HARNESSING EU FUNDS FOR ROMANIA'S RENEWABLE ENERGY TRANSITION

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Thanks

We are grateful to the European Climate Foundation for helping to fund this work. The report's conclusions remain independent.

With thanks to Adrien Assous, Eusebiu Stamate and Julie Ducasse for helpful comments and input on this report, and to Laura Nazare, Raphael Hanoteaux, Martin Moise, Thomas Garabetian, Alberto Rocamora and Robert Gavriliuc for their feedback and advice.

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Report design

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1. Introduction

The European Union has set out a vision to become climate neutral by 2050, the first economy with net-zero greenhouse gas emissions. Along with its fellow Member States, Romania has signed up to this collective goal. To achieve the 2050 and intermediary 2030 targets for reducing greenhouse gas emissions, all parts of society and the economy must play a role, especially the energy sector. One of the key objectives of the European Green Deal is to decarbonise the energy sector by reducing demand, increasing energy efficiency and investing in environmentally friendly technologies. To achieve these objectives, significant investments in renewable energies and energy efficiency are required, along with an end to funding for environmentally damaging activities, especially investments in fossil energy production.

Romania could almost be set for success in the EU's race to a net-zero economy by 2050. Due to changes in the structure of the economy following the post-1990 transition, Romania has experienced massive drops in emissions, being among the four EU Member States which have seen the swiftest emission reductions compared to 1990 levels.[1] Nevertheless, the country is not yet on a predictable and sustainable trajectory to net zero by 2050. On the one hand, Romania has some of the best enabling conditions for the energy transition in the South and Central East European regions: the largest onshore wind farm in the EU, huge renewable energy potential and a diverse energy mix of which almost 50% is already greenhouse gas emissions free. Yet, Romania continues to be one of the most lignite intensive countries in the EU, and Romanians still pay more than their European counterparts for the costs of this carbon intensive energy system.

In Romania, the leading source of greenhouse gases is the burning of fossil fuels, primarily for the energy sector. (Other areas such as agriculture, waste, various industrial processes, land-use and land-use change also contribute significantly to the emissions budget.) Romania has a significant potential for renewable energy production, and renewable energy sources make up a growing share of the national energy mix, reaching 24% in 2018.[2] Nevertheless, fossil fuels, especially coal and natural gas, remain the primary sources for electricity and heat generation. Romania is still highly dependent on the import of petroleum products, gas, and coal, and the exploitation of domestic fossil fuel sources is decreasing. To counteract this, efforts are being made to exploit offshore gas reserves in the Black Sea, and the expansion of gas transmission and distribution networks remain a matter of public policy. Meanwhile, the country has yet to set a phase-out date for coal, with the National Energy and Climate Plan (NECP) envisaging 2GW of installed coal capacity in 2030.[3]

[1] EEA Report 06/2019, Annual European Union greenhouse gas inventory 1990-2017 and inventory report 2019, submissions under the UNFCCC and the Kyoto Protocol. https://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2019
[2] European Commission (2020) Energy statistical country datasheets. https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en
[3] Romania's National Energy and Climate Plan (2020). https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en#documents

Romania has a way to go before realising its renewable energy potential and a Just Transition. However, significant EU funds are currently available to tackle this challenge. The Recovery and Resilience Facility, Cohesion Funding and EU Emissions Trading System (ETS) revenues can provide substantial financial momentum to Romania's energy transition. A strategic and forward-looking use of these funds will be necessary to avoid stranded assets and fully realise the renewable transformation of the heating sector and the wider energy system. Authorities responsible for the disbursement of these funds must be equipped with clear information on the potential of various renewable resources and technologies, and any associated drawbacks or pitfalls.

This report analyses the critical juncture Romania now faces for shaping its planning and investment decisions for the next decade, a decade that will be decisive for climate action. It outlines the various funding possibilities that could be operationalised to drive the renewable energy transition. Finally, the report presents an in-depth assessment of two "less exploited" renewable energy sources, geothermal and bioenergy.[4] These are sectors in which major knowledge gaps persist, with existing information often based on outdated technological assessments. This report examines the potential of these two energy sources, and highlights their advantages and disadvantages, with the aim of increasing awareness of these energy sources in the planning process.

[4] Biomass, biogas and geothermal energy are considered less exploited resources under Specific Objective 6.1 of the Ministry of EU Funds' Large Infrastructure Operational Programme.

