303 million Lei.

The company is listed on the stock exchange and the structure of the shareholders is as follows: the Romanian State through the Ministry of Energy - 82.48% of the shares, the Proprietatea Fund - 9.10%, the other shareholders - 8.42%.

Nuclearelectrica has two branches, without legal personality - CNE Cernavoda Branch, which operates Power Units 1 and 2 from Cernavoda NPP, as well as ancillary services, and FCN Pitesti Branch, qualified enterprise to produce nuclear fuel.

Nuclearelectrica is also the sole shareholder of the project company EnergoNuclear, for the construction of reactors 3 and 4 from Cernavoda.

The company number of employees in 2017 was 1,975.

SNGN ROMGAZ SA

ROMGAZ is the largest producer and main supplier of natural gas from Romania. The company has been admitted to trading on the Bucharest Stock Exchange and the London Stock Exchange (LSE) since 2013.

The main shareholder is the Romanian State through the Ministry of Energy with a 70% stake.

The natural gas production of the company was higher than that for the year 2016 by 22.2% and 939 million cm respectively (5,158 million cm in 2017 vs 4,219 million cm in 2016). With this production, according to estimates, Romgaz had a market share of 50.53% of domestic gas deliveries and a 46.27% share of deliveries in Romania's total consumption.

The company registered in 2017 a net profit of 1,854.7 million Lei.
The number of employees at the end of 2017 was of 6,246.

SOCIETATEA COMPLEXUL ENERGETIC OLTENIA SA

The company Complexul Energetic Oltenia produces lignite-fired electrical and thermal energy. The mining and preparation of lignite are also part of the company's activity object.

The Romanian State, through the Ministry of Energy, owns 15% of the Complexul Energetic Oltenia capital. Fondul Proprietatea owns 21.56%, Electrocentrale Grup SA 0.84% and the Societatea de Inchidere si Conservare Mine 0.44%.

In 2017, Complexul Energetic Oltenia produced 15 TWh of energy. In percent, this represents 24% of the country's total energy production, at a production level of 22.5 million tons of coal.

The Complexul Energetic Oltenia reported a net profit of approximately 181 million lei for 2017, compared to a loss of approximately 140 million lei registered in 2016.

At the end of 2017, the Complexul Energetic Oltenia had 13,281 employees.

SNTGN TRANSGAZ SA

TRANSGAZ is the technical operator of the National Gas Transmission System and ensures the efficiency, transparency, safety, non-discriminatory access and the competitiveness of the national strategy established for internal and international transport, natural gas dispatching, research and design in the field of natural gas transport, with the observing of the national and European legislation and standards for quality, performance, environment and sustainable development.

The company is listed on the Bucharest Stock Exchange. The state owns 58.5% of the shares through the Ministry of Economy, the rest being owned by other legal or physical persons.
In 2017, TRANSGAZ's turnover was over 1.8 billion Lei, and the net profit exceeded 582 million Lei.

According to the National Gas Transmission System Development Plan in the period 2017-2026, TRANSGAZ has set a series of investment objectives that shall have as result the ensuring of an adequate degree of interconnectivity with neighbouring countries, the creation of natural gas transport routes at the regional level for the transport of natural gas from different new supply sources. The company also invests in the necessary infrastructure for taking over and transport of the natural gas from the Black Sea offshore perimeters for its capitalisation on Romanian market and on other markets in the region. TRANSGAZ expands the natural gas transport infrastructure with the purpose to improve the supply of natural gas to deficient areas and it contributes to the creation of a single integrated market at the level of the European Union.

In 2017, TRANSGAZ had 4,628 employees.

CNTEE TRANSELECTRICA SA

TRANSELECTRICA has the mission to ensure the public transport of electricity simultaneously with maintaining the safety of the functioning of the National Energy System under non-discriminatory conditions of access for all users, to actively participate in the development of the infrastructure of the electric transmission network to the sustainable development of the energy system and to support and facilitate the operation and integration of energy markets.

The key role of TRANSELECTRICA is Transmission System Operator (TSO), plus the manager of the balancing market, measurement operator and capacity allocation operator on interconnection lines.

The company is listed on the Bucharest Stock Exchange. The Romanian State owns 59.68% of the shares, through the Ministry of Economy, the rest of the shares being held by other legal and physical persons.

In 2017, TRANSELECTRICA recorded operating revenues of over 1.8 billion Lei.

The company's number of employees was 2,178 in 2017.

V. MEASURES AND ACTIONS TAKEN IN ORDER TO MEET THE STRATEGIC OBJECTIVES

The eight strategic objectives of the Romanian energy sector are expressed in concrete terms through a set of

operational objectives (OO). In their turn, the operational objectives are pursued through priority actions (PA).

In correlation with the priority actions and based on the results of the quantitative analysis, chapter VII are presented the quantifiable targets, through which are fulfilled a part of the priority actions in view of 2030.

Table –Correspondence between the fundamental strategic objectives and the operational objectives

Fundamental strategic objectives to which they contribute

	Energy contribution	Security	Competitiveness	Clean Energy /Environment	Governance	Consumer/ Access to energy	Vulnerable consumer /Energetically poverty	Education
OO01	x	x	x	x				x
OO02	x	x						
OO03	x	x						
OO04	x	x						
OO05		x	x			x	x	
OO06		x						
OO07		x						
OO08		x						x
OO09	x		x	x				
OO10			x	x		x		
OO11			x			x		
OO12			x			x	x	
OO13			x					
OO14			x					x
OO15				x				x
OO16				x				
OO17		x		x				
OO18					x			
OO19			x		x	x		
OO20					x			x
OO21					x			
OO22						x		
OO23							x	

(OO01) DIVERSIFIED AND BALANCED ENERGY MIX

PA1a: Continuing the sustainable exploitation of all the primary energy resources of the country.

PA1b: Maintain a diversified and flexible park of electricity production capacities according to the Romania's energy mix.

PA1c: Selection of advanced technologies in the energy sector by attracting private investment, by sustaining scientific research and by developing strategic partnerships.

PA1d: Development of electricity generation capacities with low GHG - nuclear, renewable sources, hydropower.

(OO02) CAPITALIZATION OF NEW DEPOSITS OF PRIMARY RESOURCES TO MAINTAIN A LOW LEVEL OF ENERGY DEPENDENCY AND FOR THE SAFETY OPERATION OF NES

PA2a: A stimulating investment environment for the exploration and development of oil, natural gas and lignite deposits, as well as for the increase of recovery degree from mature fields.

PA2b: Timely delivery of necessary infrastructure for market access to the production of new natural gas deposits.

PA2c: Establishment of development areas for energy capacities using renewable energy sources.

(OO03) INCREASING INTERCONNECTION CAPACITIES OF THE ENERGY TRANSMISSION NETWORKS

PA3a: Establishing corridors for the energy transmission networks and establishing a special regulatory framework in order to ensure lands, licenses and other measures needed for their execution.
PA3b: Providing financial resources for interconnection capacity with bidirectional flow and related components of national energy transmission systems.
PA3c: Coordination at regional level for timely development, financing and exploitation of international energy infrastructure projects.
PA3d: Harmonize the network codes and incoming / outgoing charges to / from national energy transmission systems in order to facilitate the regional energy flows.
PA3e: Closing the 400 kV ring in the national electricity transmission system.
PA3f: Making new lines for the linking of new production capacities with interconnection points.
PA3g: Rehabilitation of hydrocarbons transport systems.

(OO04) ENSURING THE ENERGY STORAGE CAPACITY AND OF BACKUP SYSTEMS
PA4a: Establishment of compulsory stocks of crude oil, petroleum products and natural gas.
PA4b: Development of energy storage capacities in hydroelectric pumping systems; construction of Tarnita-Lapusesti Pumped Storage Hydroelectric Power Station.
PA4c: Developing of capacities and mechanisms for integrating the RES intermittent in NES, into electrical battery systems, including small storage capacities at the prosumer location.

(OO05) INCREASING THE FLEXIBILITY OF NATIONAL ENERGY SYSTEM BY DIGITALIZATION, INTELLIGENT NETWORKS AND THE DEVELOPMENT OF ACTIVE CONSUMER CATEGORY (PROSUMER)
PA5a: Digitalisation of the national energy system in the transmission, distribution and consumption segments.
PA5b: Encouraging of prosumers, both domestic and industrial and agricultural, along with the development of networks and smart meters.
PA5c: Integration of distributed production systems and prosumers into the power system.

(OO06) CRITICAL INFRASTRUCTURE PROTECTION AGAINST PHYSICAL AND COMPUTER ATTACKS, AND CALAMITIES
PA6a: Implementing physical security measures for critical infrastructure against possible terrorist acts.
PA6b: Computer security of energy network control systems by strengthening protection barriers, as well as through international cooperation.
PA6c: Ensuring the maintenance and modernization works of the energy system as a whole in order to maintain the safety standards of critical objectives (lakes, dams, dikes, etc.).
PA6d: Implementation of population warning/alert systems and performing civil defence exercises.

(OO07) ROMANIA'S PROACTIVE PARTICIPATION TO EUROPEAN INITIAVES IN THE FIELD OF ENERGY DIPLOMACY
PA7a: Romania's participation in setting up solidarity mechanisms to ensure energy security in crisis situations of energy supply.
PA7b: Romania's participation in the incipient elaboration stages of European documents with normative and strategic character, in the sense of promoting the national interests.
PA7c: Increasing Romania's capacity to attract European funding for the development of strategic infrastructure projects and for energy efficiency programs.
PA7d: Diplomatic approaches for Romania's accession to the Organization for Economic Co-operation and Development and involvement in the activities of the International Energy Agency.

(OO08) DEVELOPMENT OF STRATEGIC PARTNERSHIPS OF ROMANIA IN THE FIELD OF
PA8a: Attracting the investments of leading energy companies in Romanian energy sector.
PA8b: Development of cooperation in the field of scientific research and know-how transfer.
PA8c: Cooperation with partner country authorities to increase infrastructure security.

(OO09) REPLACEMENT OF POWER GENERATION CAPACITIES THAT SHALL LEAVE THE SERVICE, BY NEW ONES, MORE EFFICIENT AND WITH LOW EMISSIONS, UNTIL 2030
PA9a: Investing in new electricity generation capacities, under the constraint of achieving the energy security, competitiveness and decarbonisation objectives of the energy sector.
PA9b: Ensuring a technological neutrality framework for the development of the national energy mix.
PA9c: Providing funding mechanisms for the investments in new electricity generation capacities without GHG emissions and in terms of economic efficiency.
PA9d: Providing funding mechanisms for completing the hydro-energetic facilities with complex utilisations (irrigation, flood protection, water supply, etc.).

(OO10) INCREASING ENERGY EFFICIENCY THROUGHOUT THE ENTIRE VALUE CHAIN OF THE ENERGY SECTOR
PA10a: Clearly defining the concept of "energy efficiency" in the sense that it corresponds to the efficiency increasing and losses decreasing, in conditions of economic and consumption growth.
PA10b: Capitalization of energy efficiency potential in the building sector by thermal insulation programs in the public sector, blocks of flats and communities affected by energy poverty.
PA10c: Integrated approach to the district heating sector of buildings, with the coordination of investment projects

on the value chain - production, transport and efficient use of the thermal agent.
PA10d: Development of smart metering and of smart networks.
PA10e: Implementing measures to mitigate network technical losses and to combat the energy thefts.

(OO11) COMPETITION INCREASING ON DOMESTIC ENERGY MARKETS
PA11a: Development of the internal natural gas market by increasing the traded volumes and liquidity, and further linking to the European natural gas market.
PA11b: Integration of Romanian energy markets into the single European energy market, in order to increase the regional role of Romanian stock exchanges in the trading of energy products.

(OO12) LIBERALIZATION OF ENERGY MARKETS AND THEIR REGIONAL INTEGRATION IN ORDER TO THE ENERGY CONSUMER CAN BENEFIT FROM THE BEST PRICE OF ENERGY
PA12a: Increasing the transparency degree and liquidity of energy markets.

(OO13) IMPRUVING THE ECONOMIC ACTIVITY EFFICIENCY OF THE ENERGY COMPANIES WITH STATE CAPITAL
PA13a: Improving the management of state-owned energy companies in order to increase their value on medium and long term, without political or social considerations.
PA13b: Elimination of losses in state-owned energy companies.
PA13c: Economic optimization of asset portfolios and investment projects of state-owned energy companies.

(OO14) ECONOMIC AND FISCAL POLICIES FOR THE INVESTMENT STIMULATION IN DEVELOPMENT OF INDUSTRY PRODUCING RES EQUIPMENT, ENERGY EFFICIENCY AND ELECTROMOBILITY
PA14a: capitalization of national primary energy resources to the greatest extent possible in the domestic economy, in order to generate an economic multiplier effect.
PA14b: Sustaining the scientific research and investment in the production of equipment and components for energy transition – RES, energy efficiency and electro mobility technologies.

(OO15) DECREASING OF GHG AND NOX EMISSIONS IN THE ENERGY SECTOR
PA15a: Current activities and the projects of companies in the energy sector must comply with environmental legislation and should apply the best international environmental protection practices.
PA15b: Further decrease of pollutants emissions into the air, water and soil, related to the energy sector.
PA15c: Sustaining the scientific research for the decarbonisation of energy sector.
PA15d: Promoting alternative fuels.
PA15e: Decreasing of the volume and safe storage of radioactive waste at the producer (Cernavoda NPP) and correlation with the *"Medium and long term National Strategy on the safe management of the nuclear fuel spent and of radioactive waste"*.

(OO16) SUSTAINABLE DEVELOPMENT OF THE NATIONAL ENERGY SECTOR, BY PROTECTING THE QUALITY OF AIR, WATER, SOIL AND BIODIVERSITY
PA16a: Organizing information programs and public debates related to the major energy projects, by taking into account the interests of local communities and national interest.

(OO17) EQUITABLE PARTICIPATION TO THE COLLECTIVE EFFORT OF EU MEMBER STATES TO MEET THE TARGETS IN THE FIELD OF ENERGY EFFICINCY, RES AND REDUCTION OF GHG GAS EMISSIONS

PA17a: Fulfilment of the targets assumed by Romania for year 2020.
PA17b: Equitable participation in achieving the collective targets of the EU Member States for 2030, under the imperatives of guaranteeing energy security and the competitiveness of energy markets.
PA17c: Equitable participation in the achievement of the European GHG reduction target by 80% compared to 1990, by 2050, namely the limitation of the climatic changes to 1.5-2 °C.

(OO18) SEPARATION OF THE STATE FUNCTION OF OWNER AND SHAREHOLDER FROM THE ONE OF ENERGY MARKET ARBITRATOR

PA18a: Institutional separation of state activity as a legislator, regulator and policy maker on the one hand, that the owner and asset manager, on the other hand.

