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NUCLEAR ENERGY AND ITS SIGNIFICANCE FOR THE CURRENT ENERGY CONTEXT OF THE EU. THE CASE OF ROMANIA

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Abstract: Nuclear energy has been the source of extensive debates regarding its use, its costs, but also its contribution to ensuring a clean and safe energy climate. The European Union, through its historical connections with nuclear energy, but also Romania, as a traditional producer, are two actors that can provide us with important clues about the role of nuclear energy in the development of a state / supranational nuclear energy structure. The study aims to analyze how the EU relates to this type of energy in the context of current energy concerns: increased imports dependence and reduction of greenhouse gas emissions. It also seeks to identify EU's status in the policies adopted over time and observe the perspectives of a producer Member State (Romania) in the context of specific decisions taken at EU level. Research on nuclear energy and its role in the development of the energy sector is extensive, but references to Romania are general. Consequently, we aim to find out the position of this state on nuclear energy in both European and national contexts. Focusing on these aspects and making use of regulatory documents, statistics, but also of specialized studies, the article will try to find an answer to the following question: *What is the significance of this type of energy for the current developments in energy at the EU and national levels?*

Keywords: energy security, energy challenges, European Union, nuclear energy, Romania

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Rezumat: Energia nucleară a fost și va rămâne sursa unor dezbateri ample cu privire la utilizarea sa, la costurile sale, dar și la contribuţia sa la asigurarea unui climat energetic curat și sigur. Uniunea Europeană, prin legătura istorică pe care o are cu energia nucleară, dar și România, prin calitatea sa de producător tradiţional, sunt doi actori care ne pot oferi indicii importante despre rolul energiei nucleare în dezvoltarea unei structuri statele/supranaţionale. Studiul își propune să analizeze modul în care UE se raportează la acest tip de energie în contextul preocupărilor energetice actuale: dependența crescută față de importuri și reducerea emisiilor de gaze cu efect de seră. Totodată, avem în vedere statututul Uniunii în politicile adoptate de-a lungul timpului, dar și perspectivele unui Stat Membru producător (România) în contextul deciziilor specifice luate la nivelul UE. Cercetările privind energia nucleară și rolul acesteia în dezvoltarea sectorului energetic sunt numeroase, însă adesea referințele cu privire la

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România au un caracter general. În consecință, scopul nostru va fi să investigăm mai în profunzime modul în care acest stat se raportează la o astfel de sursă de energie atât în context european, cât şi naţional. Concentrându-se pe aceste aspecte şi folosind documente de reglementare, statistici, dar şi studii specializate, articolul va încerca să răspundă la următoarea întrebare: *Care este semnificaţia acestui tip de energie pentru evoluţia energetică actuală a Uniunii Europene şi a României?*
Cuvinte cheie: energie nucleară, provocări energetice, România, securitate energetică, Uniunea Europeană

I. Introduction and Methodology

Nuclear energy in the European Union (EU) and Romania has a history that began in the '50s and an evolution marked by pros and cons due to several events that have taken place over time. For example, if we consider some major accidents such as the Three Mile Islands (Pennsylvania, United States of America, 1979), Chernobyl (the Ukrainian Soviet Socialist Republic – then part of the Soviet Union, 1986), Fukushima (Japan, 2011), we will observe that certain European states limited their activity in the nuclear sector while others continued to argue that energy produced by the fission of the atom is an inexpensive, safe, and clean way to produce electricity. Currently, as can be seen from their regulatory documents in the energy sector, both the EU and Romania address the nuclear energy issue from several points of view: that of energy security, climate / environmental security and energy safety. These approaches create a favorable framework for discussion regarding the role of nuclear energy given that EU's energy dependence exceedes 58%, CO2 levels must be reduced to net-zero by 2050 and nuclear safety must be improved in the post-Fukushima context.

Therefore, the purpose of this research will be to find an answer to the following question: *What role plays nuclear energy in managing the above-mentioned challenges both at the EU level and at national level (Romania)?* In analysing the case of Romania, we will try to observe how the energy standards established by the EU (climate objectives and nuclear safety rules) are reflected in the national policies. We are also interested in seeing how nuclear energy contributes to the achievement of EU's energy goals as well as how it directly impacts the national energy system. To answer the research question, the study will consist of a threefold analysis: a historical analysis of the main events that marked the nuclear course in the case of both actors, an analysis of primary documents that mention the role of nuclear energy and a data analysis based on information provided by databases such as Eurostat or Statista that will help us draw the relevant conclusions about the significance of nuclear energy.

II. The historical significance of nuclear energy for the EU

"The United States of Europe means: a federal power linked to the peaceful exploitation of Atomic Energy"[1], stated Jean Monnet in 1955 when the idea of European integration first began to take shape. The meetings and documents of the time[2] show a clear intention to create a common organization that would be responsible for the peaceful development of atomic energy. This was due, at that time, to the arguments in favor of nuclear energy[3]: the abundance of uranium and thorium resources which had a much greater energy potential than the increasingly diminishing coal reserves[4]; the perspective of scientific and technological progress that had already been glimpsed with the invention of the atomic bomb; but also the certainty that the price of atomic energy would be low. Although there was an awareness that the advances in nuclear energy would not happen overnight especially when considering the hierarchy of energy sources that were in use at the time, nuclear energy was taken into account when shaping the plans for a secure and competitive energy future.