2. The Energy System in Romania

Large parts of Romania's current energy system were built during the Communist period, which saw waves of urbanisation and industrialisation leading to growing energy demand. Energy independence has long been an important aim for the energy system, leading to significant investments in the exploration and exploitation of the country's natural resources. This exploitation primarily centred on fossil fuels (due to resource availability, the state of technologies and low operating costs), but investments were also made in hydropower and nuclear energy. Until the 1970s, resource extraction and energy production were key priorities for policymakers, with large proportions of available funds being directed towards these sectors. Large power plants were built, like Iron Gate I hydroelectric power plant, with more than 1 GW installed power, and large coal thermal power plants like those in Oltenia coal basin, with a total installed power of more than 3 GW. At the time, these power plants had some of the largest energy generation capacity in Europe. To this day, the Oltenia coal basin is still the second largest energy producer in the country, after the Cernavoda nuclear power plant. During the 1970s and 1980s, large district heating systems were built to capitalise on energy production in industrial areas. District heating allowed residual heat from fossil fuel power generation to be used in residential areas.

The development of new coal mining areas associated with these power plants became a major source of employment for many regions. However, the legacy of Romania's carbon-intensive energy mix poses many challenges today. Emissions from the energy sector made up 66% of Romania's overall greenhouse gas footprint in 2018. As well as the climate impact, fossil fuel extraction also results in environmental damage to nature and wildlife. Most of Romania's thermal energy production capacities are not equipped with pollution reduction systems, leading to nitrous oxide and sulphur dioxide emissions.

Energy poverty is also a major societal issue. As much as 48% of the population still heat their homes by burning raw wood,[5] which brings many negative health and environmental impacts. Of the remaining energy demand for home heating, over 90% is sourced from fossil fuels,[6] and is therefore dependent on unstable and rising fossil fuel prices. In 2019, 9.3% of the population were unable to keep their homes adequately warm.[7] As a result, there is a large level of non-payment of energy bills. Increasing fuel costs forced the closure of many of the country's district heating systems, which suffered from significant energy inefficiencies (up to 30% energy losses) due to the age and technical condition of the pipes. The number of people served by district heating systems has dropped accordingly, from 8.5 million people in 1992 to 3.8 million in 2014 (see Figure 1).

[5] National Institute of Statistics. https://insse.ro/

[6] European Commission (2020) Energy statistical country datasheets. https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en

[7] EUROSTAT (2021) Inability to keep home adequately warm – EU-SILC survey. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdes01&lang=en

In efforts to address these issues of carbon emissions, energy poverty and unstable fuel prices, two different and often conflicting trends are developing in Romania. On the one hand, there is a move towards more renewable energy production, largely driven forward by EU policies. On the other hand is a national policy to promote the expansion of natural gas as a solution to Romania's energy woes.

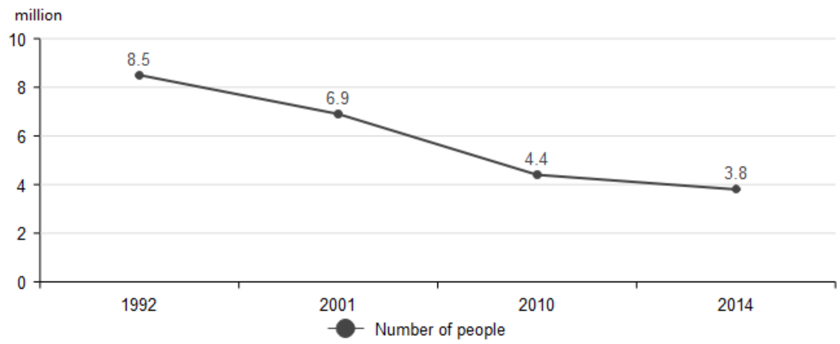

Figure 1 - Evolution of the number of people served by district heating systems in Romania.