(OO19) TRANSPARENCY OF THE ADMINISTRATIVE ACT, SIMPLIFICATION OF BIROCRATION IN THE ENERGY SECTOR
PA19a: Reducing bureaucracy through transparency, digitalization and introduction of "one-stop shop".
PA19b: Introduction of the best practices on transparency and responsibility in the interaction between the consumer and the administrative system.
PA19c: Developing institutional mechanisms (such as integrity alerts); the publication of regular reports on completed public procurement and on all sponsorship granted.
PA19d: Elimination of conflicts of interest between public institutions and energy companies with state capital.

(OO20) SUSTAINING OF EDUCATION AND PROMOTION OF SCIENTIFIC RESEARCH; HEALTH AND WORK SAFETY
PA20a: Development of higher education in the field of energy and harmonizing it with the needs of the energy sector. Partnerships with the energy industry for education and training.

PA20b: Sustaining the vocational secondary education in the field of energy.
PA20c: Sustaining the scientific research, technological development and innovation in the field of energy; development of partnerships with the energy industry, as well as with the university centres.
PA20d: Development of the capacity to attract European and international funding sources for scientific research, by participating in international consortia of research - development - innovation institutes.
PA20e: Continuous training programs for the specialists from energy sector administration;
PA20f: Continuous training in order to prevent occupational hazards, to protect workers' health and safety, to eliminate risk factors and injury.

(OO21) IMPROVING CORPORATE GOVERNANCE OF THE COMPANIES WITH STATE CAPITAL
PA21a: Implementation of the rules on corporate governance of the companies with state capital and introduction of mechanisms to monitor the managerial performance of these companies.
PA21b: Ensure the professionalism and transparency of selection process for the management team, with a detailed publication of the selection criteria and the interim and final results.

(OO22) INCREASING THE POPULATION ACCESS TO ELECTRICITY, HEATING AND NATURAL GAS
PA22a: Improving access to alternative energy sources by the development of distribution networks.
PA22b: The development, from various sources of financing, of the micro-networks and distributed electricity generation systems, with priority for households without access to electricity.
PA22c: Development of public policies at the level of local administrative units on how to provide heat for communities.
PA22d: Development of natural gas distribution networks throughout the country.

(OO23) DECREASING THE DEGREE OF ENERGY POVERTY AND VULNERABLE CONSUMER PROTECTION
PA23a: Performing public thermal insulation programs for the communities affected by energy poverty in order to reduce energy losses and lower heating costs.
PA23b: Protection of the vulnerable consumer by adequate social aid, such as heating aids and the social tariff for electricity, respectively by public service obligations.

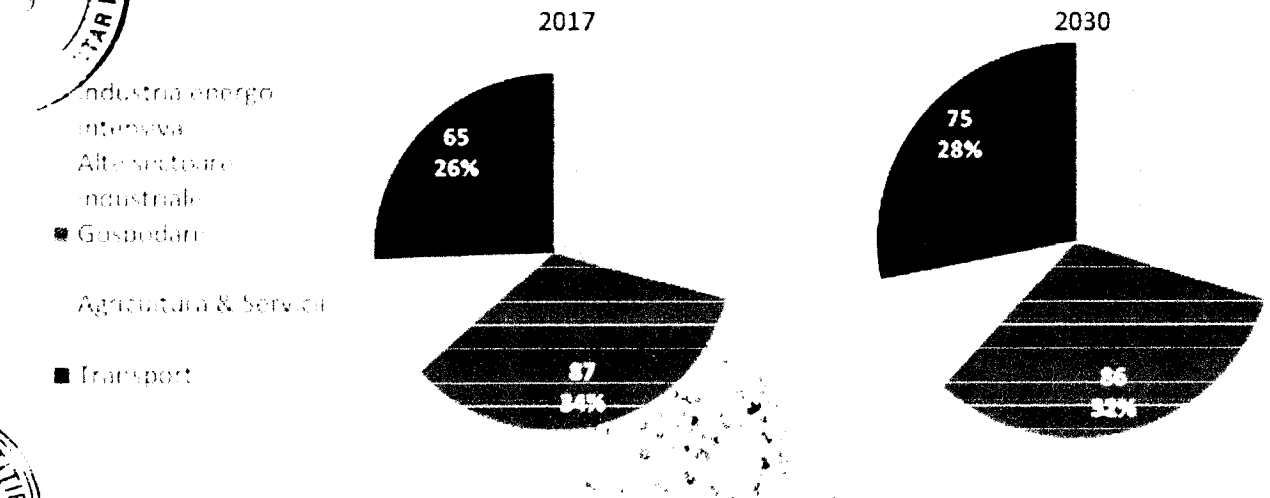
VI. EVOLUTION OF NATIONAL ENERGY SECTORS UP TO 2030

VI.1. Energy consumption

VI.1.1. Demand for energy by sectors of activity

Romania's gross energy consumption declined significantly after 1990, reaching 377 TWh (1 TWh = 0.086 mil toe) equivalent to around 19 MWh per capita in 2015 and final energy consumption of 254 TWh.

Gross energy consumption in 2030 is estimated to increase to 394 TWh and final energy demand to 300 TWh. Consumption of energy resources as raw material it follows to increase by 35%, while energy consumption and losses shall decrease by 4 TWh.



Industria energo-intensiva – Energy-intensive industry
Alte sectoare industriale – Other industrial sectors
Gospodarii – Households
Agricultura si Servicii – Agriculture and Services
Transport - Transport

Figure 2 – Demand for final energy by sectors of activity in 2017 and 2030. (Source: Primes)

VI.1.2. Mix of primary energy

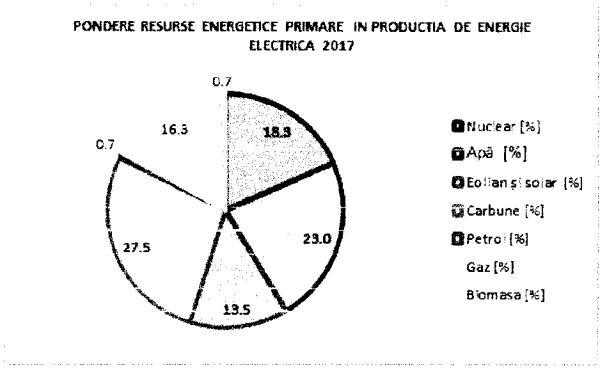
Romania has a balanced and diversified mix of primary energy resources in electricity production.

In 2017, the share of primary energy resources in electricity production had the following structure: electricity generated based on coal (lignite and hard coal) 27.5% (17.3 TWh); electricity generated by hydro power plants 23%(14,4TWh); electricity generated by Cernavoda nuclear power plant 18.3% (11.5 TWh); electricity generated based on hydrocarbons (oil and gas) 17% (10.7TWh); electricity generated by wind farms and photovoltaic parks 13.5% (8.5TWh), electricity generated based on biomass 0.7% (0.4 TWh).

By grouping the renewable energy sources, their share in the structure of electricity production in 2017 was of 37.2% (23.4TWh) followed by coal with 27.5% (17.3 TWh).

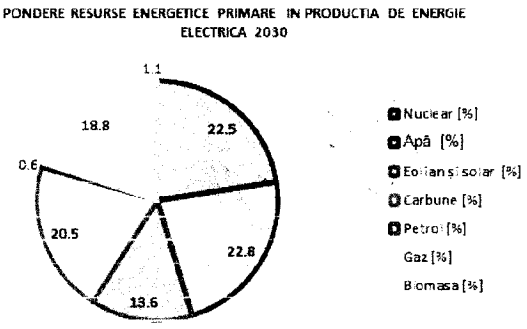
Gross average consumption in 2017 was 59.9 TWh of a production of 62.8 TWh, the difference being the export of electricity.

For the year 2030, the results of the chosen optimal scenario modelling are showing an increase in the share of energy from nuclear sources to 17.4 TWh and in 2035 to 23.2 TWh. An increase to 29 TWh shall be recorded for the total renewable sources, representing a share of 37.9% of all primary energy sources that shall make up the energy mix in 2030. Energy from coal shall drop slightly to 15.8TWh and shall have a share of 20.6%. An increase of 1.9% shall be registered by the production of electricity from hydrocarbons of about 14.5 TWh.



PONDERE RESURSE ENERGETICE PRIMARE IN PRODUCTIA DE ENERGIA ELECTRICA 2017 – SHARE OF PRIMARY ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2017

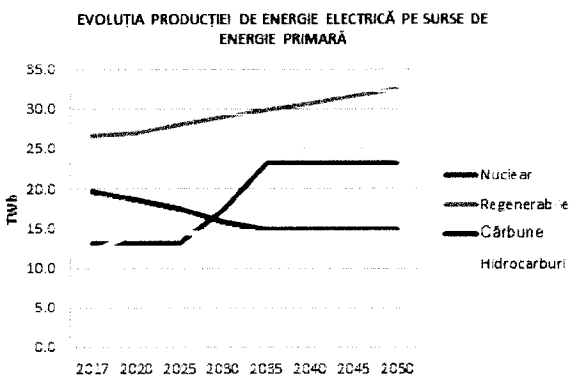
Nuclear – Nuclear power
Apa – Water
Eolian si solar – Wind and photovoltaic
Carbune – Coal
Petrol – Oil
Gaz – Gas
Biomasa - Biomass



PONDERE RESURSE ENERGETICE PRIMARE IN PRODUCTIA DE ENERGIA ELECTRICA 2030 – SHARE OF PRIMARY ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2030

Nuclear – Nuclear power
Apa – Water
Eolian si solar – Wind and photovoltaic
Carbune – Coal
Petrol – Oil
Gaz – Gas
Biomasa - Biomass

Figure 3 - Structure of the primary energy mix in 2017 and 2030



EVOLUTIA PRODUCTIEI DE ENERGIE ELECTRICA PE SURSE DE ENERGIE PRIMARA – EVOLUTION OF ELECTRICITY PRODUCTION BY PRIMARY ENERGY SOURCES
Nuclear – Nuclear power
Regenerabile – Renewable energy
Carbune – Coal
Hidrocarburi - Hydrocarbons

ELECTRICITY PRODUCTION 2017-2050 [TWh]								
	2017	2020	2025	2030	2035	2040	2045	2050
ELECTRICITY PRODUCTION ON SOURCE TYPES [TWh]	**63**	**69**	**72**	**77**	**83**	**84**	**85**	**86**
Nuclear	11,5	11,5	11,4	17,4	23,2	23,2	23,2	23,2
Water	14,4	15,8	17,5	17,6	17,6	17,6	17,6	17,6
Eolian & solar	8,5	8,8	9,6	10,5	11,4	12,3	13,1	14,0
Coal	17,3	17,5	17,8	15,8	14,9	14,9	14,9	14,9
Oil	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Gas	10,2	14,0	14,5	14,5	14,5	15,0	15,0	15,0
Biomass	0,4	0,9	0,9	0,9	0,9	0,9	0,9	0,9
SHARE ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2017-2050 [%]								
Nuclear [%]	18,3	16,7	15,8	22,5	28,0	27,5	27,2	26,9
Water [%]	23,0	22,9	24,3	22,8	21,2	20,9	20,7	20,5
Eolian & solar [%]	13,5	12,7	13,3	13,6	13,7	14,6	15,4	16,3
Coal [%]	27,5	25,4	24,7	20,5	18,0	17,7	17,5	17,3
Oil [%]	0,7	0,6	0,6	0,6	0,5	0,5	0,5	0,5
Gas [%]	16,3	20,3	20,1	18,8	17,5	17,8	17,6	17,4
Biomass [%]	0,7	1,3	1,2	1,1	1,1	1,0	1,0	1,0

VI.1.3. Consumption of final energy

Analysis of final energy consumption in 2017 (total 254 TWh) by type of energy consumption highlights the need for heating and cooling, estimated at 97 TWh (39%) - of which 76 TWh in households and 21 TWh in services. Next, in descending order, consumption in industrial processes (48 TWh) and passenger transport (48 TWh). The rest of the industrial energy consumption is 27 TWh of final energy and the freight transport consumes the equivalent of 17 TWh. Electronic equipment and appliances used in households and services consume 13 TWh (of which 10 TWh household consumption). Finally, the specific consumption in the agricultural sector is 4 TWh. Consumption for heating shall drop slightly through increased energy efficiency.

VI.2. Primary energy resources: domestic production and imports

In the field of exploration and exploitation of oil and natural gas deposits over the last decade, emphasis has been placed on the performing of geological and geophysical works programs for the discovery of new reserves and the development of existing reserves to sustain production and the ensuring by the concessionaires through their own investment programs of the production levels foreseen in by the oil agreements. Achieving the projected levels of production was possible through the implementation of modernization and rehabilitation programs aimed at maximizing the value of existing portfolios, improving economic recovery rates and minimizing the impact of production natural decline.

The perspectives for highlighting new probable and possible reserves are conditioned by the investments that shall be made in the field of geological and geophysical exploration by the concessionaires operating on the Romanian territory, as well as the results obtained by them in the exploration process, in order to identify new deposits.

On short and medium term, in order to increase the certain reserves of crude oil and natural gas, Romania should take as priority the promotion/encouragement of the concessionaires to invest in technologies that lead to the increase of the recovery degree from the existing deposits and on long term, to the development of exploration projects both in the field of conventional and unconventional production.

Investment cycles in exploration and production of hydrocarbons are long-lasting and the regulatory framework must provide a long-term perspective. For this reason, it is of strategic importance to develop a predictable, stable and internationally adaptable regulatory framework, correlated with the development type and potential of different deposits types, in order to maintain the competitiveness of domestic oil industry.

VI.2.1. Oil

The low oil price recorded on the international market between 2015 and 2016 drastically reduced the investments in exploration and development of new deposits, and the effect was also felt in Romania.

Oil market prices have risen steadily since 2017, with the Brent crude oil price reaching mid-May 2018 at the record of recent years - 80 USD/barrel respectively.

At the end of May 2018, Brent crude oil was trading at 75.38 USD/barrel, while the price of future oil was at 66.72 USD/barrel.

Crude oil production in Romania is on a downward slope with a subunit level of reserves replacement, due to the high degree of deposits depletion. The increasing of recovery level is possible, but investment efforts, which are not negligible, require packages of stimulating economic and fiscal measures.

The modelling results in 2016 indicate the halving of domestic crude oil production to around 2 million tons in 2030. Increased import dependence can be avoided in the medium and long term only by encouraging the exploration and production activities, as well as by increasing the efficiency of fossil fuel consumption.

EU policies for the use and use promotion of alternative fuels to a greater degree shall mitigate the impact of oil and oil products import dependency of Romanian market. This process shall be possible insofar as the development of infrastructure related to the production and use of alternative fuels shall be achieved in direct relation to their competitiveness on the fuel market.

VI.2.2. Natural gas

Natural gas production got stabilized in recent years as a result of investing in prolonging the life of existing deposits and the development of new ones. In 2017, domestic production provided 89.4% of domestic consumption, with imports reaching 10.60%.