Against the background of this wave of optimism, in 1957, in Rome, the "Treaty establishing the European Atomic Energy Community" was signed, together with the "Treaty establishing the European Economic Community". This marks the beginning of a joint initiative in the nuclear field of the six signatory states (The Kingdom of Belgium, The Federal Republic of Germany, The French Republic, The Italian Republic, The Grand Duchy of Luxembourg, and the Netherlands). The objective of the organization was to rapidly develop the nuclear segment through research, dissemination of technical information, and investments in the necessary facilities in a harmonious way that respected safety standards, but also "the peaceful use of nuclear material" principle [5]. The

[1] Michel Gaudet, *EURATOM* (London: Pergamon Press, 1959), 140.
[2] See: ***, "Résolution adoptée par les ministres des Affaires étrangères des États membres de la CECA", Messine, 1er au 3 juin 1955, https://www.cvce.eu/object-content/-/object/d1086bae-0c13-4a00-8608-73c75ce54fad.
[3] Louis Armand, *Some Aspects of the European Energy Problem* (Paris: Organisation for European Co-operation (OEEC), 1955), 4, https://www.cvce.eu/content/publication/1999/1/1/6761172f-1f18-45b0-a247-e50faedb0e5d/publishable_en.pdf.
[4] The period was also marked by the Suez crisis which determined the states to find other energy sources necessary to supplement the conventional one.
[5] ***, *Consolidated Version of the Treaty establishing the European Atomic Energy Community* (Luxembourg: Publications Office of the European Union, 2010), https://europa.eu/european-union/sites/europaeu/files/docs/body/consolidated_version_of_the_treaty_establishing_the_european_atomic_energy_community_en.pdf.

moment was welcomed by the leading political figures of the time: Jean Monnet[6], Paul Henri Spaak[7], Guy Mollet[8], or John Foster Dulles[9].

In 1957, another intergovernmental organization was established that aimed to pursue the same objective of cooperation and use nuclear energy for peaceful purposes. Its origins can be traced to the speech "Atoms for Peace", given by the American President Eisenhower to the General Assembly of the United Nations on December 8, 1953[10]. Since the last century, the mission of the International Atomic Energy Agency has been to harness the nuclear energy for peaceful purposes, to bring prosperity, peace and health by encouraging and supporting research in the field, by establishing guarantees aimed at preventing the use of fissile material for military purposes, by cooperating with other competent bodies and specialized agencies[11].

The desire to find the atom a nonmilitary use that will lead to the unification of a divided world begins to take shape not only at the European level but also worldwide[12]. As a result, nuclear power began to enter the electricity market, and by 1960, 17 nuclear reactors with a total electric capacity of 1200 MWh were already operational in France, United Kingdom, the USA, and USSR. This growth continued on an upward trend in the following years thanks to a favorable context marked by the oil shocks and by the rising prices per barrel, which encouraged the development of substitute energies, including the nuclear one: if in 1970, there were 90 nuclear units operating in 15 states (16,500 MWh), by 1980, the number rose to 253 nuclear units operating in 22 countries (135,000 MWh)[13].

In those days, the EU-9 countries which produced electricity using atomic fission were: France, Germany, Italy, the Netherlands and the United

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[6] Jean Monnet (1988-1979), President of the High Authority of the European Coal and Steel Community from August 1952 to June 1955.

[7] Paul Henri Spaak (1899-1972), Prime Minister of Belgium, NATO General Secretary, President of the ECSC General Assembly and President of the United Nations General Assembly.

[8] Guy Mollet (1905-1975), Prime Minister of France from 1956 to 1957.

[9] John Foster Dulles (1888-1959), US Secretary of State from 1953 to 1959.

[10] "The governments principally involved, to the extent permitted by elementary prudence, should begin now and continue to make joint contributions from their stockpiles of normal uranium and fissionable materials to an international atomic energy agency. We would expect that such an agency would be set up under the aegis of the United Nations". (Dwight D. Eisenhower, "Atoms for Peace Speech, Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly", December 8, 1953, https://www.iaea.org/about/history/atoms-for-peace-speech).

[11] IAEA, "Statute", amended December 18, 1989*,* 5, art. II and II, https://www.iaea.org/about/statute#a1-21.

[12] IAEA, "History", https://www.iaea.org/about/overview/history.

[13] N.L Char and B.J. Csik, "Nuclear power development: History and outlook. Events have changed the global prospects for nuclear power", *IAEA Bulletin*, no 3 (1987): 19, https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull29-3/29304781925.pdf.

Kingdom. Outside this group, other European producing countries and future Member States were: Slovakia, Spain, Finland and Sweden[14]. Perhaps if the Chernobyl disaster had not happened on April 26, 1986, the attitude towards the nuclear energy programs would have remained positive. While some states opted to pursue constant improvement in terms of the nuclear power plants' performance, safety, and quality of operations, others slowed down or even stopped their nuclear programs altogether. William J. Nuttal identifies three types of attitudes manifested at the EU-15 level towards nuclear energy in the post-Chernobyl context: 1) Germany, Sweden, Italy, Belgium, Greece, Ireland, and Austria showed their hostility – some of them even established policies to phase-out nuclear energy; 2) Finland, France, the United Kingdom, the Netherlands, Spain and Portugal remained supportive of it; while 3) Luxembourg and Denmark maintained a neutral attitude[15].

The second half of the 20th century was marked by the concerns surrounding the use of nuclear energy in developing energy production and securing the necessary energy supply. In the beginning of the 21st century, these concerns only continued to intensify and nuclear energy was included in the documents governing the EU's energy policy that addressed a new emerging energy context defined by increasing energy demands, energy imports, and an interest in combating climate change. For example, in 1999, primary energy production was 770.47 Mtoe (interestingly, since the early 1990s, the values recorded by nuclear energy placed it first in the hierarchy of primary energy production, surpassing coal and crude oil), gross inland consumption was 1442.43 Mtoe, and net imports were at 705.48 Mtoe. In other words, this meant that 49% of the EU's energy needs were covered from external sources of supply, and long-term forecasts indicated that this dependence would increase by up to 70% if no action was taken[16]. The Green Paper for the security of energy supply, adopted in November 2000, recognized nuclear energy's important significance in managing the increasingly uncertain European energy situation. The document highlighted the following advantages: 1) the wide geographical distribution of uranium deposits compared to oil and gas; 2) the low-carbon aspect; and 3) the ability to "fill[...] a substantial part of the gap in electricity that would be created if fossil fuel electricity generation were to be drastically reduced as to response to Kyoto"[17]. However, the document also