2.1 Developments in renewable energy

After the 1990s and Romania's accession to the European Union, energy priorities and policies have seen significant changes. Under the first Renewable Energy Directive (2009/28/EC), Romania committed to a renewable energy production target of 24%. Over the following years, investment in the energy sector increased by over 140% compared to 2008, by more than €2 billion per year.[8] Romania was at that time one of the most important players on the green energy market and had already reached its 2020 target by 2016. More than 4 GW of renewable energy production capacity was installed, mostly wind and solar energy. While hydropower, wind and solar energy are used for electricity production, biomass is mostly used for thermal energy (heat) production. Figure 2 shows the current use of renewable energy sources in national energy production for heating.[9]

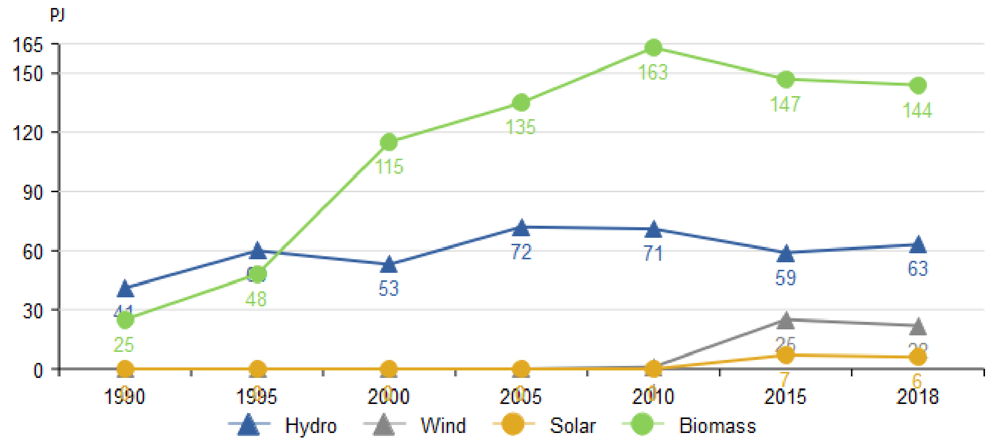

Figure 2 – Heat energy production from renewable sources.

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[8] National Institute of Statistics. https://insse.ro/

[9] EUROSTAT (2020) Energy statistics – energy datasets. https://ec.europa.eu/eurostat/web/energy/data/database

Romania’s renewable energy potential

The potential or availability of renewable resources differs from a theoretical, technical, and achievable point of view. The theoretical potential represents the totality of the energy available, while the technical potential considers technological limitations to this theoretical potential. Achievable potential also considers economic, social, and environmental limitations. All of these potentials can vary over time, and as a result, the official estimations made for energy potential in Romania are often outdated. The Romanian Energy Strategy 2019 – 2030 gives the following estimations for theoretical and technical potential of renewable energy sources:

	Theoretical potential [PJ]	Technical potential [PJ]
Hydropower	252	145.8
Wind energy	82.8	36.82
Solar energy	-	17.28
Biomass	318	-
Geothermal	-	7

Source: Ministerul Energiei (2018)

However, there are significant gaps in these estimations. For example, the technical potential of hydropower was evaluated in the year 1990, in line with the technologies available at that time. The technical wind potential was evaluated according to the technologies and data available in the period 2009 – 2016, and it does not consider the offshore energy potential, which could be significantly increased due to recent technological developments. The potential of biomass and geothermal sources are vaguely evaluated, the latter only on the basis of research studies conducted before the 1990s. Such an outdated analysis can lead to situations in which a renewable source is thought to be exploited to the maximum, although in reality this may not be the case.

The most significant developments of renewable energy have been in the production of electricity. Currently, Romania has 20,580 MW of installed electricity production capacity. While a major proportion of this electricity is generated from established fossil fuel, nuclear and hydropower production, solar and wind energies have grown to make up 21.3% of the electricity mix (see Figure 3).[10]

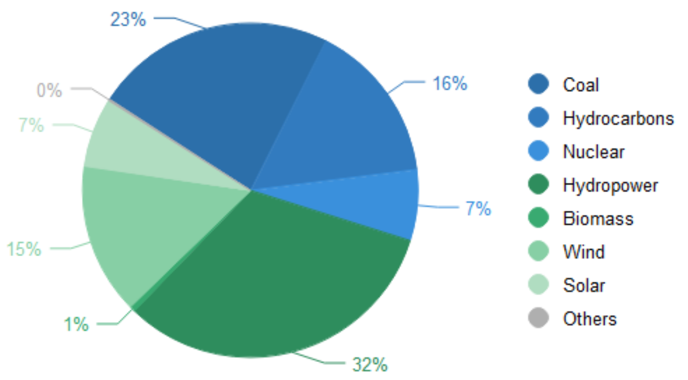


Figure 3 – Installed energy production capacities 2020

[10] Autoritatea Nationala de Reglementare in domeniul Energiei, ANRE (2020). Puterea instalata in capacitatiile de productie energie electrica. https://www.anre.ro/ro/energie-electrica/rapoarte/puterea-instalata-in-capacitatiile-de-productie-energie-electrica