Additional natural gas resources from onshore and offshore deposits are provided in all scenarios of Romania's energy mix, except for the unlikely long-term maintenance of low prices, which does not justify further investment.

Exploitation of Black Sea oil resources shall have a major contribution to the providing of Romania's energy security. Cumulated quantity levels of conventional onshore and offshore production may have the potential to be surplus to the currently estimated level of domestic demand that is relatively linear.

Romania aims to increase the consumption of natural gas in the domestic industry and to export finished products that are using as raw material also natural gas.

VI.2.3. Coal

The production of lignite and hard coal in Romania depends directly on the national demand for primary energy resources in the power generation sector and on the resources/reserves available to Romania.

The role of coal in the electricity mix shall depend on the competitiveness of the raw material price, with direct influence on the price of energy produced on the basis of this primary energy resource.

The production of lignite is performed mainly in the Oltenia mining basin, in a number of 15 mining perimeters where, through the installed generation capacities, it can be achieved a flexible production between 20 and 30 million tons/year. The lignite resources are exhaustible, and in the current perimeters the concession term granted through exploitation licenses exceeds the first half. Providing the necessary lignite for operation in terms of power plants economic efficiency shall be achieved by identifying and opening new mining perimeters, only in terms of economic efficiency.

The hard coal demand for the power generation and for thermal energy production shall be provided by the production of the Vulcan and Livezeni mines, supplemented with the necessary import, until the reconfiguration on another more efficient primary energy resource, of the unprofitable hard coal-fired thermal power plants.

VI.2.4. Hydropower

By the gradual application of policies set by the Strategy, until 2030, the installed capacity of hydropower plants from Romania shall increase compared to 2018, by about 750MW. The plants that shall provide this increase of installed capacity shall provide an additional energy production of about 1.8 TWh/year. Considering the fact that the most favourable hydropower sites have already been arranged, the new projects shall have lower indicates of investment return and shall need to be developed to provide benefits other than energy (eg. flood prevention, water supply, irrigation, etc.).

Although there shall be an increase of installed capacity by 2030, the total energy production to be recorded by Romania's hydropower plants shall remain close to those of 2018, ie about 17.6 TWh/year, as all the rules contained in European environmental policies shall be implemented. Compared to the regulated situation in 2018, the decrease of the useful water resources that can be turbid as a result of the increase of servitude/ecological flows, in 2030 shall correspond to an unachieved production of about 2TWh/year.

The evolution of the hydropower sector for the period 2019-2030 shall be achieved on the following coordinates:

1. harmonization with European environmental policies;
2. integrated planning of the capitalization of water resources and resumption of the state's financial involvement in complex hydro-energetic projects;
3. new investments and modernization of existing plants; maintaining a high degree of operation safety.

These evolution coordinates are achieved by the implementation of specific energy policies as follows:

Development of micro hydro power plants, with plants on the bypass

Since it has been found that this kind of hydro power plants can have a significant negative impact on the running waters ecological status, by 2030, the achievement of new projects of this type shall not benefit from support.

The competent environmental authorities and those responsible for water management shall establish specific rules defining and regulating the conditions for the construction and operation of this type of hydroelectric power plants.

Harmonization with European policies for environmental protection

Since the large hydropower plants are and shall remain a core element of NES security, this role shall be taken into account in the implementation way of environmental policies.

Ecological flows

For large hydropower developments, the transition to higher standards of ecological flow shall be achieved gradually by 2030, through three adjustment steps, in order to achieve compliance with the European average standards in the field. For small-scale hydropower developments, compliance with European average standards shall be achieved by 2025.

Passages for the migration of aquatic fauna

Water capture works related to hydropower facilities must ensure the movement of aquatic fauna. By the identification of feasible solutions, until 2030, the barrage works of the natural riverbeds shall be equipped with such systems.

Natura 2000 Sites

In order to establish how to regulate the hydro-energetic developments that have works in the Natura 2000 sites (or are influencing these sites), that are in operation, under construction or in the project phase and have valid building permits, shall apply the following principles:

- in the Natura 2000 sites, the new large-scale hydropower projects shall not be carried out except for those that have obtained the necessary approvals until 2018. Only for providing electricity supply of isolated communities, without access to electricity distribution networks, with respect to acceptable conservation principles for Natura 2000 sites, it shall be still allowed the implementation of hydroelectric power plants with installed capacity of up to 1 MW, that shall be able to supply the networks in island system;
- depending on the implementation stage of the projects with ongoing works and valid building permits, the investment holders together with the competent environmental protection and water management authorities, shall identify feasible solutions for adapting the hydropower projects so that the environmental impact to be as small as possible;
- for the hydropower facilities in operation, when updating the environmental and water management permits, there shall be progressively imposed, between 2020 and 2030, all necessary measures in order to minimize the environmental impact.

Integrated planning of water resource utilization and resumption of state financial involvement in hydro-energy projects with complex uses

Hydro-energetic facilities with complex uses are projects that produce effects at local and regional level. The development and operation of these facilities, which besides electricity, also bring other social benefits, it shall continue to be sustained until 2030. In this respect, in the period 2019-2025, a series of economic development policies shall be promoted in order to ensure:

- simplification of association procedures between state-owned companies, local public authorities and private investors that are wishing to develop or complete hydro-power projects with complex uses;
- state participation in investments by budget allocations, for those objects of the arrangement schemes that shall ultimately be found in the public domain of the state;
- the establishment of a special tax regime as well as differentiated taxation on water use;
- bearing the cost of services provided by the hydro-energetic facilities with complex uses by their real beneficiaries by contributing to the maintenance and operation costs of these developments.

New investments and modernization of existing plants; maintaining a high degree of safety in service

Development of the energy system means, first of all, the increasing generation capacity.

Taking into account the technically feasible potential, by 2030, the projects that are in execution in the year 2018, amounting to about 500 MW, shall be completed. There shall also be launched other new projects both by private investors and by the state-owned company Hidroelectrica.

Capacities in operation, staggered, as the normal use time shall be reached, all equipment and constructions shall be modernised.

By the fact that they are generating electricity, but also are providing ancillary system services, the hydropower facilities are a key factor for ensuring Romania's energy security. It is therefore vital that these capacities be exploited having a proper technical condition. Between 2019 and 2020, specific policies shall be promoted to address:

- assessment of the technical condition of constructions, equipment and the way in which are performed the maintenance activities and the monitoring of buildings behaviour;
- reviewing the regulations, norms and technical normative regarding the monitoring activities of buildings behaviour and of equipment monitoring;
- updating the regulations, norms and prescriptions for the designing of repair works in order to correspond with the modern technical solutions;
- updating the regulations and norms regarding the modernization and rehabilitation works;
- implementation and maintenance in the proper functioning state of all warning and intervention systems in case of calamities caused by damage to hydro technical constructions.

By 2020, hydroelectric development schemes with complex uses included in Hidroelectrica's development portfolio shall be resized according to the current levels of these complex uses and shall be completed by 2030, on the basis of integrated planning policies and state participation in securing the funding.

The recovery of budgetary funds to finance them shall be achieved by setting an appropriate level of the royalty charged by the state to Hidroelectrica for the use of the entire package of goods belonging to the concessioned public domain.

VI.2.5. Wind and solar energy

Compared to the total capacity installed in 2018 for electricity generation, at the level of 2030 there shall be an increase in wind capacities up to a power of 4,300 MW and photovoltaic up to 3,100 MW.

According to these installed capacities, in 2030, the average annual power supplied in the national energy system from wind sources shall be of about 8.4 TWh and from photovoltaic sources of about 2.1 TWh/year.

In 2030, from the total installed power of photovoltaic systems, 750 MW shall be achieved in the form of distributed capacities owned by the energy prosumers.

In order to achieve until 2030 the development degree of valorisation of these renewable energy resources, it is essential to promote policies aimed at:

1. construction of energy storage capacities and development of the transmission network;
2. declaring of some areas for energy development using renewable sources, for large projects and providing their connection to the network with Transelectrica support;
3. providing conditions that allow the replacement of capacities at the end of their lifecycle;
4. development of small, distributed capacities and encouraging the prosumers.

Construction of energy storage capacities and development of the transmission network

The increasing of renewable sources share up to the level forecast for 2030, it shall be achieved only if simultaneously in the national energy system, shall be developed also the energy storage solutions, which shall ensure the loading/unloading cycles with longer durations than 6-8 hours and a total power of 1,000 MW. For this purpose, considering the technological realities of 2018, the Strategy foresees that the Tarnita-Lapusesti Pumped Storage Hydroelectric Power Station to be assumed as a strategic investment of national interest. In order to create the premises for increasing the energy generation capacity from wind and solar sources it is necessary to start this project by 2025 and at the level of 2030 to be operational in full capacity.

As the maturity degree of other energy conversion and storage technologies shall allow their commercial use, than after 2025 it shall be possible to analyse the possibility of a higher share of renewable capacities at a level corresponding to the implementation level of the storage solutions based on these technologies. As current estimates of the development of these technologies indicate that they can be implemented as distributed and low-capacity storage capacities, after 2025, it is envisaged

that to the energy producers from dispatched wind and photovoltaic resources to be required to compensate their imbalances.

In order to increase the participation of the Romanian energy producers on the European regional markets, it is foreseen that until 2025 to be completed the closing of the main transmission ring by 400 kV lines and the achieving of new interconnection points with the networks in the adjacent area of Romania.

Declaring of some areas for energy development using renewable sources

The distribution of wind potential allows the capitalisation with high economic performance only for a few regions of the country. In these regions there is a concentration of wind capacities that causes, in these areas the overloading and the capacity exceeding of the energy transmission and distribution network. As regarding the environmental protection, it has been found that the development so far acted as a limiting factor in the development of new wind farms and solar parks due to the proximity to Natura 2000 sites as well as the overlapping with avifauna migration corridors.

Although the solar potential is characterized by some degree of uniformity, the development of large-scale solar projects has been limited by regulations on the use of agricultural land and the limited capacity of the electricity

Until 2025, there shall be elaborated studies to enable the establishment on the national territory of at least ten areas for the development of wind farm and photovoltaic parks, to each area being set the delimitation and maximum capacity that can be installed. In these development areas, simplified procedures shall be set up for the authorization of works, for connection to the system and for their authorization after commissioning.

Providing conditions that allow the replacement of capacities at the end of their lifecycle

The vast majority of photovoltaic or wind farms from Romania were built and put into operation during 2010-2016. Because the lifetime of the main equipment in these power plants is of 20-30 years, starting with 2030 some of them shall be subject to replacement. For this reason, between 2025 and 2030, it shall be necessary to promote energy policies that shall allow the operators who own and operate these plants to make the necessary replacements.

After 2025, it shall be established a policy package including the ones of tax bonuses nature, under the support schemes that operators receive, with the obligation to provide the necessary financial resources to prepare plants for a new life cycle.

Development of small, distributed capacities. Prosumer

New support schemes in order to stimulate the renewable energy investments shall occur only after 2020 for the electricity generation capacities developed by consumers who, in the context of bidirectional electricity exchange with distribution networks, shall be considered prosumers.

The maximum limit of installed power in the solar systems of prosumers is set at 750 MW, which shall be reached by 2030.

The new updated Directive for the promotion of RES (EC 2016b) proposes the guarantee of the right of individual consumers and local communities or industrial and agricultural to become prosumers and to be remunerated for the electricity supplied to the grid, as well as other mechanisms that facilitate this transition. Until 2030, the promotion of this policy shall be ensured by the implementation of some measures to guarantee the energy taking over and its improved used by implementing *a feed-in-tariff* type of scheme, by accessing funding programs for investment, by setting up of guarantee funds that shall allow to credit institutions to participate in financing, and also tax regulations that shall allow the clearing of double direction transactions between prosumer and distribution operators. It shall be provided support to finance investments only for household consumers, so they can become prosumers.

New production capacities that shall be able to benefit from support schemes should not cause congestion in the distribution and transmission networks that shall take over their energy, and for this reason the maximum power supply in the grid should be equal to the maximum approved power for the connection of consumer who shall become prosumer. The distribution operators as well as the transmission operator may set, depending on the load degree and the network topology, lower limits for the installed power, and the maximum total installed power limit for the setting up of prosumers.

Under Sectoral Development Programs, support shall be provided to ensure the energy component for agriculture and industry. The energy needed to operate new modernised irrigation systems, or their rehabilitation can be provided from renewable sources, and for this purpose can be installed new capacities that shall supply electricity in the network during periods of time when no own consumption is recorded. Industrial prosumer shall benefit from priority access to the grid, in order to develop its own energy generation capacities from renewable sources,

dimensioned so that it's long-term consumption to be equal to its own energy generation capacity.

In order to regulate energy exchanges between agricultural and industrial prosumers with the network, a *feed-in tariff* mechanism shall be set up by 2022.

Transmission and distribution operators shall continue to modernize and develop their grids in a smart grid concept that are able to facilitate the real-time interaction with the prosumer.

VI.2.6. Biomass for energy purposes

Until 2030, the consumption of firewood shall record a decreasing by about 20% compared to the level of 2018. As firewood has the highest share within the biomass, as a result of the decreasing of firewood consumption, by 2030 total energy consumption generated from biomass shall drop to 39 TWh.

By 2030, bio fuels consumption shall have an increase up to the value of 4.1 TWh/year, enough to reach the national target for 2020, of 10% share of RES in the transmission sector. The biogas shall register a rapidly increase up to a production of 3,500 GWh in 2030, amid the development of the agricultural sector and, to a lesser extent, the modernization of sewage treatment plants.

Until 2030, shall be developed small power plants powered by biomass, bio liquids, biogas, waste and fermentation gas of waste and slurry, until such plants shall have a total installed capacity of 139 MW. The boilers of some of existing thermal power plants shall be adapted to allow the burning of biomass addition. In total, in 2030, by burning biomass, shall be ensured an electricity production of 0.9TWh.

Until 2020, complete regulations on the use of biomass for electricity generation shall be elaborated so as to prevent the wasteful use of this resource.

VI.2.7. Waste intended for energy

Romania produces more than 8.0 million tons of municipal waste annually, from which it continues to store more than 90%.

According to the European rules in force resulting from Directive 2008/98/EC and the principle of circular economy, 55% of this waste, ie the recyclable fraction (25%) and the wet-organic fraction (30%), must be recovered (not incinerated).

From the wet-organic fraction can be obtained:

- gas - which can be injected into the existing natural gas network;
- CNG (Compressed Natural Gas) used for vehicles operating on this type of fuel.

The remaining 45%, i.e. the dry fraction (20%) and the dry-organic fraction (25%), is a waste that by an appropriately processed can become an alternative fuel that can achieve calorific values up to twice the lignite calorific value.

The dry fraction and dry-organic fraction are combined in order to obtain an alternate solid fuel (SSF - Secondary Solid Fuel).

According to the same European standards, energy-related waste must meet certain quality standards in order to be considered as non-polluting alternative fuel.