[14] William J. Nuttall, "Nuclear energy in the enlarged European Union", in *Security of Supply in Europe. Natural Gas, Nuclear and Hydrogen*, ed. François Lévêque, Jean-Michel Glachant, and Julián Barquín (Cheltenham: Edward Elgar, 2010), 68.
[15] Ibid., 170.
[16] European Commission, *2001 – Annual Energy Review* (Luxembourg: Office for Official Publications of the European Communities, 2002), 76-79, http://aei.pitt.edu/46132/1/2001_energy_review.pdf
[17] Commission of the European Communities, "Green Paper. Towards a European Strategy for Energy Supply Security. Annexes", Brussels, November 29, 2000, 4-5, http://aei.pitt.edu/1183/1/energy_supply_security_gp_annex.pdf.

acknowledged the unfavorable political climate for nuclear energy in the above-mentioned states that could significantly impact the contribution of nuclear energy to supply. Renewed growth was seen to be unlikely.

In the following years, the EU continued to consider nuclear energy an important component of the primary energy mix for electricity generation, a choice "less vulnerable to fuel price changes than coal or gas-fired generation", and "the cheapest source of low carbon energy", as mentioned in the European Commission's document *An Energy Policy for Europe*, adopted in 2007. The document also stated that in terms of electricity generation, a reduced nuclear output should be supplemented with other low-carbon energy sources, otherwise neither the climate targets nor those concerning the security of supply will be met[18].

Nevertheless, the policies of some Member States continued to reverse the upward trend in nuclear energy. If by 2004 (compared to 1990), gross nuclear electricity production increased (from 728 018 GWh to 928 400 GWh), the level dropped in the following decade (for example, in 2018, it dropped about 16 percent, to 761 943 GWh). This was the result of the policies that sought to limit the operating lives of the reactors in order to, eventually, decommission them. The most eloquent example in this situation is Germany, the country that together with France produced the largest amount of nuclear power in the EU and which in 2003 began to shut down its reactors with a lifetime up to 32 years. This was not enough, and, in May 2011, additional measures when in effect. *Energiewende*[19] was the name of the plan that aimed to close eight out of the 17 remaining reactors and reduce nuclear production by 54%. By 2022, the plan intended to completely eliminate the nuclear factor from the energy mix. This policy direction was also heavily influenced by the Fukushima nuclear accident (spring of 2011) whose consequences affected the policy of several other Member States as well[20] and led to a comprehensive rethinking of nuclear safety policy.

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[18] Commission of the European Communities, "An Energy Policy for Europe", Brussels, January 10, 2007, 18, https://eur-lex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:52007DC0001&from=EN.

[19] *Energiewende* or energy transition is a policy adopted by the German government in 2010, which promotes the transformation of the energy system into one with low carbon emissions through the use of renewable energy sources and the phasing out of nuclear reactors by 2022, even though they were the main source of low-carbon electricity. As far as figures are concerned, the plan was ambitious: sought to reduce greenhouse gas emissions by 40% by 2020 and by 80-95% by 2050 (compared to 1990), reach 60% renewable energy by 2050 in total consumption, 40-50% in the electricity mix by 2025 (***, "Germany's Energiewende", *World Nuclear Association*, updated March 2020, https://www.world-nuclear.org/information-library/energy-and-the-environment/energiewende.aspx.).

[20] After Fukushima Italy, which shut down all its nuclear power plants after the Chernobyl accident, reaffirmed its anti-nuclear stance in a referendum, and Spain decided to ban the construction of new reactors (European Environment Agency, "Overview of electricity production and use in Europe", https://www.eea.europa.eu/data-and-maps/indicators/overvie

At EU level, the Council of the European Union adopted "Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations" on June 25, 2009. The Directive referred to organizational and cooperation modalities, such as national competent regulatory authority or other national arrangements, that could ensure high levels of nuclear safety so that workers and the general public would be protected against the dangers arising from the ionizing radiation emitted by the nuclear installations[21]. It was amended in July 2014. The new provisions consolidated the initial framework by "setting up a European system of regular topical peer reviews", "increasing transparency on nuclear safety matters or introducing a high-level EU-wide nuclear safety objective", "emphasizing accident prevention and the avoidance of significant radioactive releases"[22], etc.

Subsequently, the Commission published a report[23] with regard to the ways the Directive was implemented and the results were encouraging. The national arrangements regarding the legal framework and the regulatory authority had been implemented even though there were some uncertainties regarding financing issues or personnel. Furthermore, the report noted that the safety rules imposed on nuclear facilities were widely applied.

Besides promoting high safety standards regulating nuclear activity, the EU also regulates other important aspects in this field[24]: from the exposure to ionizing radiation to the management/transport of radioactive substances and wastes – two issues which can easily become major risks both in terms of human health and the environment.

w-of-the-electricity-production-2/assessment-4).

21 Council of European Union, *Directive 2009/71/EURATOM of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations*, Official Journal of the European Union, L. 172/18, July 2, 2009, 3, accessed March 22, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0071&from=EN.

22 European Nuclear Safety Regulators Group, "Nuclear Safety Directive", http://www.ensreg.eu/nuclear-safety-regulation/eu-instruments/Nuclear-Safety-Directive.

23 European Commission, "Implementation of Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations", Brussels, November 18, 2015, 15, https://ec.europa.eu/energy/sites/ener/files/documents/9_Report%20NSD.pdf.

24 See for example: Directive 2013/59/Euratom of 5 December 2013 which laid down basic safety standards for protection against the dangers arising from exposure to ionising radiation; Directive 2013/51/EURATOM of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption; Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel; Council Directive 2011/70/Euratom on the management of radioactive waste and spent fuel. For more information: European Parliament, "Nuclear Energy", *Fact Sheets on the European Union*, 2020, https://www.europarl.europa.eu/ftu/pdf/en/FTU_2.4.10.pdf.