However, in recent years the renewable energy sector has been hampered by repeated legislative changes and the closure of access to the Green Certificates support scheme. This led to many planned projects being suspended[11] and damaged the reputation of renewable energy, making it harder for projects to avail of loans from banks. Political preferences for large, centralised power plants disadvantage independent, decentralised renewable energy producers. Funding schemes for renewable energy prosumers (producer-consumers) have been beset by bureaucratic delays and mishaps.[12] Renewable energy planning is fragmented, and the network planning of the transmission system operator Transelectrica only considers half of the new renewable electricity capacity presented in the National Energy and Climate Plan.[13] As a result, the growth in renewable energy capacity has stagnated since 2014.

2.2. Growth in the gas sector

While growth in the renewable energy sector is stalling, natural gas use is on the rise, and playing an increasingly important role in the heating sector. Natural gas is not currently available throughout the country, but significant investments in expanding transmission and distribution networks have been made in the last 30 years. In areas with access to the gas network, natural gas is often the most accessible heating solution. Natural gas consumption, mainly for the provision of thermal energy, reached 3 billion cubic metres in 2018, emitting more than 6.9 million tons of greenhouse gases into the atmosphere (see Figure 4).

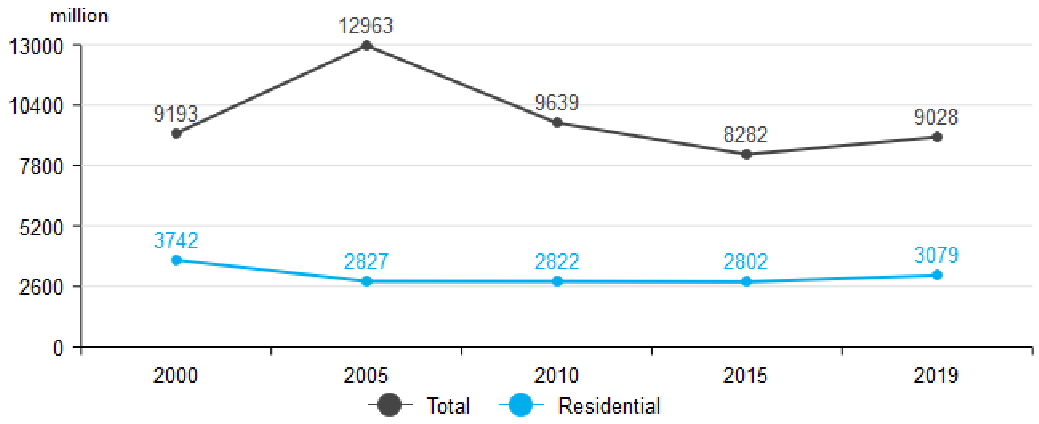


Figure 4 - Distributed natural gas, total and for residential use.

While the quantities of gas consumed for heating purposes have remained fairly constant over the last two decades, this is due to significant investments in energy efficiency which were made simultaneously to the extension of the gas grid. These energy-saving updates included significant thermal rehabilitation projects of apartment buildings in urban areas. The

[11] National Institute of Statistics. https://insse.ro/

[12] Exchange with Romanian Renewable Energy Producers' Association, 11 March 2021.

[13] Exchange with Romanian Renewable Energy Producers' Association, 11 March 2021.

evolution of the length of the natural gas distribution networks can be observed in the following Figure 5 and shows the full extent of the development of Romania's gas network.