Solid secondary fuel (SSF) is defined as a viable alternative related to the "replacing of conventional fuels to meet environmental and economic objectives, in order to reduce pollutant emissions, including the gas emission that are influencing the climate, for increasing the use of renewable energy sources by a sustainable use for energy purposes".

European Directive 2008/98/EC accepts the use of SSF as a fuel in the following situations:

- coal-fired thermal power plants with power units with unit capacity higher than 50 MW;
- cement plants with production capacities higher than 500 t of clinker/day.

The European Union considers as "neutral "the emissions from power plants that use SSF as added fuel instead of fossil fuels, thereby reducing CO2 emissions.

The using of SSF shall have also immediate economic benefits, by reducing the invoice paid by business operators for CO_2 Certificates.

VI.2.8. Geothermal energy

Taking into account the high potential of the geothermal resource in the areas where it was identified, until 2030, the higher use shall be extended, especially for heating, domestic hot water preparing and recreational or balneal activities. Only a small part of the drillings made before 1990 for geological research in which it was identified the geothermal resource, are used to capitalize this resource. Until 2020, there shall be initiated programs to assess the technical condition of these drillings, in order to establish

whether they can be used for the exploitation of geothermal energy. Also, by 2020, it shall be updated the regulatory framework so that these drillings can be capitalized by investors.

VI.2.9. Net imports of energy resources

Romania is an exporter of electricity and petroleum products, but at the same time imports approximately 69% of crude oil consumption, 10.6% of natural gas consumption, small quantities of hard coal (about 3%) and uranium ore. Taking into account the fact that the exports of petroleum products, the degree of dependence on crude oil imports to cover domestic consumption is about 50%.

In 2017, the import of primary energy resources accounted for 37.8% of the total primary energy resources.

Gas from national production are continuing to play an important role in some countries from the Southern Corridor region, especially in Romania, where the coverage of annual demand by the national production was 89.4% in 2017 and is expected to be 104% in 2026, Croatia (52% in 2017 and 14% in 2026), Bulgaria (2% in 2017 and 35% in 2026), Austria (15% in 2017 and 2026), Italy (12% in 2017 and 14% in 2026) and Hungary (19% in 2017 and 9% in 2026).

In the medium term, Romania shall continue to be the main producer in the region, among the countries that already have national production, with 46% of the region's production followed closely by Italy by 41%.

The information on indigenous EU production was collected from Transmission System Operators (TSOs). Indigenous EU production shall continue to decline significantly in the next 20 years. This decrease could be easily mitigated by the development of production fields from the Romanian sector of the Black Sea and Cyprus.

The total production could fall by more than 60% until 2040 or even more, if eventually non-FID developments are not put into operation.

In such a market environment, Romania, through the opportunities offered and by its geographical position, has the possibility to become a regional balancing/trading hub contributing significantly both to securing/streamlining of the cross-border trade with natural gas as well as the Europe's energy security.

VI.3. Electricity

VI.3.1. Electricity Demand

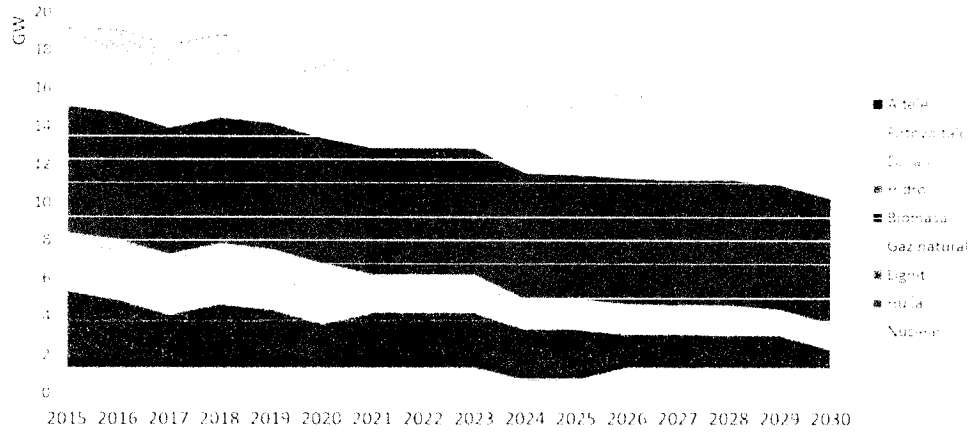
Electricity demand depends on the rhythm of economic growth, the standard of living, the evolution of industrial sectors with development potential, respectively the perspectives of the electricity use by new consumption segments such as heating, cooling, electro mobility, etc.

Scenarios require a sustained increase of the living standards - and thus of the household consumption - and of the manufacturing industry, but the results of the modelling do not indicate substantially changing at systemic level related to in electrical heating and electro mobility. The results for 2030 are influenced by the early stage of these technologies in Romania and the inherent inertia in the face of change. However, a sustained increase in final demand for electricity is expected from about 60 TWh to 73 TWh in 2030.

VI.3.2. Installed capacity and electricity production

Romania intends to remain a major net exporter of electricity in the region.

Until 2030, the retirement is expected for the natural gas and coal fired capacities at the end of life and in which respect modernization is not justified in order to meet the emission standards. As the old capacities are subject to backup retirement or decommissioning, new capacities are required in their place.



Altele – Others
Fotovoltaic – Photovoltaics
Eolian – Wind
Hidro – Hydro
Biomasa – Biomass
Gaz natural – Natural gas
Lignit – Lignite
Huila – Hard coal
Nuclear – Nuclear power

Figure 7 –Availability of the existing capacities during 2017-2030 (excluding reserves)
(Source: Ministry of Energy according to the data provided by Transelectrica, ANRE – Romanian Energy Regulatory Authority and the companies reports)

Nuclear power

Nuclear power is a strategic option for Romania. Making the lifetime extension of the Power Unit No.1 on time, it shall mobilize nuclear expertise in Romania. During Power Unit 1 rehabilitation, it shall be necessary to provide energy from alternative sources or from import. For this reason, the postponing of the definitive withdrawal of coal or gas capacities could be justified.

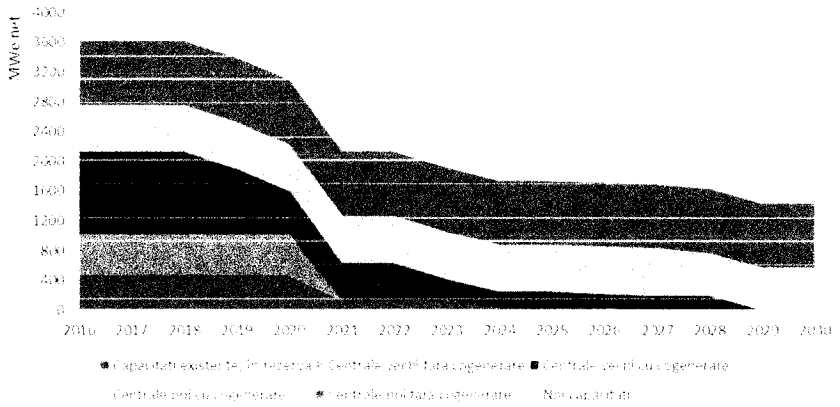
The expansion of nuclear capacities at Cernavoda represents a strategic decision. The design of two new units shall mainly use the existing infrastructure and the significant reserves of heavy water produced in Romania shall be better used. In addition, it shall provide the continuity and the development of the Romanian experience in the nuclear sector, as well as the prerequisites for the reinstatement of the entire nuclear cycle in Romania.

The project related to Units 3 and 4 at Cernavoda is the largest potential project in Romania in the coming decades.

Taking such considerations into account, the results of the quantitative modelling shows the opportunity to expand the nuclear capacities in Romania. The Strategy provides for the construction of two new reactors under conditions of economic efficiency and compliance with the technical and environment conditionalities agreed at the European level.

Natural gas

Romania has a net installed gas-fired capacity of about 3,650 MW, out of which 1,750 combined heat and power. 450 MW are in reserve, and other 1,150 MW are almost at the end of the normal lifetime, to be retired until 2023. A new capacity of 400 MW is in progress of completion at Iernut.



Capacitati existente, in rezerva – Existing reserve capacities
Centrale vechi fara cogenerare – Old power plants without cogeneration
Centrale vechi cu cogenerare – Old power plants with cogeneration
Centrale noi cu cogenerare – New power plants with cogeneration
Centrale noi fara cogenerare – New power plants without cogeneration
Noi capacitati – New capacities

Figure 8 –Evolution of net available capacities using natural gas (with or without cogeneration)
(Source: PRIMES, according to the input data validated by the Ministry of Energy)

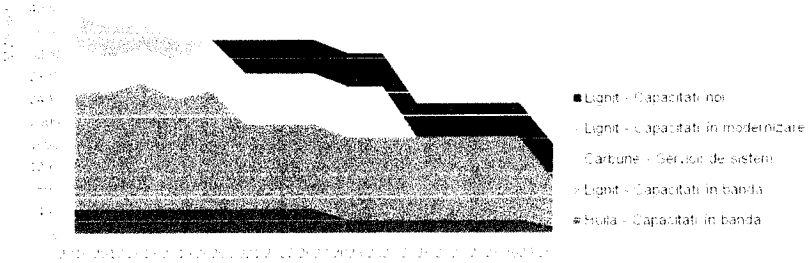
Instead of the old capacities to be retired in reserve or decommissioned in the near future, the investments in new capacities are required, some of which are intended for cogeneration in localities with operational District Heating System: Bucharest, Constanta, Galati and others. This aspect also includes the replacement of Iernut capacities. The cost of the investment is relatively low, below 1,000 €/kW installed power, so that financing can be provided even under high capital cost conditions, and turbines are efficient and flexible with relatively low maintenance costs.

In order to avoid the significant increase in the dependency on imports, even if they shall be available from alternative sources and routes, it is required to develop offshore deposits discovered in the recent years in the Black Sea. This is a *sine-qua-non condition* to be able to count on the natural gas in the energy mix.

Coal

Currently, Romania has a net installed and available capacity of 3,300 MW (including those reserved for ancillary services) within lignite and hard coal fired thermal power plants, and other capacities are under rehabilitation.

All lignite-fired power units were commissioned during 1970-1990, and the oldest power units are approaching the end of their lifetime, requiring either rehabilitation investments to extend the lifetime of the existing equipment or their replacement by new power units through larger investments. The competitiveness of coal in the energy mix shall depend on: (1) the efficiency of each power unit, rather low for the existing capacities; (2) the relatively high level of the cost of lignite supplied to the power plant; (3) the price of EU ETS emission allowances.



Lignit – Capacitati noi – Lignite – New capacities
Lignit – Capacitati in modernizare – Lignite – Capacitati under modernisation
Carbune – Servicii de sistem – Coal – Ancillary services
Lignit – Capacitati in banda – Lignite – Baseload
Huila – Capacitati in banda – Hard coal - Baseload

Figure 9 –Evolution of the coal-fired net available capacities
(Source: PRIMES, according to the input data validated by the Ministry of Energy)

New lignite-fired capacities should have supercritical parameters, high efficiency, operational flexibility and low GHG emissions.

Maintaining coal-fired capacities requires streamlining of the activity across the entire production chain in this sector, including the implementation of technologies to provide an emission level complying with the requirements of the environmental laws.

In the long term, the role of the lignite in the energy mix can be maintained by developing new capacities provided with CO2 capture, transport and geological storage (CCS) technology.

After 2030, the competitiveness of lignite is difficult to be assessed for the old power units, depending on the materialization of new projects.

For reasons of energy security, lignite still remains a significant part of the energy mix also in 2030.

The role of lignite shall be even more important in providing the adequacy of the National Energy System in stressful situations, such as long-lasting drought or severe frost periods.

The hard coal fired power units within Deva, except for power unit 3, shall be retired with very limited perspectives for restarting.

The hard coal reserves in Romania are impossible to be exploited under economic efficiency conditions, which means the construction of new power units instead of the retired power units is unlikely.

Hydropower

The Strategy provides a slight increase in the hydropower capacity by completing the ongoing projects. The essential role played by the hydropower on the balancing market should be strengthened by the achievement on due time of the maintenance and rehabilitation works.

The hydropower capacities can provide ancillary services with variations in the instantaneous production of up to 4,500 MW in 24 hours.

Hidroelectrica shall have available an investment budget of more than € 800 million by 2020 for modernisation and rehabilitation works at the power plants currently in operation.

The investments necessary for the completion by 2030 of the hydropower arrangements of complex use, optimized according to the current requirements, amount to approx. EUR 2.5 billion which shall be provided by Hidroelectrica and by other companies and authorities benefitting from such complex use.

In 2030, the total installed power within the hydroelectric power plants in Romania shall reach 7,490 MW compared to 6,741 MW in 2018. Further to this increase in the installed capacity, in 2030 the electricity production in hydroelectric power plants shall increase from 16,55 TWh in 2018 up to 17.60 TWh.

Renewable energy sources (RES – E)

The technological evolution leads to the decrease in costs related to wind and photovoltaic equipment, opening new perspectives for the prosumer, and also the implementation of some policies establishing a special regulatory framework for energy development areas shall make the share of renewable technologies to increase slightly by 2030 without a need for a financial support scheme (assimilated to a State Aid). On the other hand, the share of renewable technologies in the energy system shall be higher if there are any energy storage technologies.

In the wind energy sector, capacities with a total installed power of approx. 4,300 MW shall be present in 2030 in the system to provide a production of approx. 8.4 TWh. The new wind farms shall be built inside the energy development areas to be stated.

The photovoltaic capacities are to be developed both in the form of medium capacity solar parks built on degraded or poorly productive land, and in the form of low dispersed capacities built by the energy consumers who can make the transition towards the prosumer. The photovoltaic systems shall reach a total installed power of approx. 3,100 MW (a production of approx. 2.1 TWh/year) by 2030.

The support schemes shall be oriented only towards the capacities developed by the prosumers.

It is expected that in 2030 to be only biomass, bioliquids or waste fired operated power plants with a total capacity of 139 MW.

The total electricity production achieved through the improved use of biomass is estimated at approx. 0,9 TWh in 2030.

The total investments to be recorded by 2030 to build new power plants or to adapt the existing power plants are around EUR 280 million. These investments shall be provided by the operators who want to improve the use of this relatively cheap energy resource in new projects or by the holders of the thermal power plants who want to

decrease their costs by using a mix of fuel including the primary renewable resources.

VI.3.3. Electricity import and export

Both the history of cross-border trades in the recent years, and the market simulations at regional and European level indicated that the National Energy System balance is dominated by the tendency towards export. However, there are import situations determined by the energy situation of the regional systems.

The results of the modelling show that Romania shall remain a net electricity exporter. A significant factor of impact on the level of net exports is the achievement of strategic projects of national interest. The above mentioned projects shall increase net electricity exports from approx. 3 – 7 TWh in the last three years (the export balance was approx. 3 TWh in 2017, and the export balance was approx. 7 TWh in 2015), at 11 TWh yearly.