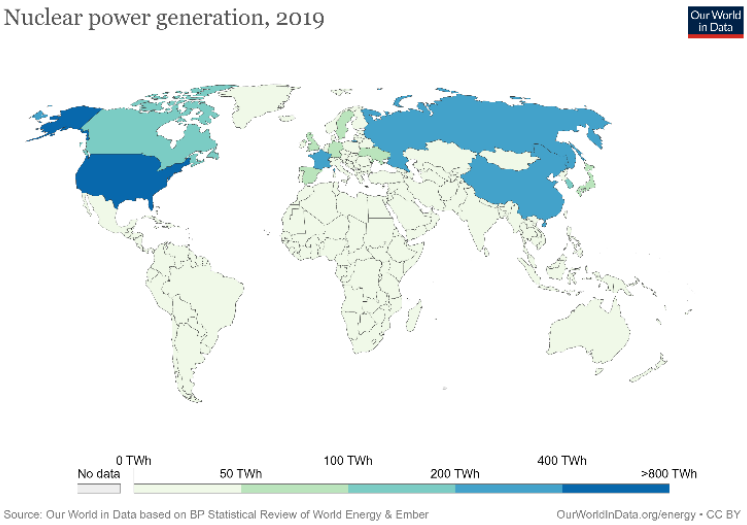
III. The significance of nuclear energy for managing current energy challenges in the EU

The picture outlined throughout the previous decades with regards to the energy situation of the European Union still retains some of its initial characteristics even today. The latest data provided by Eurostat shows that the energy dependence rate equaled 58.2% in 2018 due to low primary energy production: 636.5 Mtoe compared to a gross inland consumption of 1479.27 Mtoe[25]. The EU is also becoming increasingly ambitious in terms of its climate targets, which is reflected in new regulations such as the Green Deal adopted in 2020. One of the key targets set for 2030 spoke about cutting at least 40% of the greenhouse gas emissions compared to 1990. Currently, this target was updated: EU aims to cut the emissions by at least 55%, which will enable it to move towards the 2050's climate neutrality objective. What would be the significance of nuclear energy in this energy context manifested at EU level?

Nuclear energy is defined in the EU documents adopted in recent years as a contributing factor to the production of electricity free of greenhouse gas emissions, but also as an important vector in energy security. In support of this statement, the EU Energy Security Strategy adopted in 2014 identified several advantages which could encourage the use of nuclear energy: the availability of uranium resources in a stable global market; the technological leadership of the EU in this area (both in enrichment and reprocessing); and the investments it makes in nuclear safety. In practical terms, the energy produced by nuclear reactors ranks second, after renewables, in the total EU primary energy production (30.8% in 2018[26]) as well as in the total gross electricity generation (25.9% in 2018, which increased in 2019 by 0.8 percent[27]). These values were recorded by the 111 reactors located in 13 Member States[28], of which 56 are found in France. This country is the largest producer of nuclear power in the Union, covering more than half of the total and 71% of its national electricity production[29]. Having said that, throughout the EU, 67 reactors have been permanently shut down and only 4 are under construction in France, Slovakia and Finland[30]. In a broader context, at the end of December 2019, the global

[25] European Commission, *EU energy in figures. Statistical Pocketbook* (Luxembourg: Publications Office of the European Union, 2020), 24-44.
[26] Ibid., 38.
[27] Eurostat, "Evolution generation statistics – first results", July 2020, https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_generation_statistics_%E2%80%93_first_results#Production_of_electricity.
[28] Including the United Kingdom, there are 126 operational reactors.
[29] Statista, "Electricity production in France 2019 (by source)", May 26, 2020, https://www.statista.com/statistics/768066/electricity-production-france-source.
[30] Statista, "Nuclear reactors in European countries 2020 (by status)", May 15, 2020,

nuclear power output was produced by 443 operational nuclear reactors found in 30 countries that supply 10% of the total global electricity and nearly a third of the world's low-carbon electricity production. Moreover, as of December 31, 2019, 189 reactors had been shut down worldwide and 54 reactors were under construction in 19 countries[31].



Source: Hannah Ritchie, "Nuclear Energy", *Our World in Data*, https://ourworldindata.org/nuclear-energy

From the data mentioned above, we observe the emergence of two rather divergent directions. While the nuclear sector contributes significantly to the EU's energy potential, the number of reactors under construction is low. In parallel, there are many reactors that have been closed or are nearing the end of their lifespan. According to an analysis conducted by the IEA published in June 2020, unless new directions of action are adopted, the nuclear power capacity will fall to 5% by 2040 (contrary to the Commission's long-term target of 15% in 2050)[32] which will have significant implications for the cost of electricity and the security of supply.

Another direction identified focuses on the issue of greenhouse gas emissions. Most documents adopted in the EU recognize the low-carbon quality of nuclear energy. Moreover, the findings confirm this, given that operational nuclear power reactors provide more than half of its low-carbon electricity

https://www.statista.com/statistics/792589/operational-nuclear-reactors-european-union-eu-28/.

[31] Marta M. Gospodarczyk and Marianne Nari Fisher, "IAEA Releases 2019 Data on Nuclear Power Plants Operating Experience", *IAEA*, June 25, 2020, https://www.iaea.org/newscenter/news/iaea-releases-2019-data-on-nuclear-power-plants-operating-experience.

[32] IEA, "European Union 2020", *Energy Policy Review*, June 2020, https://www.iea.org/reports/european-union-2020.

output thus avoiding the emission of 700 million tons of CO2 each year[33]. Globally speaking, nuclear power has substituted about 55 Gt of CO2 emissions over the past 50 years[34]. However, the European Green Deal – the effort to turn the EU into a society free of greenhouse gas emissions by 2050 –does not include nuclear energy. According to the document,

> "Further decarbonising the energy system is critical to reach climate objectives in 2030 and 2050 […] A power sector must be developed that is based largely on renewable sources, complemented by the rapid phasing out of coal and decarbonising gas. At the same time, the EU's energy supply needs to be secure and affordable for consumers and businesses"[35].