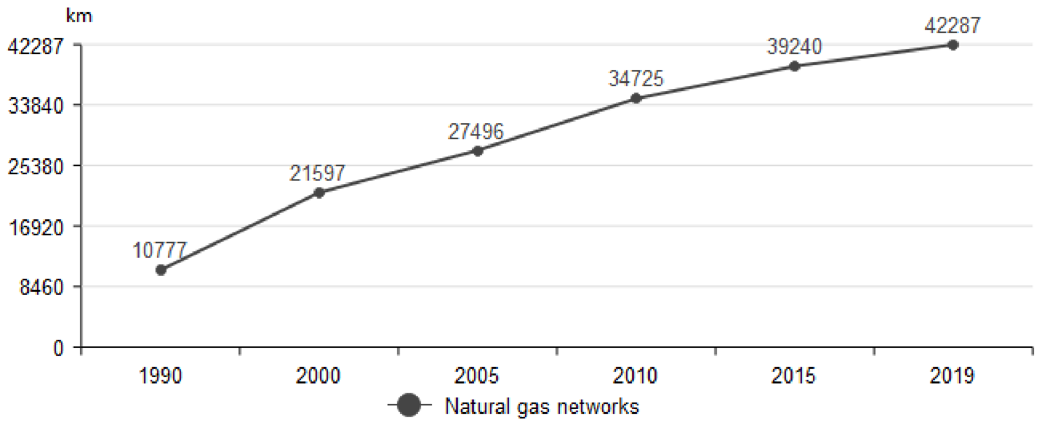


Figure 5 - Total length of natural gas distribution networks

Policy decisions have further incentivised the expansion of the gas grid. Modifications to the energy law now require the distribution company to cover the cost of connecting new gas customers who live within 2.5km of the gird.[14] This had led to a significant increase in requests for gas connections. National energy policy continues to view natural gas as the main means to provide affordable and secure heating for the coming decades, despite growing recognition at EU level about the risks of stranded assets and fossil fuel lock-in.

Transition fuel: what's in a name?

Natural or fossil gas is often referred to as a transition fuel, in part due to concerted advertising and lobbying efforts by the oil and gas industry which continue to claim that, as the CO_2 emissions from the combustion of fossil gas are relatively lower than those of coal and oil, gas can act as a stepping stone between "dirtier" fossil fuels and renewable energies. In reality, even the CO_2 emissions from gas would still push planetary warming beyond 2°C if all global coal capacity were replaced with gas. On top of this, however, gas also produces methane emissions throughout its life cycle. Methane is a potent greenhouse gas with a much greater warming effect on the climate than CO_2, particularly over periods of 10-30 years. A lot of these methane emissions come from unintentional leakage and are not monitored, so there is no accurate global assessment of methane emissions from fossil gas. However, if only a tiny amount of total fossil gas (3-5% according to the IEA's 2017 World Energy Outlook) is leaked, gas' overall climate impact matches that of coal.

[14] Law 155/2020 amending and supplementing the Law on electricity and natural gas no. 123/2012 and amending and supplementing other normative acts. https://www.correggionet.eu/wp-content/uploads/2020/11/Law-155-of-2020_EN.pdf

All trends (and policy stimuli) point to the replacement of district heating and wood burning with natural gas. However, these policies are coming up against EU funding instruments that increasingly demand investments that are in line with the bloc’s 2050 climate neutrality commitment. The following chapter will detail these funding sources and their relevance for investments in climate action and renewable energies.

3. Funding opportunities for the Energy Transition

Romania has the second lowest GDP in the Union and therefore the large investment needs of the energy transition can pose a challenge. According to a public statement by the Minister for Energy, the estimated cost of transitioning the power sector will be €15-30 bn up to 2030,[15] while the country's NECP estimates investment needs of €22.6 bn for the electricity transition over the same period.[16] Through a combined channelling of EU funding and recycled EU ETS revenues, this amount can in fact be made available.

3.1 The EU budget and climate mainstreaming[17]

The EU budget, known as the Multi-annual Financial Framework (MFF), covers a period of seven years and disburses many billions' worth of funding at EU and national level. EU funds and the conditions attached to them play a crucial role in shaping public investments. For example. 44.86% of all Romania's public investments between 2015 and 2017 came from EU Cohesion Policy funding.[18] EU funding instruments also put a large emphasis on climate action and as a result have a huge role in driving investments into the low-carbon economy. Romania's strategy for climate mitigation during the last EU funding period has been "mostly EU-led", as the Government did not envision additional or complementary policies to address climate change apart from the EU obligations.[19] The new EU funds for the 2021-2027 period will also have a large impact on the nature and quality of future investments in the low-carbon economy. For the 2021-2027 period, 37% of the funding under these programmes must go to climate action, in what is termed 'climate mainstreaming'. This represents not merely an obligation, but also an opportunity for Member States to avail of these funds to boost their energy transition plans.