Thus, Romania shall remain a significant electricity and resilience supplier in the region.

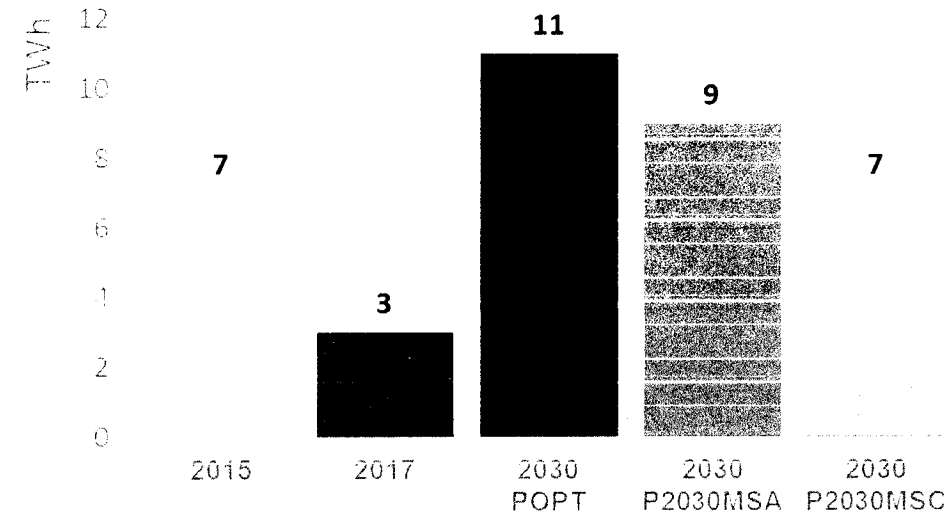


Figure 10 –Net electricity export (Source: PRIMES)

VI.3.4. Conclusions on the optimal energy mix in 2030

Romania has a balanced and diversified energy mix. It contains all types of primary energy sources available in Romania at competitive costs.

For energy security reasons, the Strategy defines the place of traditional fuels in the mix: hydropower, nuclear power, coal and natural gas.

The relative role of natural gas and coal in the energy mix after 2025 shall depend on the price of ETS emission allowances. The current projections show a sustained increase in the cost of emissions up to 40 €/ton of CO2 equivalent in 2030 to facilitate the achievement of decarbonisation targets. At this ETS price, natural gas is competitive in the mix compared to lignite at a price level of 19 €/MWh. If the ETS price remains lower than it is currently estimated, there shall be the possibility of further maintaining coal in the mix, as it is unlikely to keep the long-term natural gas price below 15 €/MWh.

Without doubling the production of nuclear power, the energy mix shall include larger amounts of natural gas and coal.

New capacities based on intermittent RES shall continue to develop without support schemes. A key factor for the viability of RES projects is the access to low capital cost financing. Through appropriate support mechanisms, the use of biogas and waste shall increase slightly, particularly in cogeneration capacities complying with the environmental standards.

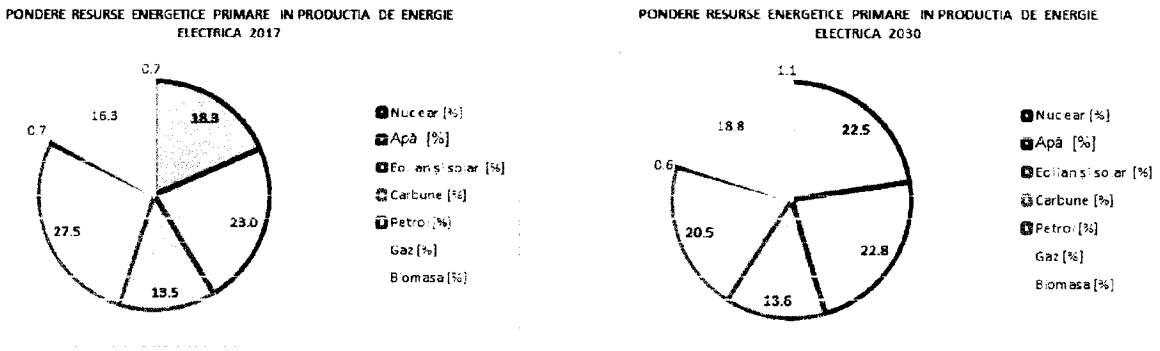


Figure 11 – Energy mix in 2017 and 2030 (Optimal Scenario)

PONDERE RESURSE ENERGETICE PRIMARE IN PRODUCTIA DE ENERGIE ELECTRICA 2017 = SHARE OF PRIMARY ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2017

PONDERE RESURSE ENERGETICE PRIMARE IN PRODUCTIA DE ENERGIE ELECTRICA 2030 = SHARE OF PRIMARY ENERGY RESOURCES IN ELECTRICITY PRODUCTION 2030

Nuclear – Nuclear power

Apa – Water

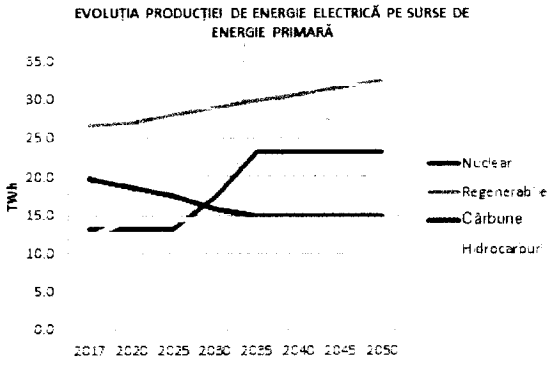
Eolian si solar – Wind and photovoltaic

Carbune – Coal

Petrol – Oil

Gaz – Gas

Biomasa – Biomass



EVOLUTIA PRODUCTIEI DE ENERGIE ELECTRICA PE SURSE DE ENERGIE PRIMARA – EVOLUTION OF ELECTRICITY PRODUCTION BASED ON PRIMARY ENERGY

Nuclear – Nuclear power

Regenerabile Renewable energy sources

Carbune – Coal

Hidrocarburi - Hydrocarbons

Figure 12 Evolution of net electricity production – nuclear, renewables, coal and hydrocarbons

VI.4. Heating

VI.4.1. Heating through district heating system

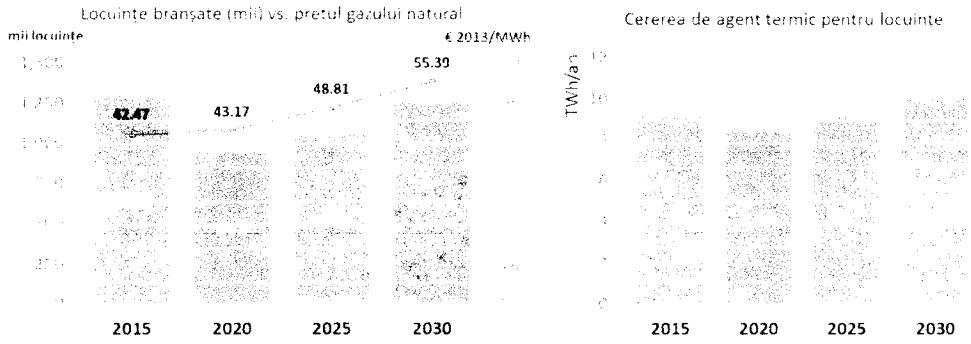
The Romania's Report-2015 concerning the implementation of the Directive on energy efficiency (2012/27/EU) presents a baseline scenario and four alternative scenarios for the development of the district heating systems of the municipalities (SACET) until 2030. The total value of investments for the networks in this period ranges between € 1.3 and 2.6 billion, depending on the ability to provide funding sources and it aims at

reversing the current trend of disconnecting the apartments from the district heating system.

After 2020, all scenarios predict a return of a number of apartments connected to the district heating system, as a result of the increase in the natural gas prices for households, and the rehabilitation of networks and the increase of service quality in more and more localities with functional district heating system, respectively.

There are examples of good practices, such as: Iasi, Oradea, Focsani, Buzau and others. A good system management and heat pricing below the alternative level – natural gas used by apartment heating boilers – can attract into the system the new residential complexes built over the past 10 years, thus increasing the operating efficiency of the district heating system.

Looking ahead to 2030, the thermal rehabilitation targets for the apartment blocks in the cities with district heating system may lead to a significant drop in the heat demand. This is the reason why the rehabilitation and re-dimensioning of the district heating networks and the sizing of the new cogeneration power plants should be coordinated anticipating the evolution of the consumption curve. Therefore, the heat demand is expected to decrease for the same number of apartments connected to the district heating system. This tendency can be mitigated by the increase in the population incomes which shall determine an increase of the inhabited areas and a higher level of comfort desired by the population.



Locuinte bransate (mii) vs. pretul gazului natural – Housing connected (thousand) vs. natural gas price
Cererea de agent termic pentru locuinte – Heating demand for housing

Figure 14 –Heating through the district heating system – number of households and total heat demand. (Source: PRIMES)

The number of apartments connected to the district heating system in 2030 is estimated to be 1.25 million, meaning the return to the actual level after a decrease in the following years. Thus, the optimal scenario involves investments of about EUR 4 billion in networks, hot water boilers and new natural gas fired cogeneration units instead of the units approaching the end of lifetime and not meeting the environmental requirements. The modernisation works reduce the price differences of heating agent between the localities, reflecting the operation under economic efficiency conditions of some modern, efficient and low-loss systems.

The main fuel for providing heat in the district heating system is natural gas, and only a few localities use lignite, hard coal or biomass. The situation is expected to continue until 2030. It is foreseen that the new luxury residential properties to use also the electric heating solution, more expensive, but more comfortable.

VI.4.2. Natural gas-fired heating

Individual natural gas-fired heating boilers have increased in popularity over the past 20 years, being preferred by households without district heating either due to the bankruptcy of the district heating system to which they were connected or due to voluntary disconnection. Also, much of the new housing, both houses and blocks of apartments choose the natural gas-fired heating boiler.

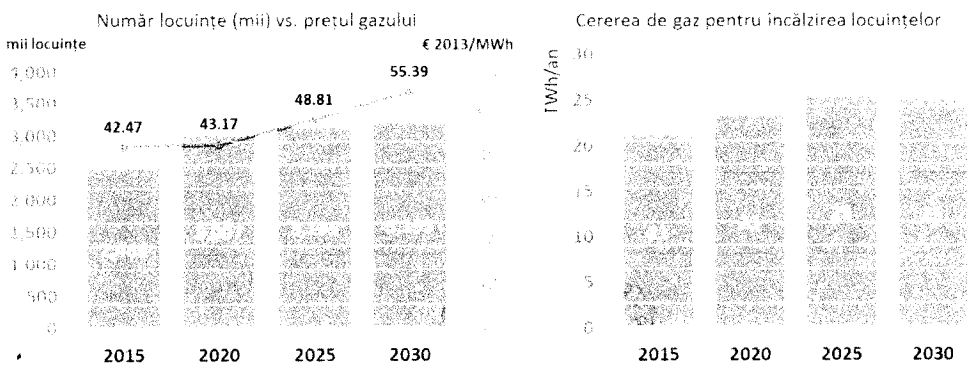
Currently, there are more than 2.2 million households with individual heating boilers, most of them in urban areas. Although such heating boilers can safely provide the thermal comfort of the entire housing during the cold season, some households choose the partial heating of housing for economic reasons – especially those with individual housing where the heating costs are higher.

The households using natural gas for heating, but not having individual heating boilers, have either gas fired convectors or traditional terracotta stoves. In urban or

semi-urban areas, it is a common practice to use in parallel gas and firewood in terracotta stoves. More than 250,000 households use such heating systems.

Natural gas shall remain the fuel preferred for heating in urban areas in Romania, at least until 2030. Most new housing to be built by 2030 shall adopt natural gas for heating over the district heating system, biomass and electricity (heat pumps). Moreover, some of the existing housing is to transfer from the district heating system to heating with firewood to natural gas heating. Transition is expected to occur mainly in the urban and semi-urban environment with access to the natural gas distribution network, even if the network expansion shall continue in the rural areas as well.

In 2030, the projections show that approx. 3.2 million households shall mainly use natural gas for heating. The total consumption of natural gas for direct heating of households is expected to slightly increase in the coming years, being influenced by the following factors: (1) increasing the number of housing using mainly natural gas for heating by 700,000; (2) increasing thermal comfort in housing heated with natural gas along with improving living standards; (3) decreasing consumption by increasing energy efficiency of housing, determined also by the liberalization of natural gas prices and gradual increase of prices on international markets.



Numar locuinte (mii) vs. pretul gazului – Number of housing (thousand) vs. gas price
Cererea de gaz pentru incalzirea locuintelor – Gas demand for housing heating

Figure 15 –Natural gas heated housing and total gas demand (without cooking and water heating) (Source: PRIMES)

Households gas price is expected to increase from 42 €/MWh at present to 55 €/MWh in 2030. Modelling provides an improvement of the household living standards at a rate at least equal to the price increase so that the overall level of energy poverty shall not increase due to natural gas price.

VI.4.3. Heating with firewood

About 90% of rural households and 15% of urban households are predominantly heated with firewood using inefficient stoves with incomplete combustion and without particle filters. Household heating is usually partial, and the thermal comfort is low. It is a total of approx. 3.5 million housing plus tens of thousands of housing in mining areas, heated directly with coal.

By 2030, the results of modelling indicate a transition towards natural gas heating in the urban area, gradually giving up heating with wood or coal in inefficient stoves due to air pollution and thermal comfort. In the rural area, without any additional support measures, transition towards gas heating shall occur much more slowly in localities with a gas distribution network.

The demand for firewood shall enter on downward path also as a result of thermal insulation of housing in rural areas. An increasing number of households, especially new housing, shall adopt efficient biomass heating systems with full combustion and without polluting emissions. This transition towards more efficient and greener forms of biomass heating shall be felt more and more in the coming years and shall continue beyond 2030.

Considering that the quantity of wood required for heating has decreased significantly, the necessary steps have been taken to approve the National Program for Natural Gas for the extension of natural gas distribution networks. Funding shall be provided by state budget funds, non-reimbursable funds, funds of the distribution operators, and other legal sources (Sources: MDRAP – Ministry of Regional Development and Public Administration).

The main purpose of promoting and approving the National Program for Natural Gas is to support the population by providing the required infrastructure for the

distribution of natural gas in order to heat households and to preserve the existing wood, as well as to protect the environment. The beneficiaries of the program shall be the administrative-territorial units, members of the Intercommunity Development Associations, as well as the administrative-territorial units.

VI.4.4. Heating with electricity and heating from alternative energy sources

The low price of natural gas compared to the electricity price makes housing heating with electricity not economical in Romania, which is not expected to change fundamentally until 2030. However, the peak in electricity consumption in Romania is recorded in winter during cold periods, as a result of intensive use of electric radiators. The low pressure in the old natural gas distribution and transport network creating difficulties especially during periods of low temperatures explains the need for heating with electricity for short periods.