Also, the document regulating the role of the instrument that will provide the necessary funds for the transition process (Just Transition Fund), clearly states that "the commissioning and the construction of the nuclear power stations shall not be supported"[36]. In response to this approach, the IEA emphasizes that nuclear technology should be treated on equal footing with other low-carbon technologies and should be included in the transition technology taxonomy because it can contribute to "easing the technical difficulties of integrating variable renewables and lowering the cost of transforming the electricity system by offering the necessary flexibility"[37].

IV. The significance of nuclear energy for Romania

Romania is among the 13 states producing nuclear energy in the EU. Uranium resources available in the country contribute almost exclusively to obtaining nuclear energy[38] responsible for approx. 22% of the national electricity

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33 ***, "EU Green Deal ignores its own biggest clean energy source", *World Nuclear News*, January 15, 2020, https://world-nuclear-news.org/Articles/EU-Green-Deal-ignores-its-own-biggest-clean-energy.

34 IEA, "Nuclear Power in a Clean Energy System", May 2019, https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system.

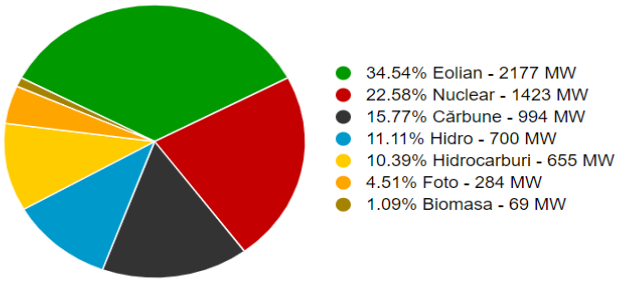
35 European Commission, "The European Green Deal", Brussels, 11 December 2019, 6, https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f 01aa75ed71a1.0002.02/DOC_1&format=PDF.

36 European Commission, "Proposal for a Regulation of the European Parliament and of the Council establishing the Just Transition Fund", Brussels, January 14, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0022

37 ***, "IEA urges EU to financially support nuclear", *Nuclear Engineering International*, June 29, 2020, https://www.neimagazine.com/news/newsiea-urges-eu-to-financially-support-nuclear-7999133.

38 For a long time, the supplier of uranium dioxide powder necessary for the operation of Units 1 and 2 from Cernavoda was the National Uranium Company (CNU) through the Feldioara branch where the uranium ore produced by the Suceava Branch is processed (two mineralized

production (the rest of the ranking comprises of the following resources: 34.54% wind, 15.77% coal, 11.11% hydro, 10.39% hydrocarbons, 4.51% photo and 1.09% biomass[39]). According to Romania's Energy Strategy, a national strategic objective is to increase energy production from nuclear sources from approx. 14 TWh today to 17.4 TWh in 2030 and 23.2 TWh in 2035[40]. This will be accomplished by redesigning the units whose lifespan is nearing the end and by extending the country's nuclear capabilities.



Source: Transelectrica, „Sistemul Energetic Național", 01.11.2020

The preoccupation for the study and production of nuclear energy began in 1955 when a Committee for Nuclear Energy was inaugurated. It continued one year later with the establishment of an Institute for Atomic Physics, after the Institute of Physics of the Romanian Academy (1949)[41] was partitioned, and an Institute for Nuclear Technology Piteşti in 1970[42]. The

structures are exploited, Crucea and Botuşana). Later, another supplier, Carneco Inc. Ltd, was added. Considering the stability, predictability and continuity of the production and in order to ensure the supply of raw materials in the long term, Nuclearelectrica approved the *Strategy for diversification of sources of supply with raw materials necessary for the production of nuclear fuel*. This foresaw the purchase of uranium oxide from at least two different international suppliers, but leave the storage and processing to the CNU. See: Nuclearelectrica, „Sumar Plan Administrare. 2019-2022", Martie 2019, 11, https://www.nuclearelectrica.ro/wp-content/uploads/2019/03/AGOA-Punctele-2-si-5-Sumar-Plan-management-06.03.2017.pdf.; Robert Iulian Tudorache, „Nota privind aprobarea Adunarii Generale a Actionarilor a Strategiei de diversificare a surselor de aprovizionare cu materie prima necesara producerii combustibilului nuclear", *Nuclearelectrica*, 22 martie 2018, 1, https://www.nuclearelectrica.ro/wp-content/uploads/2018/03/2018.03.22-Nota-AGA-Strategie-aprovizionare-cu-U3O8_cg.pdf.

[39] Translectrica, „Sistemul Energetic Național", March 26, 2020, http://www.transelectrica.ro/web/tel/sistemul-energetic-national.

[40] Ministerul Energiei, „Strategia Energetică a României 2019-2030 cu perspectiva anului 2050", Draft 2019, http://www.mmediu.ro/app/webroot/uploads/files/Strategia_Energetica2019_2030.pdf.

[41] ***, "IFA between legend and hope", *Institute of Atomic Physics*, https://ifa-mg.ro/about_en.php.

[42] Ioan Rotaru, "Romanian Nuclear Power Program", Annual ICTP/IAEA Nuclear Energy Management School Trieste, Italy, November 5-23, 2012, 2-3, http://indico.ictp.it/event/a11195/session/96/contribution/68/material/0/0.pdf.

research in the field contributed to the development of a project consisting of five nuclear reactors, using Canadian technology (CANDU type) which was going to be located in Cernavodă. The contracts for the first unit were signed quickly and its construction began in 1981. ROMENERGO, Atomic Energy of Canada Limited, Ansaldo Italy, and General Electric USA became parties to the project's implementation.

So far, only two units have been completed and connected to the national energy system, both with an installed capacity of 700 MW, which ensures, as mentioned, 22% of the national energy consumption: Unit 1 in 1995 (cost: $ 2.2 billion) and Unit 2 in 2007 (cost: EUR 666 million). Starting with 1998, the activity of the Cernavodă nuclear power plant is carried out within the S.N. Nuclearelectrica S.A (SNN) in accordance with the regulations established by the National Company for the Control of Nuclear Activities and its results have been recognized over time even at the international level[43].