[15] Reuters, 14 March 2019, 'Romania needs 15-30 bln euros in energy investment by 2030 – ministry'. https://www.reuters.com/article/romania-energy-strategy-idUSL8N21141Z

[16] Romania's National Energy and Climate Plan (2020). https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en#documents

[17] This chapter is based on and updates the report 'Financing the low-carbon transition in Romania', produced by Bankwatch and Sandbag in February 2020. With thanks to Laura Nazare and Raphael Hanoteaux for their assistance in revising the report. https://sandbag.be/index.php/project/financing-the-low-carbon-transition-in-romania/

[18] European Commission (2021) Share of cohesion policy per Member State to public investment 2015-2017. https://cohesiondata.ec.europa.eu/Other-Eurostat/Share-of-Cohesion-Policy-per-Member-State-to-publi/drqq-sbh7/data

[19] Bankwatch (2014) Climate's enfants terribles. https://bankwatch.org/sites/default/files/enfants-terribles.pdf

Cohesion Policy

With a budget of €377.8 bn under the MFF 2021-2027,[20] the future Cohesion Policy will be the biggest investment policy of the EU, accounting for approximately 30% of the total EU budget and covering seven years in the critical decade that will lead us to 2030. Within the scope of Cohesion Policy 2021-27, Romania will receive €18.72 bn under the European Regional Development Fund (ERDF) and €4.63 bn under the Cohesion Fund. With a climate mainstreaming requirement on 30% and 37% respectively, this should mean that at least €5.62 bn from the ERDF and €1.71 bn from the Cohesion Fund will go to climate objectives.

However, Cohesion Policy is not always used to its full potential. While 20% of all spending should have gone to climate objectives under the budgetary period 2014-2020, only 7.8% of investments realised in Romania under the Cohesion Policy went to actual clean energy projects.[21] In the final version of Romania's NECP, a total of €8.42 bn from the ERDF and Cohesion Fund is proposed for spending that falls under Policy Objective 2 of the Cohesion Policy, 'a greener, carbon-free Europe'. This includes funding for biodiversity, pollution prevention, climate adaptation and mobility measures. Of the total amount, €1.05 bn from the ERDF and Cohesion Fund is allocated to energy and energy efficiency.[22] These increased resources dedicated to climate action through the Cohesion Policy is certainly a positive sign, but it will have to be checked thoroughly at the level of the implementation of the actual programmes.

Next Generation Climate Funding

The EU's response package to the COVID-19 crisis, named NextGenerationEU, has a strong climate action focus. At EU level, the message is clear; the recovery will be green, creating opportunity out of the crisis by mobilising large-scale investments in a just energy transition.[23]

The largest instrument in the package is the Recovery and Resilience Fund (RRF). 37% of the funds allocated under the RRF must go towards climate action, while all projects supported under the fund must comply with the 'Do No Significant Harm' principle. Romania will receive €13.7 bn in grants and €16.6 bn in loans from the RRF[24] and therefore €11.2 bn of this must go to climate purposes. This additional funding presents a clear opportunity for Romania to

[20] European Commission (2020) EU's Next Long-term Budget and NextGenerationEU: Key Facts and Figures. https://ec.europa.eu/info/sites/info/files/about_the_european_commission/eu_budget/mff_factsheet_agreement_en_web_20.11.pdf

[21] Climate Action Network Europe (2019) Negotiating the MFF 2021-2027 : EU budget for higher climate ambition. http://www.caneurope.org/docman/fossil-fuel-subsidies-1/3573-can-europe-recommendations-mff-cohesion-dec-19/file

[22] Romania's National Energy and Climate Plan (2020). https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en#documents

[23] European Commission (2020) EU's Next Long-term Budget and NextGenerationEU: Key Facts and Figures. https://ec.europa.eu/info/sites/info/files/about_the_european_commission/eu_budget/mff_factsheet_agreement_en_web_20.11.pdf

[24] Ministry for EU Funds (2020) National Recovery and Resilience Plan. https://mfe.gov.ro/wp-content/uploads/2020/11/587f2474d66bdf5f222009242d23f292.pdf

accelerate its renewable transition and implement investments into the country's large renewable energy potential.