Heating mainly with electricity in Romania has potential especially in individual semi-urban and rural housing where the investment in air source – ground source heat pump of high energy efficiency is economically justifiable. Accompanied by heat accumulators, heating with heat pumps could be feasible by using the electricity generated during low load periods overnight representing also a form of electricity storage.

The ongoing long-term Casa Verde (Green House) Plus program would encourage the development of national market for heat pumps.

The geothermal energy has a relatively low potential at national level, but it could cover a significant part of the energy demand for heating in some localities – including Bucharest, with geothermal sources supply from Bucharest area.

A number of individual housing in Romania could provide for itself a part of the hot water by using solar thermal panels. Their development is a long process requiring continuation and extension of Casa Verde (Green House) Plus program.

VI.4.5. Heating in public services and institutions sector

Most of the public institutions (administrative buildings, schools, hospitals, etc.) and office buildings use natural gas for heating. It is noticed a significant share of heating and cooling based on air source – ground source heat pumps using electricity (32% in 2015). The share of electricity in the heating of office buildings is expected to remain relatively constant. The level of thermal comfort in office buildings is high with no significant increase in demand.

However, there are public institutions, mainly schools in rural areas, with deficient heating systems, usually based on firewood. In this respect, investments are required in modern installations using biomass or depending on the access to the distribution network investment are required in order to provide natural gas heating. Addressing these issues should be a priority for local authorities, but it does not have a systemic impact on the energy demand. The increase in the energy efficiency of office buildings and public institutions, mainly by thermal rehabilitation, shall lead to a slight decrease in demand.

VI.5. Mobility. Energy component in the transport industry

The results for 2030 do not indicate any substantive change to the use of alternative fuels as this transition is long lasting. According to the age of its vehicle fleet, Romania is almost 10 years behind the developed countries and shall only partially recover this gap in the coming years.
With respect to 2030, the results of modelling indicate a significant increase in the vehicle fleet in Romania, up to 356 vehicles per 1,000 people without reaching the European average. The improvement of the standard living shall lead to the gradual increase in the share of new vehicles in the total of newly registered vehicles so that the average age of vehicle fleet shall decrease.

Given the age of the Romanian vehicle fleet, the high share of used vehicles among the newly registered and the relatively low average price of the purchased vehicles, the Strategy does not foresee a strong development of electric mobility by 2030. The PRIMES model estimates the vehicle fleet to 30,000 in 2025 and 126,000 in 2030. At the same time, the number of hydrogen vehicles could exceed 10,000.

Air pollution caused by vehicles shall decrease significantly due to the stricter standards the new generation comply with. Thus, the detailed results of modelling show that the total particulate emissions shall decrease by 25%, NOx by 45%, and carbon monoxide (CO) by 70%.

Goods and passengers transport vehicles fleet

The Strategy estimates for 2030 a slight increase in the bus and minibus fleet to 24,000, and 33,000 units, respectively. A small part of the minibuses shall have hybrid or electric propulsion. It is expected a fast increase in the goods transport vehicles fleet by 45% up to 1.12 million, out of which 560,000 heavy duty vehicles. In 2030, 30% of the light duty utility vehicles (less than 3.5 tons) shall be powered by hybrid technology reducing pollution at low speeds, especially in urban areas. Another 10% of the light duty utility vehicle would be hybrids with battery, fully electric or hydrogen-powered or LPG (*liquefied*

petroleum gas). Among the heavy duty goods transport vehicles, approx. 50,000 would have hybrid motors, and 25,000 would use compressed natural gas (CNG).

The hidden costs of air pollution associated with heavy duty road transport shall be reduced to half, to € 95 million in 2030.

Rail transport

The rail transport (including subway and urban passenger transport by tram) is more efficient in terms of energy and less polluting compared to the road transport, being encouraged both at European level and in the Romania's sustainable development strategies.

Around 2030, it is expected that the railway distance travelled (number of wagon-km) to increase by approx. 50% through substantial works for the modernization of railway infrastructure.

Thus, while the passenger mobility in road transport is estimated to increase by 35%, the mobility in the railway transport shall increase by 40%. The volume of road freight transport shall increase by 60% while the railway freight transport shall increase by 65% (tons – km indicator). The result is a slight increase in the share of railway transport in the total mobility: from 5 to 6% in the mobility of passengers and from 39 to 40% in the volume of freight transport.

Almost the entire increase in the railway sector activity shall be taken over by electric locomotives with the demand for diesel remaining almost constant at about 120,000 toe, and an increase of 10% in the biodiesel share. The electricity demand in rail transport shall increase from 1080 GWh in 2015 to 1860 GWh in 2030. A section of the rail transport is the urban transport of passengers by subway and tram. In accordance with the Bucharest Subway Network Development Strategy for 2019-2030, it is estimated an increase in the activity by approx. 60% leading to an estimated electricity consumption of 285 GWh in 2030. By comparison, the electricity demand in the rail transport is estimated to increase from 0 to 500 GWh in 2030, meaning that the rail transport shall dominate the growth of electricity demand in the transport sector until 2030.

Air and water transport

The air transport with the origin or destination in Romania is to register a high growth rate over the assessed period, compared to the current level, much lower than the Western world. Thus, it is estimated that the air traffic at least to double by 2030, the energy efficiency of the new generation of airplanes to increase and the kerosene demand to grow to over 400,000 toe.

The increase is estimated at approx. 60% for short distances (less than 500 km), 70% for average distances (between 500 and 2500 km), and 75% for long distances (over 2500 km).

It is unlikely that alternative fuels share to increase in the air transport before 2030. Thus, the increase in CO2 emissions caused by air traffic is estimated at the same 70% up to a level of 1.2 million t CO2 in 2030. The emissions related to domestic flights of Romania represent only about 10% of the total. The emissions related to international air and marine traffic are separately accounted at European and world level. The impact of air pollution by air traffic is mainly associated with pollutant emissions expecting to grow by approx. 40% - less than the increase in fuel demand. The share of pollutant emissions caused by air transport in the total pollutant emissions related to the transport sector shall increase from 7% in 2015 to 16% in 2030. The hidden costs related to the air pollution caused by the air transport shall also increase from 80 to € 110 million in 2030.

The water transport in Romania corresponds almost entirely to the transport on the Danube and Danube – Black Sea Canal. The passenger water transport is limited to the Danube Delta when crossing the river by ferry or cruise ships. Water freight transport is more developed. The results of modelling estimate a 35% increase in the volume of freight transported on the Danube, with a corresponding increase in the energy demand estimated at 40% which may be justified by an increase in exports and increased upstream traffic.

The diesel consumption for freight transport on the Danube would rise from 37,000 toe to 45,000 toe, as the Optimal Scenario provides a share of 9% in the total consumption for natural gas, and a 10% increase of the biodiesel share in the diesel mix. The European Commission aims to reduce the polluting emissions related to the water traffic in Europe by introducing alternative fuels, LNG (*liquefied natural gas*) being the most advantageous solution.

Energy mix in the transport sector

The economic growth and the improvement of the living standards, along with the increase in the quality of transport infrastructure are leading to a fast-growing mobility in Romania with about one third for passenger transport and two-thirds for freight transport by 2030.

The total energy consumption in the transport sector shall increase by 16%, i.e. from 5.55 million toe to 6.45 million toe, limited by the increase in the energy efficiency of vehicles and airplanes. The energy demand shall increase by 10% in the passenger transport (from 4.1 to 4.5 million toe) and by 40% in the freight transport (from 1.4 to 1.9 million toe). 73% of the total increase in the fuel demand

is related to the road traffic to consume 5.7 million toe in 2030 with 18% of the increase related to the air traffic. The most significant fuel demand growth shall be determined by trucks – 460000 toe, just over half of the total transport demand growth.

Considering the demand for energy in the transport sector by type of fuel until 2030, the modelling shows a drop in the gasoline demand by 20%, *i.e.* from 1.44 to 1.14 million toe while the diesel consumption shall increase by 13%, *i.e.* from 3.5 to 4 million toe. The total gasoline and diesel consumption would increase by no more than 4%.

The overall growth of the demand for petroleum fuels, including kerosene and LPG would be 7%. In total, the share of petroleum fuels in the total energy demand in the transport sector would decrease from 94.6% in 2015 to 87.2% in 2030 – the sum of the shares for diesel (62%), gasoline (18%), kerosene (6%) and LPG (1%).

The share of alternative fuels in the total energy demand for transport shall grow from 5.4% in 205 to 12.8% in 2030. 12.8%, the energy equivalent of 9600 GWh, represents the sum of shares of 8.1% for biofuels, 3.1% for electricity, 1.5% for natural gas and 0.1% for hydrogen. Thus, it is expected a 2.5 times increase in biofuels demand, to 520,000 toe; a 2.2 times increase in electricity demand, to approx. 2400 GWh; and an almost equal increase in natural gas demand, up to 1100 GWh.

CO2 emissions related to the transport sector are to reach nearly 17.4 million t CO2 in 2030, an increase by 9% compared to 2015. Air pollution and other greenhouse gas emissions shall decrease considerably: by 25% particulates, by 37% NOx, by 40% CO and by 45% sulphur oxides. The PRIMES model calculates a one-third decrease in the hidden costs related to the air pollution caused by transports, *i.e.* to € 780 million in 2030. The downward trend shall also be maintained during 2030-2050, so that the cost shall reach € 410 million in 2050, one third of the cost recorded in 2015.

VI.6. Energy efficiency

Energy efficiency is often figuratively characterised as the most valuable form of energy as it reduces costs and the negative impact on the environment associated with the energy consumption, as well as the dependency on the energy imports. The highest potential to increase the energy efficiency in Romania is found in building heating, in conversion of primary energy resources into electricity within the thermal power plants, and in transmission and distribution of electricity and gas, and in transport and industry, respectively.

VI.6.1. Evolution of energy intensity

The main indicator of energy efficiency at national economy level, i.e. energy efficiency, reports the gross energy consumption to the unit of gross domestic product. The data for 2015 show an energy intensity for Romania of 248 toe/million €2013, meaning 75% higher that the European average. But in terms of purchasing power, the Romanian energy intensity is slightly below the European average, although the industrial sector has a share above the European average.

The level of energy intensity corresponds to the structure of the national economy and its competitiveness. The main way to reduce the value of the energy intensity is to prioritise the development of high added value economic sectors. Thermal insulation of buildings is also required to provide that heating costs can be sustained in the light of the development of the European single market in electricity and the global rise in energy prices from the actual low level.

With respect to 2030, under sustainable economic growth, the PRIMES model estimates a 30% decrease in energy intensity for Romania, up to 153 toe/million €2013. This level would be 65% higher than the European average with the gap difficult to reduce, as the EU Member States have ambitious energy efficiency targets.

VI.6.2. Energy efficiency of buildings

The energy consumption for heating and cooling housing is estimated according to the heating space, approximated by the total area of housing (m^2); the energy need for heating the surface unit (kWh/ m^2) which depends in its turn on the quality of the thermal insulation of housing and the number of degree days (outdoor temperature); and many housing in Romania are only partially heated (indoor temperature).

The area of approx. 7,47 million permanently occupied housing in Romania in 2015 is estimated at 350 million m2 (average net area of 47 m2) of which nearly half are partially heated. The trends in ageing of the population shall lead to a slight decrease in the number of households, up to 7.14 million permanently occupied housing in 2030. However, the net area of housing is expected to increase by almost 40%, *i.e.* 490 million m2; the average net area shall reach 68 m2/household in 2030, increasing by almost 50% compared to 2015.

Conversion efficiency increases by adopting efficient heating solutions, such as modern heating boilers, terracotta stoves replaced by natural gas-fired heating boilers or larger-scale heat pumps, etc. Some investments are recovered in short time being the object of activity of energy services company, ESCO.

VI.6.3. Thermal power plant efficiency and self technological consumption

The Romanian thermal power plants built mostly during 1960-1990 have a relatively low average efficiency of conversing primary energy into electricity by up to 35%. It should be noted that the design efficiency of these power units was 36-37% comparable to the design efficiency of other similar power units built in the same period in other countries in Europe and in the world. Thus, in 2017, coal, natural gas and heavy-fuel oil (in insignificant quantities) with a calorific value of 86 TWh were used for a gross electricity production of 29 TWh within thermal power plants. Cogeneration plants have additionally improved the use of 18 TWh as thermal agent for heating and/or industrial steam so that the conversion losses were only 39 TWh. The frequent use of thermal power plants on the balancing market – and not in the normal mode as designed – implies the operation at partial loads, increase and decrease in capacity, even frequent shut downs/start ups, reducing significantly their efficiency.

In the recent years, lower capacity production units with higher efficiency technology have been available in Romania. S.C. Electrocentrale Bucuresti commissioned in 2008 the first cogeneration combined cycle power unit of 200 MW, OMV Petrom operates a combined cycle of 840 MW, and ROMGAZ is investing in another combined cycle. Complexul Energetic Oltenia also seek to build a partnership with a foreign investor for the construction of a lignite-fired power unit of 600 MW with supercritical parameters. This is a strategic project for Romania and it is necessary to find a backup financing solution (with state support) in case the public-private partnership under negotiations shall not be concluded this year.

It is important that the natural gas capacities able to provide and balance the intermittent RES production to have high efficiency, including frequent and fast power variations by using state-of-the-art technologies available at a reasonable cost.

Increasing the thermal power plants efficiency shall lead to the decrease in the demand of primary energy needed to provide the final electricity consumption and a significant drop in the greenhouse gas emissions.

Thermal power plants using old technology initially had a high self technological consumption (over 11%). After 1989, the modernisation works performed for most of the power units remained in operation resulted in a reduction below 10% of the self technological consumption of the thermal power plants. The self technological consumption shall drop by replacing the old and inefficient power plants when they reach the end of their lifetime from technical or economic point of view. The modelling results for 2030 estimate the self technological consumption to 4650 GWh, decreasing by 11% compared to the level in 2015 due to the fall in the gross electricity production within thermal power plants, and to their increased use on the balancing market.

VI.6.4. Energy efficiency in industry

The industry's energy efficiency compared to the gross value added increased by 23% in 2015 compared to 2000, and the modelling results estimate an additional increase by 20% until 2030. Energy efficiency additional measures become economically feasible by rising energy prices, and the amounts available for European and Governmental programs concerning efficiency increase.

VI.6.5. Investments in the energy sector

Romania needs substantial investments in the energy sector in the coming decades, firstly to provide the ongoing consumers supply, but also to participate in the global energy transition and to be among the beneficiaries of the complex process of the energy sector transformation in the light of sustainable development.

As a Member State of the European Union, Romania is a regional and European supplier of energy security and it is able to strengthen its role, actively contributing to the achievement of the European Union's energy goals through its policy and programs.

VI.6.6. Investments in the oil sector

Considering the Romanian need for investments in the energy field, the favourable geographic position, the existing infrastructure, the availability and interest, Romania can play a significant role on the European energy market.