In pursuing an energy diplomacy strategy, two other units have been the subject of studies, negotiations, and agreements between local and foreign investors since 2006. The Government of Romania approved, in 2007, the "Strategy for Attracting Investors", immediately afterward, conducting several negotiation stages finalized with the establishment of the Energonuclear project company through an investment agreement that involved the following actors: Nuclearelectrica (51%), ArcelorMittal (6.2%), CEZ (9.15%), GDF SUEZ (9.15%), ENEL (9.15%), Iberdrola (6.2%) and RWE Power (9.15%)[44]. The cost of the works was estimated at four billion Euros, and Romania's contribution would exceed 50% which will come from the coffers of the National Development Fund[45]. The project obtained the approval of the European Commission after passing the feasibility study thresholds, but the investors withdrew one by one, until Nuclearelectrica remained the only shareholder in the project company in 2013. According to an official press release, the withdrawal of GDF SUEZ, CEZ, RWE, and Iberdrola in 2011 was due to "the uncertain economic situation incompatible with the capital requirements for a new nuclear power project"[46]. The last two remaining investors motivated their choice claiming that the initial investment strategy was incompatible "with a new

[43] *Platts Nucleonics* magazine (February 2010) ranked Unit 1 first in a top of CANDU power stations, with an average capacity factor of 100.1% and, overall, it came in 12th place out of the total number of 436 nuclear reactors in operation (Colegiul Director, „Energia nucleară în România", *Federația Națională Mine Energie*, 2, https://fnme.ro/_files/energia%20nucleara%20in%20Romania.pdf).

[44] Ibid.

[45] Ibid.

[46] Claudia Pârvoiu, „Update. Veste proastă pentru autoritățile române: GDF Suez, Iberdrola şi RWE se retrag din proiectul privind construcţia reactoarelor 3 şi 4 de la Cernavodă", *HotNews.ro*, January 2011, https://economie.hotnews.ro/stiri-energie-8224875-veste-proasta-pentru-autoritatile-romane-gdf-suez-iberdrola-rwe-vor-retraga-din-proiectul-privind-constructia-reactoarelor-2-4-cernavoda.htm.

potential shareholder structure" (Enel Investment Holding BV) and that "the challenges of the business environment [...] no longer support[ed] the company's involvement in the project" (ArcelorMittal Galați SA)[47].

However, the implementation of the project became important for Romania's energy security in the context of the energy and environmental objectives set at the European level (for 2020 – compared to 1990, the level of greenhouse gas emissions had to be reduced by 20%, the energy efficiency had to increase by 20%, and the share of renewables in the final energy consumption had to be 20%; similarly, for 2030, the emissions had to decrease by 40%, the energy efficiency had to increase by 32.5%, and the share of renewable energy needed to reach a maximum of 32%[48]). The example of the two existing units encouraged investments in endeavors that produced electricity at competitive prices and with a minimal impact on the environment. Consequently, the "Strategy for the continuation of the Cernavodă NPP Units 3 and 4" proposed the creation of a joint venture or a Project Company, where SNN and a private investor will be the shareholders. This company would later receive from SNN the investment made in the subsidiary EnergoNuclear SA (EN)[49].

Shortly after, the investor selected was China General Nuclear Power Corporation. What made the People's Republic of China the ideal partner in the nuclear field? First, China is a major actor in the world of nuclear power generation. With 20 operating reactors, 28 under construction, and other 16 approved for construction, China is interested in becoming a strong nuclear

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47 ***, „EnergoNuclear va continua să funcţioneze ca filială integral deţinută de Nuclearelectrica, până la finele lui 2014", *Capital*, December 2013, https://www.capital.ro/energonuclear-va-continua-sa-functioneze-ca-filiala-integral-detinuta-de-nuclearelectrica-pan.html.

48 According to the Community requirements, each Member State has set its targets in accordance with the internal context. For Romania, the targets for 2020 were the following: emissions by 19% lower than in 2005, share of renewable energy in final energy consumption of 24% and primary energy consumption of 43 Mtoe (relative to energy efficiency). The target for renewable energy has been reached and exceeded since 2014, and the other targets are close to being achieved. For 2030, Romania reached, according to the Integrated National Plan in the field of Energy and Climate Change 2021-2030, the following quotas: -43.9% ETS emissions compared to 2005, 30.7% renewable energy sources in gross final energy consumption, 32.3 Mtep primary energy consumption, respectively energy savings of 45.1% (European Commission, "2030 climate & energy framework", https://ec.europa.eu/clima/policies/strategies/2030_en; European Commission, "Europe 2020 targets: statistics and indicators for Romania", https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/european-semester-your-country/romania/europe-2020-targets-statistics-and-indicators-romania_en; ***, „Planul Naţional Integrat în domeniul Energiei şi Schimbărilor Climatice 2021-2030", reviewed January 2020, htts://financialintelligence.ro/wp-content/uploads/2020/02/PNIESC-revizuit_31-01-2020.pdf).

49 Nuclearelectrica, „Strategia Revizuită de Continuare a Proiectului Unităţile 3 şi 4 CNE Cernavodă", August 22, 2014, 5, https://www.nuclearelectrica.ro/wp-content/uploads/2018/07/Anexa_1_Strategie-U3-si-U4_revizuita_track-changes_16.07.2018_dupa-sedinta-CA-fara-track.pdf.

power country[50]. Second of all, China has a vast experience in the field, including long-term cooperation with France, and has provided an example of good practice regarding safety standards. Also, it was considered to be the sole viable option for the construction of reactors 3 and 4 given that some states with nuclear tradition reassessed their priorities after the Fukushima accident (Germany, Canada, Japan) while others did not have the necessary expertise in CANDU technology (Russia).