Funding a Just Transition

A new and important topic in the climate action and EU budget discussion is the just transition. In January 2020, the European Commission proposed a Just Transition Mechanism, to be composed of three pillars:

- a Just Transition Fund of €7.5 bn
- an InvestEU Just Transition scheme mobilising €45 bn
- a public sector loan facility mobilising €25 bn to €30 bn in investments.

In the wake of the COVID-19 pandemic, another section of the Just Transition Fund was added under the NextGenerationEU package. The Just Transition Fund is therefore split across two funding packages. Romania will receive a total of €1.947 bn in Just Transition funding; €1.112 bn under NextGenerationEU and €834 million under the MFF. Moreover, according to the Commission's own calculations, Romania would, all pillars combined, benefit from over €10.11 bn in investments under the Just Transition Mechanism.

The primary aim of the funding available under the Just Transition Mechanism is to ensure an economically and environmentally sustainable future for workers and regions impacted by the energy transition. However, investments in renewable energy projects can go hand in hand with these goals. Investments in renewable energy can bring new employment opportunities to carbon-intensive areas and can make use of existing skill sets of the workers there. Furthermore, as Romania has traditionally been a net exporter of electricity (despite the reverse trend in 2019), the accelerated transformation and investment in renewable energy production could bring about benefits for the whole region.

Romania's Recovery and Resilience Plan

A first draft version of Romania's Recovery and Resilience Plan (RRP) was published in November 2020. However, the Commission made observations that it does not contain a clear set of policy reforms and it only contains a list of vague projects. Following the national elections and changes in the government, the plan has been revised, and the latest version has not been made public. The first draft RRP contained many proposals that would put Romania on the wrong track for the energy transition.

A major priority under the energy section of the draft RRP is natural gas. The plan proposes to circumvent the limit on the funding of gas under the ERDF/ Cohesion Fund by funding these projects under the RRF. Projects classed as "smart gas grids" are intended to fall under the 37% climate mainstreaming requirement. There is a large focus on the expansion of the gas transport and distribution networks, a coal-to-gas switch and gas-powered district heating networks, aiming to connect 123,000 extra households to the gas grid. The plan exclusively refers to gas as "transition fuel", and notes that the modernisation of gas infrastructure is "a necessity and a priority in achieving a coherent energy transition". Connecting new consumers to the gas grid when other, renewable options exist is not a strategic management of the energy transition and risks prolonging Romania's dependency on fossil fuels.

The RRP gives limited attention to investments in renewable electricity generation other than hydropower, as wind and solar projects are covered under other funding programmes. Some concrete examples are given of renewable energy projects that can avail of the RRF funding; these cover the expansion of the electricity grid (not directly linked to renewables production) and hydropower projects. While the plan also includes a strand on energy efficiency, which will help reduce energy demand, one of the funding streams for energy efficiency includes funding for district heating grids from fossil fuel cogeneration (as well as renewables).

However, as mentioned above, this is only a draft of the plan, and there is an opportunity for the draft to be revised with a focus on truly renewable decarbonisation solutions.

Sources: Ministry for EU Funds (2020), WWF Romania (2020)

3.2 The EU ETS as a revenue recycling scheme

The EU's carbon market, known as the EU ETS, is not traditionally perceived as a policy tool to alleviate the economic disparity across the EU, but rather as the cornerstone climate policy to promote cost-effective decarbonisation across the whole European landscape. However, this scheme shifts significant financial flows, firstly by putting a price on carbon and secondly by creating streams of revenues which are either allocated to funds with specialised purposes (i.e. the Innovation Fund, the Modernisation Fund) or go into Member States' budgets. To fast-track climate investments, Member States can recycle these auction revenues to support further investments in low carbon technologies.

In acknowledgement of the need for cohesion and solidarity, the EU ETS has several built-in funds and options that aim to boost the investment possibility of those Member States with a GDP below the EU average. As Romania has the second lowest GDP in the EU, the following revenue streams will be available to the country during this phase of the EU's carbon market (2021-2030):

- Auctioning revenues from the sale of emission allowances (EUAs) to the power sector and certain industry and aviation actors.

- Under the Solidarity Provision, which allocates additional allowances to countries with a lower-than-average GDP, Romania's share of the EU-wide total of auctioned allowances is increased by 53%, giving Romania 4.77% of all auctioned allowances in the EU, and their associated revenues.