The resumption of investments in the exploration and production sector, as well as in the transport and storage infrastructure for improved use of natural gas reserves is essential. The completion of the interconnection of the national gas transmission system with the systems of neighbouring countries and the integration of the Romanian gas market into the European market, as well as reconsidering the role of the underground storage facilities are important factors in mitigating the risks related to the security of natural gas supply.
Crude oil , and mainly natural gas are playing and shall play an important role in the domestic energy market. The factors imposing the share of natural gas in the Romania's primary energy balance:

- relatively high levels of natural gas resources;
- the existing infrastructure for natural gas extraction, transmission, underground storage and distribution throughout the country;
- natural gas has the lowest impact on the environment compared to other fossil fuels;

- the favourable position of Romania in the international transmission system in Central and Eastern Europe;
- the opportunity of the National Gas Transmission interconnection with the Western European system and the gas resources in the Caspian Sea and the Middle East.

In this context, the Romanian Government pays great importance to encouraging investments in order to discover new hydrocarbon reserves and increasing the reserves replacement rate.

In the oil sector, the investment efforts are mainly directed towards:

- geological and geophysical research for the discovery of new crude oil and natural gas reserves, maximization of recovery rates in terms of economic efficiency, and the portfolio streamlining;
- development of the underground natural gas storage capacity;
- maintaining transmission capacity and increasing safety in the use of transmission pipelines;
- development of national crude oil and natural gas transmission systems;
- bi-directional interconnections of the National Gas Transmission System with the adjacent systems in the neighbouring countries;
- rehabilitation of the gas distribution systems by replacing the corroded steel pipelines (with lifetime expires or a high degree of wear and tear), mainly with polyethylene pipelines;
- protection of the environment.

The perspectives concerning the new potential and possible reserves are subject to the investments to be made in the geological and geophysical exploration field by the domestic grantees, producers and the foreign companies operating on the territory of Romania, as well as subject to the success level of the exploration wells discovering new deposits.

In the short and medium term, in order to increase the safe reserves of crude oil and natural gas, Romania should take as a priority the investments in technologies to lead to the increase in the rate of extraction from the existing deposits, and in the long term the development of the projects for the exploration of depth (below 3000 m), onshore area with complicated geology and offshore deposits in the Black Sea.

Strategic objectives of the oil sector

The overall objective of the oil sector strategy is to provide the conditions for meeting the medium and long term hydrocarbons (crude oil and natural gas) at an affordable price appropriate to a modern market economy and a civilized standard of living under food quality and safety conditions in compliance with the principles of sustainable development.

In a more and more globalized context, the Romania's approaches in the gas sector are made within the changes and developments performed at national and European level. In this context, the sectoral policy of Romania should be correlated with the existing similar European documents in order to provide the convergence of our country's policy with the European Union policy in the field.

The strategy of the gas sector seeks to fulfil the main objectives of the new energy – environment policy of the European Union; such objectives being assumed also by Romania.

The ways and measures to achieve the objectives presented below shall be identified:

1. security of gas supply;
2. competitiveness on domestic and regional market;
3. sustainable development of the gas sector in relation to the objectives concerning protection of the environment and limiting climate change;
4. attracting the capital required for the modernisation and development of the gas sector on all its components (production, transport, storage, distribution);
5. ongoing development of a competitive market characterized by competition, transparency and liquidity.

Investment needs in 2030 trans-European energy infrastructure

An analysis of all projected capital expenditures in the domains of electricity transmission, gas transmission, storage, oil supply connections, carbon networks and power-to-gas grid injections highlights an overall expenditure of EUR 229 billion in the decade 2021-2030 in the EU28 region. This adds to the EUR 67 billion of infrastructure investments still pending for commissioning up to 2020.

The appropriate investment policies stimulated by the regulation framework shall be crucial for strengthening the market liquidity and security of supply. In this respect, solving only physical interconnection is not a sufficient condition. It should exist the possibility for natural gas to be easily transferred between different systems through „commercial" interconnections achieved by the availability of transmission services (mainly, short term „hub-to-hub") provided in accordance with common and harmonized rules enabling the commercial operators to gain access through a single sale process to the transmission output capacity of a system and the input capacity within the

interconnected system. Similarly, the availability of short-term storage services allows to meet the flexibility needs of the commercial operators.

At the same time, the investment processes should also take into consideration addressing issues related to the existing risk scenarios in the Romanian gas sector.

VI.6.7. Investments in the electricity sector

The final price of electricity consists of two main components: the total cost of production within the power plants and the cost related to the transmission and distribution networks. The investments are reflected in the costs for the rehabilitation of the existing power plants and for the construction of new power plants, and the costs for the modernisation and expansion of power grids, respectively.

The PRIMES model estimates the investment needs related to the power grids to about 500 million € yearly by 2030. These costs include the power grid interconnection and development projects provided in Transelectrica Development Plan for 2016-2025 and its ongoing progress until 2030, and the estimated level of the investments in the distribution networks. The investments include equipment and technologies that make the transition to "smart grids" with bi-directional communication, efficient management and high flexibility in operation. It is also estimated the cost related to the gradual development of the distributed electricity production with a particular impact on the distribution networks. Such investments are not likely to increase the level of network tariffs.

The most important investment objectives in the electricity generation and transmission sector are, as follows:

- completion of units 3 and 4 within Cernavoda Nuclear Power Plant;
- construction of a new power unit of 600 MW in Rovinari;
- construction of Tarnita-Lapustesti Pumped-Storage Hydroelectric Power Station;
- a new power unit of 400 MW with ultra-supercritical parameters at Turceni;
- Turnu-Magurele – Nicopole Hydroelectric power plant , 500 MW;
- a new gas-fired 200 MW power unit CCGT – Craiova II with flexible operation, including storage of energy resource in Ghercesti underground deposit;
- a new gas-fired 400 MW power unit CCGT with flexible operation – Mintia;
- Rastolita Hydroelectric Power Station – 35 MW;
- hydroelectric power stations on Jiu river – 90 MW;
- hydroelectric power stations on Olt (defile) river – 145 MW;
- Transelectrica Development Strategy aims at closing the 400 kV Romanian ring. Among a number of other projects, it provides for a new 400 kV OHL between Gadalin and Suceava stations. It has a significant impact on the operational safety, interconnection capacity, but it also contributes to strengthening the link between the two network areas in the Northern area of the country;
- closing the 400 kV Bucharest ring on the Eastern area through the realization of the 400 kV power line from Bucharest South Power Station to Brazi West power station, including the construction of a new power station in the Northeastern area of the city (Bucharest city and Ilfov county reach up to 15% of the national electricity consumption).

The total investments for 2019-2030 period is about 14 billion €.

VI.6.8. Investments in the thermal power sector

The district heating systems consist of two main elements: thermal power plants or combined heat and power plant, and heat distribution networks, respectively. More than half of the 60 localities with district heating system need substantial investments in the modernisation of the heat distribution by the replacement of the old pipelines by new ones.

The level of investments in the heat distribution networks is estimated between 1.3 and 2.6 billion €, according to the most recent study of the potential for district heating and high efficiency cogeneration in Romania (ME 2015a) submitted to the European Commission at the end of 2015. The required annual investments are estimated to 87-175 million € with the high level assumed in the Optimal Scenario in order to provide the long term development of the sector.

At the same time, it is required to replace the old combined heat and power plants approaching the end of their lifetime with an estimated investment requirement of 1-1.5 billion €. In addition, investments shall be made for the replacement of some hot water boilers approaching the end of their lifetime with an estimated cost of 45-60 million €/year. Investments in new cogeneration capacities are foreseen at a level of 90 million €/year by 2030 and a minimum of 45 million €/year

of investments is foreseen for hot water boilers, with units generating combined heat and power being preferred.

VI.6.9. Financial resources for the implementation of investment programs

The Strategy identifies substantial investments required for the modernisation and rehabilitation of the Romanian energy system over the next 15 years. The analysis of alternative development scenarios estimates the total investments in the energy sector (excluding energy consumption) to a level of 15 -30 billion € for 2019-2030 period, with a central estimate of approx. 20 billion €.

In addition to the use of private and/or state capital, the other significant financing sources are made available through the European investment programs – structural funds and the strategic investment fund (expected to be extended until 2020 and supplemented), and those of the investment and development banks (EIB, EBRD, etc.). An important role can be also played by the public-private partnerships, and investment schemes such as ESCO in order to increase the energy efficiency of buildings.

The State may also define support mechanisms for certain type of investments, such as guaranteed incomes.

A possible investments financing source for the energy sector over the coming decades is represented by budget revenues related to the ETS emissions permits auctioning. Depending on the evolution of emission allowances price, such revenues shall be higher or lower, but in any case the amounts available for investments are substantial, *i.e.* billion euro over the next 15 years.

VII. PERSPECTIVES OF THE ROMANIAN ENERGY SECTOR FOR 2030-2050

The development perspective of the energy sector by 2050 is useful for two main reasons: (1) the energy sector has a high capital intensity, and many projects have a long investment cycle, so much of the investment decisions taken in the near future shall continue to produce their effects in 2050; and (2) the European Union energy and environment policies, including the 2030 targets are built around the long term goal of reducing the greenhouse gas emissions by at least 80% until 2050.

The overall goal of mitigating the climate change can only be achieved through transformational actions and measures on a planetary level. A major direction related to action shall be the accelerate the energy transition. Many of the long-term transformations of the energy sector can be anticipated, given the slow replacement of the energy infrastructure.

The Romanian energy sector evolution in view of 2050

The development trends specified below relate to: increasing the sustainable role of biomass in the energy mix; the future of electromobility; increasing the share of RES in the energy mix and the use of CCS technologies; new forms of energy storage; energy efficiency, especially related to buildings; electric heating using heat pumps.

Although all such developments are expected to reduce the greenhouse gas emissions, they could have a strong impact on the environment, and the opportunity to develop new large scale technology should be analyzed in detail. Most likely, new generations of such technologies, more efficient and greener, shall be widely adopted.

Electricity generation using low GHG emissions technologies

The 2020-2030 period shall bring moderate increases in the RES production capacities, mainly wind and photovoltaic.

Modelling only includes capacities developing without a dedicated support scheme in locations with high energy potential where projects are economically feasible.

As the cost of GHG emissions increases, and the performance of wind and photovoltaic technologies increases in relation to costs, the energy transition shall accelerate also in Romania by growing the expansion rate of wind , photovoltaic and other low GHG technologies. In parallel, a reduction in the capital cost shall be recorded for the RES investments in Romania. These developments are expected to have a strong impact on energy mix, particularly after 2030.

The net capacity installed in RES-based plants in 2050 implies higher investments compared to the simple addition of new capacities to the existing ones, as it shall also be necessary to replace the existing capacities installed in the 2010-2016 period, when they shall reach the end of their lifetime during 2030-2040.

Furthermore, after 2035, prerequisites shall be created for the implementation of generation IV small modular nuclear reactors (SMRs) that could increase the share of low GHG energy. The achievement of lead-cooled fast reactors technology with a significant contribution of Romania shall lead to the possibility of participation in global investment projects.

All scenarios start from the premise of the use of hydropower and long-term nuclear energy in Romania. Hydropower is the backbone of the energy system, and the nuclear energy adds an essential contribution to the diversified and balanced energy mix in Romania. Along with hydropower, RES and nuclear energy, the energy mix also includes coal in view of 2050. Thus, the modelling results indicate since 2035 the feasibility of the projects related to new lignite-fired thermal power plants, provided that they shall be equipped with the CO2 capture, transport and geological storage (CCS) technology. Depending on the scenario, the modelling shows that a lignite-fired capacity equipped with CCS of 300-1000 MW could be built.

Large scale energy storage

After 2030, and especially after 2040, it shall be a need to develop new solutions for the storage of energy generated by wind farms and photovoltaic parks.

In view of 2050, NES might require capacities able to provide the balance for 15-20 GW installed in intermittent production power plants. In addition to the capacities currently available, high-capacity battery systems shall be implemented as a marginal solution on the balancing market, and a series of smaller capacity batteries geographically distributed. Two significant solutions, which are currently expensive, but could become economically feasible, are represented by the pumped-storage hydroelectric power stations, i.e. after 2035, the RES-based hydrolysis process to produce hydrogen. Hydrogen can be further used either directly in transport or in the form of renewables syngas from RES injected into the gas

transmission/distribution system after it is brought to the methane standard by the reaction with CO2.

The pumped-storage hydroelectric power stations become necessary in the mix of capacities in all scenarios under review, but after 2030 only. The scenarios provide pumped-storage capacities of approx. 1000 MW in 2050, with variations between 850 MW and 1100 MW. The two scenarios where the pumped-storage capacities need is the lowest (450 MW, and 750 MW, respectively) refer to the ambitious decarbonation.

In other scenarios, the lower need for pumped-storage hydroelectric capacities is reasoned by the parallel development of the syngas production capacities. The modelling results for two scenarios indicate a fast development of this technology after 2040, reaching a syngas production of 28 TWh in 2050.

The renewables syngas production is welcome in the energy mix towards the end of the energy transition in the 2050, because it can contribute to the natural gas decarbonisation. The sustainable methane is needed in the industrial processes using flame where it is difficult to be replaced.

Both water pumping in hydroelectric power stations and hydrolysis have a relatively low efficiency. For this reason, even if large-scale storage capacities are implemented, it is preferable to use electricity at the time it is generated or to store it in batteries.

Significant role in the National Energy System balance shall be determined by smart grids and the energy demand management, including the increase in the role of local communities and prosumers holding small storage capacities geographically distributed.

Energy efficiency of buildings

The building stock in Romania has a relatively low energy efficiency, and the specific energy consumption for heating and cooling is relatively high with a national average of 157 kWh/m2/year considering that half of the housing is only partially heated. The national programs concerning the energy efficiency growth along with the increase in energy costs shall encourage the investments in housing thermal insulation over the next 15 years in all the development scenarios.

After 2030, the additional increases in the energy efficiency in heating shall be more expensive implying more extensive and complex rehabilitation works. Thus, a drop in the energy specific consumption for heating and cooling may be expected between 2030 and 2050, from 108 to 81 kWh/m2/year with average annual investments of 2.6 billion €.

The total energy consumption of households shall largely follow the need for heating and cooling. The households energy demand for cooking, heating, lighting, electronic devices and home appliances is expected to increase slightly as a result of gradual implementation of new eco-design technologies with lower specific consumption.

Long-term role of the electric vehicle in transports

The electric mobility is a solid and credible long-term alternative to the internal combustion engine. Natural gas, LNG and hydrogen are alternative fuels viable for the transport sector, but are unlikely to offer a large-scale replacement solution for petroleum products in the energy mix.

On the other hand, the main problem of the electric vehicle is the difficulty of electricity storage. In terms of sustainability, it is also a question of the emissions related to the electricity generation dominated by fossil fuels. However, in the long term, it is expected that the electric vehicles to play a major role, as the battery efficiency increases, i.e. high clean energy production.