Finally, since October 17, 2014, respectively, since the signing of the "Joint Letter of intention on completing the Project", many rounds of negotiations were initiated, underlying the cooperation between Nuclearelectrica and the Chinese side, but they did not lead to a productive result. On November 9, 2015, the "Memorandum of Understanding on the development, construction, operation, and decommissioning of Units 3 and 4 of the Cernavoda NPP" was signed. It established the principles of cooperation between the Parties and the steps they must follow to form a joint venture and effectively implement the Project. In terms of legal regulations, the parties needed to further agree on the following documents: the Investors Agreement, the Constitutive Act, and the Investment Documents. This stage would then be followed by the elaboration of a feasibility study, the setting up of a joint venture, and the transfer of the SNN investment in EN to it. Once all these were completed, the construction phase, the operation, and the maintenance of the Project would be carried out[51].

Although the Memorandum set a period of 16 weeks from the signing to the finalization of the Investment Documents, this phase was was extended several times due to the complexity of the project and the long-term commitment it involved[52]. In 2019, representatives of Nuclearelectrica and China Nuclear Corporation signed the Investor Agreement in a preliminary form, which indicated that within 60 days, the project company was to be established. The Company will be the sole technical and operational platform involved in the development of the two reactors. Despite the initial enthusiasm shown at the signing of the Agreement, the project company was not established within the deadline. On July 29, 2019 the shareholders of Nuclearelectrica were called to approve the mandate of the Board of Directors that would amend the terms provided in the Preliminary Agreement. Moreover,

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50 Eliza Gheorghe, "The Chinese-Romanian Nuclear Cooperation", *ROEC*, September 2014, https://www.roec.biz/project/the-chinese-romanian-nuclear-cooperation/#post-4725-footnote-4.

51 *Nuclearelectrica*, „Memorandum de Înţelegere privind dezvoltarea, construirea, operare şi dezafectarea Unităţilor 3 şi 4 de la CNE Cernavodă", Societatea Naţională Nuclearelectrica S.A., China Nuclear Corporation, October 22, 2015, 6-7, https://media.hotnews.ro/media_server1/document-2015-09-21-20441982-0-memorandum-reactoare-3-4.pdf.

52 Nuclearelectrica, „Unităţile 3 şi 4", https://www.nuclearelectrica.ro/activitati-pentru-dezvoltarea-proiectelor/unitatile-3-si-4/.

the sources mention that China's contribution to the construction of the reactors needed to be approved by the European Commission[53]. Given that China was a third party, things could be very challenging. Romanian political opinion changed over time and was no longer positive about the collaboration, with Prime Minister Ludovic Orban announcing on January 22, 2020, that things would change in regard to the Chinese company. The government sought a new partner to fund the project and motivated this development by underlying that the Romanian-Chinese partnership would not work[54]. This change in attitude can be explained by the foreign policy direction adopted by the Orban Government which gave a greater importance to the relations with China's competitors: USA and Republic of Korea – the only Asian country with which Romania has a strategic partnership. According to the press releases, the Units 3 and 4 project has already received $ 8 billion in funding from Washington and the new direction will involve a consortium comprised of American, Romanian, Canadian, and French companies.

This approach is the opposite of what was pursued by the government during the period when the agreement with China was signed. The Prime Minister of that time, Viorica Dăncilă, considered "the relations between the two countries as priorities for Romania's foreign policy"[55]. To this day, the project remains a strategic priority for Romania and there is a possibility that it will become operational by 2030.

Romania's Energy Strategy also mentions the refurbishment of Unit 1 since its operational duration of about 210 000 hours or the equivalent of 30 years at a utilization coefficient of the installed power of 80% will end in 2023. The Administrative Plan of Nuclearelectrica envisaged the extension of this duration to 245 000 operating hours at nominal power due to the industry studies conducted on the components of the reactor assembly and the aging mechanisms[56]. Other countries have also shown their interest. South Korea through Korea Hydro & Nuclear Power, the country's largest electricity producer, and the US through Sargent & Lundy, an engineering services provider, signed on January 29, 2019, an agreement to upgrade Cernavodă's operating units. This decision was made on account of similar experiences with PHWRs (pressurized heavy-water reactors), regardless of whether we are talking about Korean reactors or American involvement in upgrading Canadian

[53] *Rumyana Vakarelska,* "Completing Cernavoda", *Nuclear Engineering International*, August 20, 2019, https://www.neimagazine.com/features/featurecompleting-cernavoda-7374985/.
[54] ***, "Romania cancels China deal on Cernavoda but proceeds with life extension", *Nuclear Engineering International*, January 24, 2020, https://www.neimagazine.com/news/newsromania-cancels-china-deal-on-cernavoda-but-proceeds-with-life-extension-7653710.
[55] Embassy of the People's Republic of China in Romania, „Urările noului prim-ministru al României, Viorica Dăncilă, către poporul chinez", February 23, 2018, http://www.chinaembassy .org.ro/rom/aa/t1536850.htm.
[56] Nuclearelectrica, „Sumar Plan Administrare. 2019-2022", 9.

PHWRs[57]. Eventually, Nuclearelectrica signed on January 22, 2020 a contract with Candu Energy, part of the SNC-Lavalin Group, to prepare the extension of Unit 1's life. With a value of $10.8 million, the contract aims to compile engineering analyzes and evaluations of fuel channels and feeders[58].

These internal developments are in accordance with the guidelines of the European Community, as well as with the international regulations in the nuclear field. After the Fukushima accident, the Romanian nuclear industry began to reassess nuclear safety and proceeded with the implementation of several measures. To ensure that nuclear facilities in Europe have received licenses that address safety standards capable of dealing with unexpected events, the European Commission has asked all states with such structures to conducts a series of safety assessments or stress tests as indicated in the "Conclusions" of the European Council from March 2011[59]. After effective cooperation between the Commission and the responsible parties, the tests were carried out by 2012, the results were positive, and the situation did not require the closure of any of the existing nuclear power plants, although upgrading measures had to be considered. The evaluation for improving the functioning of the 132 reactors existing at the time reached 10-25 billion Euros[60]. The stress test for Romania was finished on October 31, 2011 and included an in-depth analysis of serious accident scenarios and mitigation strategies based on examples taken from research in the field. The findings showed that the risk of a nuclear disaster in Cernavodă was low. Additionally, measures for design improvement were identified and their implementation would be reviewed within a reasonable timeframe since financial resources had already been secured.