The transition from the internal combustion engine to the electric engine is likely to occur passing through the intermediate stage of hybrid vehicles (equipped with both types of engine) with or without power supply from the power grid. The earliest development shall be related to the hybrid vehicles for which the electric engine has a marginal role only at low speeds in urban traffic.

The second phase shall refer to the increase in the number of hybrid plug-in vehicles whose average capacity battery can be charged from an external power source.

Finally, the third phase shall refer to the fast increase in the share of electric vehicles with high capacity batteries as their cost drops, and electricity is generated mostly from low GHG sources.

For Romania, it is not appropriate to pass through these phases faster than it is economically efficient except for limited support schemes for the development of the public recharge infrastructure and a marginal market support at the early stages of developments coordinated with the development of the Romanian electric vehicle industry.

Thus, nearly 60% of the vehicles fleet would have a form of electric propulsion in 2050. Among the diesel and gasoline vehicles, most of them could use biomass-based energy products. Of course, the transition to the electric mobility may occur faster or slower, depending on the evolution of the main factors detailed above.

Romania's energy consumption for the 2030-2050 period

The analysis of the energy consumption by types of resources and demand segments shows no major changes in the energy consumption by demand segments and

activity sectors, but significant transformations shall be made in the energy mix, notably in the demand of different types of energy at sectoral level and in terms of technologies used.

Gross primary energy consumption by type of resources

The modelling results for the Optimal Scenario indicate a 7% decrease in the primary energy demand between 2030 and 2050, i.e. from 394 TWh to 365 TWh. The share of fossil fuels in the primary energy mix also decreases from 61% to 47% being replaces by RES.

In the industry, the final energy consumption shall drop slightly from 80 TWh in 2030 to 75 TWh in 2040 followed by a slight increase up to 77 TWh in 2050.

The final energy consumption in the energy-intensive industries shows a similar trend to the industry's trend, as a whole, after a drop from 45 TWh in 2030 to 40 TWh in 2040, the consumption remains relatively constant at this level in all scenarios by 2050.

In the residential sector, the final energy consumption remains at a level similar to the actual one of about 86 TWh by 2040 followed by a drop to 79 TWh in 2050. In this event, the results shows a middle evolution within a model relatively consistent with the other scenarios with a stronger decline in consumption only in decarbonisation ambitious policies scenarios through substantial investments in the energy efficiency of buildings.

In the service sector, it is projected a stable energy consumption between 2030 and 2050, around 23 TWh. The consumption in agriculture is about 4 TWh. It is a median level ranging from the slight increase projections of the Reference Scenario and the slight decrease of the decarbonisation ambitious scenario.

The final energy consumption in the transport sector indicates a slow increase from 75 TWH in 2030 to 77 TWh in 2035 followed by a gradual decrease to 74 TWh in 2050.

In total, the gross final energy consumption is expected to drop slightly from 269 to 257 TWh.
The share of the consumption sectors remains almost the same in the 2030-2050 period.

Gross final energy consumption by type of resources

The final consumption of petroleum products shows strongly divergent evolutions from one scenario to the other.

The final consumption of natural gas remains constant between 2030 and 2050 at the level of 68 TWh. The maximum level of demand is estimated at about 73 TWh, and the minimum level from 63 TWh in 2030 to 47 TWh in 2050.

The evolution of demand for all fossil fuels depends on their prices, the level of ambition of the decarbonisation policies, and the European prices of the ETS emission allowances.

The biomass and waste final energy consumption can show a significant increase from 45 TWh in 2030 to 53 TWh in 2050.

The final electricity consumption shows a robust and consistent growth in all the scenarios studied.

The final steam consumption might show a slow drop from 18 TWh in 2030 to 17 TWh in 2050.

Concerning the share of electricity in the final energy consumption, the modelling indicates a clear and solid growth trend, from 19% in 2030 to 25% in 2050.

The share of natural gas in the final energy consumption in the long run is almost constant, at around 25%.

Net energy production and import between 2030 and 2050

The total primary energy production shall show a slight drop, from 304 TWh (the equivalent of 26.2 million toe) in 2030 to 287 TWh in 2050.

The total coal production shall decrease from 32 TWh in 2030 to 12 TWh in 2050, following the downward trend of coal in the energy mix (45 TWh in 2020).

It is estimated that the crude oil production shall continue to decline slowly between 2030 and 2050, from 22 to 13 TWh (1.93 to 1.15 million toe).

The natural gas production shall drop after reaching a new peak of 132 TWh in 2025, as a result of the production in the Black Sea, to 96 TWh in 2030 and 65 TWh in 2050.

The renewable energy production shall increase steadily from 86 TWh in 2030 to 129 TWh in 2050. The upward trend is consistent in all the scenarios.

The total biomass and waste energy production in all the scenarios shows a consistent increase in the analyzed period, i.e. 2030-2050. The trend towards accelerating the biomass energy production after 2030 is notable by the development of modern and efficient large-scale technologies, mainly in the rural areas.

The evolution of the dependency on the energy imports shows difference from one scenario to the other. Crude oil

remains the main form of energy imported in Romania throughout the assessed period and in all the scenarios.

Investments estimated in the energy sector during 2030-2050

Sustained investments shall be required also for 2030-2050 period. The expenditures related to the investments in the energy sector shall be EUR 15 billion between 2031 and 2050, returning to an annual average of EUR 750 million.

Equitable participation in reaching the EU28 targets in 2030 and 2050

Romania shall meet its commitment with respect to the national targets for energy efficiency, renewable energy and greenhouse gas emissions for 2020, an additional sustained effort being required only to increase the share of RES in transport (RES-T) to 10%. The strategic effort in the coming years shall consist of giving to the energy sector a development direction in line with the priority strategic goals, including the participation in the long and complex transformation process for climate change mitigation.

In this context, the results of the quantitative modelling with respect to the Romanian energy sector for the 2016-2030 period substantiate the negotiation mandate of Romania for determining the national indicative targets for 2030 concerning GHG, RES and energy efficiency in a fair manner. The modelling results for 2030 in all the scenarios with respect to RES share, GHG and energy efficiency are briefly presented below.

- *Greenhouse gas emissions reduction*

Romania had reduced its GHG emissions in 2015 by 54% compared to 1990, far above the average level of 20% set as the EU28 target for 2020 and 40% target for 2030. The decrease is, first of all, the result of a comprehensive and difficult transformation of the industrial sector, which can be considered significantly concluded.

The industry remains the main engine of the economic sustainable growth for Romania, and it has very good prerequisites for the development in the coming decades, especially in the manufacturing of vehicles, machinery and equipment, with increasing added value. In the short term, the increase in the energy efficiency and the decrease in the GHG emissions shall not progress the same way. The drop in GHG emissions shall be slower compared to the last 25 years, being the result of small improvements in all the sectors of activity. However, a key role shall be played by the increase in the energy consumption and the growth of the share of clean energy in the energy mix.

For 2030, the modelling results indicate a further drop in the total GHG emissions by 6-9% to 60-63% compared to 1990. In absolute terms, the yearly emissions shall decrease from 116 million t_{CO2}, the equivalent in 2015, to 94-102 million t_{CO2}, the equivalent in 2030. Both ETS and non-ETS activities shall contribute.

The GHG emissions in the ETS system decreased by 43% in the 2005-2015 period, from 75 to 43 million t CO2 equivalent. The EU28 average target for 2030 for ETS emissions reduction is 43% compared to 2005, a level already reached by Romania.

Of course, by participating in the ETS, Romania shall continue to reduce the related GHG emissions – most likely to 30-35 million t CO2 equivalent, depending on the evolution of the energy mix. However, if the price of ETS emission allowances remains at the European level lower than it is necessary to achieve the decarbonisation targets, the GHG emissions in the ETS system shall be higher. There are no national targets and they are not required for the GHG emissions covered by the ETS scheme.

With respect to non-ETS GHG emissions, the European Commission proposed for Romania a 2% reduction target in 2030 compared to 2005, while the EU28 average is a 35% reduction. This target is fair and takes into account the Romania's need to increase the energy consumption at the same time with the economic growth, particularly in certain non-ETS sectors, such as transport and housing heating.

In short, Romania contributes fairly to the EU28 decarbonisation process with a reduction of at least 60% of the total GHG emissions in 2030 compared to 1990 in all the scenarios under review. The average reduction of 60% is to be the intermediate target for 2040 at the European level.

Increasing the role of RES in the energy mix

Romania could introduce a support mechanism for the development of biomass potential in modern and efficient forms, but the ongoing development of wind farms and photovoltaic parks shall probably only continue when the costs of such technologies make them competitive without any support schemes. This is expected to occur in the next decade, so new wind and photovoltaic capacities shall be built in Romania, even in the absence of a support scheme after 2020.

The most important factors that shall determine the development rhythm of renewable capacities are (1) the evolution of RES technologies costs, (2) the cost of coal and natural gas and (3) the price of ETS. All these cost elements are difficult to estimate, but the greatest degree of uncertainty is related to the ETS price.

A relatively low ETS price, which would not lead to the exit of coal from the electricity mix, but misses the achievement of decarbonisation targets, it would keep RES-E at a level close to the current one, below 45%. More likely, however, is the increase in the ETS price to the minimum, which would still allow the achievement of decarbonisation targets. At this ETS price level, RES-E share shall increase to 52% in 2030.

Another factor that shall considerably influence the development of RES-E production, on short and medium term, is the level of capital cost for investments financing. Romania has one of the highest levels of capital cost of the EU28, which means, for example, that it is considerably more expensive to build a wind turbine in Romania than in Germany. In the absence of a European mechanism for guaranteeing investments in RES, Romania shall be less attractive for new investments, slowing down the growth rate of the RES share.

RES share in gross final energy consumption for heating and cooling

Building heating and the use of steam in industrial processes represents the main segment of energy consumption, more important than electricity or consumption for transport. In 2015, Romania covered more than 28% of gross final energy consumption for heating and cooling (RES-H/C share).This indicator shall influence the utmost total share of RES in 2030.

Scenarios that show a rapid transition to modern forms of biomass use for heating and the passing, of a significant number of rural localities, to the heating based on natural gas and with heat pumps, resulting a 5% decrease of RES-H/C share, to 23% in 2030. It is unlikely to take place such a deep change of the household heating, but the tendency for a slight decrease of the share of RES-H/C is clear. If transformation of heating and the thermal insulation of households are made slowly and are mainly limited to urban areas, the share of RES-H/C could easily increase to no more than 30%.

Share of RES in gross final energy consumption in transport (RES-T).

Romania shall reach its 10% target for RES-T in 2020, but a rapid increase in the volume of biofuels is unlikely, not least because of the sustainability considerations of their production.

Between 2020 and 2030, the share of RES-T shall increase mainly as a result of the electrical mobility increase in the, on rail and road segments. Thus, depending on the penetration rhythm of hybrid and electric cars, the share of RES-T in 2030 could reach to 13-15%.

The increase by 3-5 percentage points is not negligible, coming on the background of a sustained increase of the transport sector. It anticipates a much faster growth between 2030 and 2050.

REGULAR UPDATING OF THE ENERGY STRATEGY

The Ministry of Energy constantly monitors the energy sector, including the implementation stage of the Energy Strategy 2019-2030 in view of 2050. The action plans and the necessary measures to achieve the strategic objectives shall be closely monitored to provide the funding sources and the development in optimal conditions of investment projects.

The regular updating of the Strategy takes into consideration the changes that are taking place at local, regional, European and global level. The implementation of the Energy Strategy is correlated with the national and international context, both evolving into dynamic interdependence.

The transformation of economic climate requires new trends in the development of society and its needs. New technologies and energy products redirects the investment choices, confidence in energy processes, and the structure of the power system.

To respond to context changes, once every five years, there shall take place:

- updating data and system analysis;
- a new qualitative analysis of trends in the national energy system;
- redefining scenarios and a new quantitative modelling;
- review of targets and action priorities.

The Energy Strategy is based on the development of competitive markets for electricity, natural gas and other primary resources, which leads to the need for new approaches, along with the changing of market trends.

Document prepared by the Working Group
for updating and drawing up the National Energy Strategy
for 2019-2030 period in view of 2050
Working Group Coordinator

State Secretary

Andrei Petrisor Maioreanu

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Round Seal with the following text:
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Abbreviations

ANRE	Romanian Energy Regulatory Authority
ANRM	Romanian Agency for Mineral Resources
ANRSC	Romanian Regulatory Authority for Community Services and Public Utilities
BRUA	Bulgaria-Romania-Hungary-Austria gas pipeline
CCGT	combined cycle gas turbine
CCS	capture, transport and storage of CO_2 emissions
EC	European Commission
CEH	Complexul Energetic Hunedoara
CEO	Complexul Energetic Oltenia
CNU	Compania Nationala a Uraniului
NED	National Energy Dispatcher
ELCEN	Electrocentrale Bucuresti
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
ESCO	Energy Services Company
ETS	Emission Trading System
GEM-E3	macroeconomic and sectoral model for the European countries and world economy
GHG	greenhouse gas
CNG	compressed natural gas
LNG	liquefied natural gas
LPG	liquefied petroleum gas
HHI	Herfindahl-Hirschmann Index
IEA	International Energy Agency
Mill t	million tons
Bill m3	billion cubic meter
Mtoe	million of tons of oil equivalent
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries
PCI	„Projects of Common Interest" proposed for funding from *the Connecting Europe Facility*
PRIMES	Price-Induced Market Equilibrium System, a series of models used in the quantitative modelling
RADET	Autonomous Administration for Thermal Energy Distribution in Bucharest
ETN	electricity transmission network
SACET	District heating system
NES	National Energy System
NTS	National Transport System (for natural gas, and crude oil)
RES	renewable energy sources
AS	ancillary services
EU	European Union
WACC	Weighted Average Cost of Capital
TSO	transmission system operator
toe	tons of oil equivalent, unit of energy 1 toe = 11.628 MWh
TWh	Terawatt-hour, the equivalent of 1 billion kilowatt-hours (kWh), unit of energy. Some other multiples of kWh are used, i.e. MWh (one thousand kWh) and GWh (one million kWh).

The undersigned, **MARCU STEFANIA**, certified as a Romanian/English translator and interpreter, under the Authorisation No. 16481/2006, issued by the Romanian's Ministry of Justice, herewith certify the accuracy of the foregoing translation from Romanian to English, that is a complete translation of the text submitted for translation purposes, it contains no omissions whatsoever, and that the translation has in no way distorted the text's content and meaning.

The document whose full/excerpt translation is requested consists, as a whole, of 62 pages, it is named "Romanian Energy Strategy for 2019-2030 in view of 2050", was issued by the Ministry of Energy and it was submitted entirely/excerpt to me.

Translation of the document submitted consists of 64 pages and was conducted pursuant to a written request registered under no.- / - and kept in the archives of the undersigned.

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