The post-Fukushima effort to increase the safety of the activity of nuclear reactors is strengthened by the elaboration of a national action plan

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57 ***, "South Korea seeks collaboration on refurbishment of Romania NPPS", *Nuclear Engineering International*, January 30, 2019, https://www.neimagazine.com/news/newssouth-korea-seeks-collaboration-on-refurbishment-of-romanian-npps-6956774.

58 David Dalton, "Romania/Candu Energy Wins $10.8M Cernavodă Contract", *NUCNET*, January 22, 2020, https://www.nucnet.org/news/candu-energy-wins-usd10-8m-cernavoda-contract-1-3-2020.

59 "The safety of all EU nuclear plants should be reviewed on the basis of a comprehensive and transparent risk and safety assessment ("stress tests"); the European Nuclear Safety Regulatory Group (ENSREG) and the Commission are invited to develop as soon as possible the scope and modalities of these tests in a coordinated framework in light of the lessons learned from the accident in Japan and with the full involvement of Member States, making full use of available expertise" (European Council, "Conclusions", EUCO 10/11, March 24/25, 2011, 11, https://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2010%202011%20INIT).

60 European Commission, "Communication from the Commission to the Council and the European Parliament on the comprehensive risk and safety assessments ("stress test") of nuclear power plants in the European Union and related activities", Brussels, October 04, 2012, 8, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0571&from=EN.content/EN/TXT/PDF/?uri=CELEX:52012DC0571&from=EN.

developed by the National Commission for Nuclear Activities Control[61], which brings together multiple international actions and recommendations. The latest review (from January 2020) reveals the commitments made by the Romanian authorities. These include the approval of the *National Strategy on Nuclear Safety and Security*, the adoption of new regulations regarding nuclear installations (NSN-18, NSN-21, NSN-24), personnel training (NSN-23), radiological safety (NSN-26, BRRS, 2018) and measures to be taken in emergencies[62]. In addition to strengthening the legal framework, many actions regarding the design of the Cernavodă nuclear power plant have been carried out, whether we are talking about purchasing and testing equipment, installing a supplementary uninterruptible power supply, or streamlining operating procedures in exceptional situations[63].

All in all, Romania is one of the European countries in which nuclear energy completes the energy mix, contributes to the production of electricity to a significant extent and facilitates the road to reaching EU's climate targets. Its recent efforts have been aimed at improving safety standards, upgrading existing reactors, but also at attracting investors to build two new units (thus providing a basis for the study of what, today, we call energy diplomacy). The future envisaged for this sector is one of growth and development and, as such, it has been included in the strategic approaches to the energy field.

V. Conclusions

This article sought to understand *what is the significance of nuclear energy for the energy evolution of the European Union and Romania?* When we talk about evolution, we refer to a starting point, a direction of action and visible results and perspectives. The study tried to identify the way the EU and Romania relate to nuclear energy – an energy source that has always generated debates regarding its use and significantly shaped the energy future of many countries.

Both the EU and Romania started in this sector by inaugurating institutions for research in the field, namely: the European Atomic Energy Community (EU) and the Committee for Nuclear Energy (RO). Gradually, nuclear power began to play a role in the electricity market which increased or decreased depending on different contexts. However, recent debates help us

[61] The National Commission for Nuclear Activities Control (CNCAN) is the national authority and has regulatory and control responsibilities in the nuclear field in Romania (Comisia Națională pentru Controlul Activităților Nucleare, "CNCAN presentation", http://www.cncan.ro/about-us/cncan-presentation/).
[62] At length in: ***, "Romania National Action Plan post – Fukushima", Revision 3. January 2020, 2-3, http://www.ensreg.eu/sites/default/files/attachments/stress_test_nacp_romania_2020.pdf.
[63] Ibid., 10.

best understand the significance of nuclear energy. At EU level, the current situation is marked by an increased energy dependence and by the objective of reducing greenhouse gas emissions. These two directions have provided fertile ground for reaping the benefits of this energy source. Most official documents of the European Union have over time emphasized the importance of nuclear energy in terms of the availability and diversity of uranium resources in global markets, low price volatility, contribution to electricity generation, employment and income generation. The proven low-carbon quality has also been taken into account. Having said this, we have also noted that in pursuing the most ambitious climate goal assumed by the European Green Deal – neutrality by 2050 – the EU excludes support for the nuclear option. Reasons for this decision have been attributed to the uncertainty surrounding the role of nuclear energy: the possibility of accidents or the production of highly toxic waste. The specialized institutions point out that without investing in nuclear energy, the climate objectives and the electricity security of the EU will be put in difficulty.

In the case of Romania, the views on nuclear energy are also reflected in the official documents. Part of the electricity mix in a significant proportion, nuclear energy is seen as playing an important role in the energy future of Romania. The construction of two new reactors at Cernavodă nuclear power plant is a strategic priority given that the plant is a strategic resource equipped with internal infrastructure that provides Romania with a high degree of independence in electricity production. For several years, multiple negotiations have been carried out in order to attract investors. The options have varied over time, but recently it seems that they have been directed at the US with which an Investment Agreement has already been signed. According to the same strategy, this investment measure will supplement the energy input in the energy system, will raise the efficiency and reliability indicators, and will produce net positive effects for Romania's energy security.

In conclusion, nuclear energy plays a significant role in the European Union and Romania given that similar conditions are met at both the European and national level: availability of raw material; share in the electricity mix; contribution to a safe and clean energy climate; recognition in official documents, and shared perspectives in the field. We noticed that both actors also recognize a set of advantages that result from the use of nuclear energy, such as: low-carbon, flexible, dispatchable, cost effective. The figures show significant contributions in the energy field, but the uncertainty caused by the risks associated with nuclear operations, fuel production, and waste management will continue to remain a subject of major debates.

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