- The Modernisation Fund designates 2% of all auctioned allowances to 10 lower-income Central and Eastern European countries, to create revenue for modernising their energy systems and supporting energy efficiency. Romania will receive 11.98% of the Modernisation Fund allowances, which is currently set to comprise of over 275 million EUAs for the period 2021-2030. Romania chose to increase its number of Modernisation Fund allowances by transferring over 167 million EUAs from the Solidarity Provision and Article 10c derogation into the Modernisation Fund.

- Lower-income countries have the possibility under Article 10c of the EU ETS Directive to allocate some allowances for free to power sector installations (while normally the power sector does not receive free allocation). Romania has chosen to avail of this Article 10c derogation for Phase IV of the EU ETS, but has opted to redistribute most of these allowances to the Modernisation Fund, where they will become a source of revenue.

The total number of auctionable allowances which will be available to Romania over the next 10 years, and the amount of revenue which these will produce, cannot be precisely calculated at this time. Firstly, the EU ETS is currently under review and the total number of allowances available will have to be reduced in order to be brought in line with the EU's new 2030 climate target. The 2030 EU-wide emissions reduction target is yet to be confirmed, with the Commission and the Council calling for net reductions of 55%, while the Parliament supports a 60% real reduction. Beyond this, the share of this target that will be covered by ETS sectors is yet to be determined. There are also other proposed changes to the EU ETS (e.g expansion to other sectors, rebasing) which will also influence the total number of allowances available to Romania for auction.

The amount of revenues that these allowances will earn is also not set in stone. The EU ETS carbon price will likely increase in line with increased climate ambition, but the future EUA price will depend on many factors including the design of the EU ETS and the wider climate policy package of the EU. The Impact Assessment on the EU's 2030 climate targets foresees a variety of potential prices for different scenarios, from €32/tCO_2 to €60/tCO_2.[25] In February 2021, EUA prices were between €32 and €40 per tonne of CO_2.[26]

The table below shows the revenues available to Romania from the auctioning of EUAs between 2021-2030, for a range of potential carbon prices. It assumes an EU-wide real emissions reduction target of 55%, with the EU ETS sectors representing 35% of total emissions in 2030. No additional changes to the ETS parameters (e.g. rebasing of the cap) are considered here. In these scenarios, the 3% buffer that allows for an increase in the amount of allowances allocated for free is utilised. In a scenario where this buffer is not utilised, the number of allowances available for auction would be slightly higher. The three carbon prices shown are those used in the European Commission's Impact Assessment on increased 2030 climate ambition, under three different policy scenarios (REG, MIX and CPRICE).

	Number of allowances	Revenue @ €32t/ CO_2	Revenue @ €44t/ CO_2	Revenue @ €60t/ CO_2
Auction share	149,076,346			
Modernisation Fund	200,766,069			
Total	349,842,415	€11.2 bn	€15.4 bn	€21 bn

ETS Reform and Revenue Generation

Between 2021 and 2030, Romania could generate between €11 and €21 bn through auctioning EUAs under the current division of allowances and revenues. However, this division of revenues could also be up for reform in the coming months. The European Commission has been mandated through an Interinstitutional Agreement to consider how the EU ETS could be used to generate an 'own resource' for the EU, which will be used to service the debt accrued under the NextGenerationEU package. This would potentially decrease the funds available to Member States. On the other hand, another area of major reform under the EU ETS will be free allocation. Providing EUAs for free to heavy industry and aviation essentially acts as a subsidy for polluting activities and deprives the EU and Member States of potential auction revenues. Free allocation could be ended through the introduction of a Carbon Border Adjustment Mechanism, freeing up almost as much revenue as is currently available through auctioning. While the EU ETS is first and foremost a climate policy and should not be prioritised as a revenue generating tool, there are reform options that can, through the application of the polluter pays principle, make more resources available for the societal energy transition.

[25] European Commission (2020). Impact Assessment on Stepping up Europe's 2030 Climate Ambition. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SC0176
[26] Sandbag (2021). Carbon Price Viewer. https://sandbag.be/index.php/carbon-price-viewer/

If climate mainstreaming requirements are fully respected and EU ETS revenues are recycled towards the energy transition, Romania will be able to avail of at least €32 bn in revenues for climate and Just Transition purposes over the next decade (even presuming a relatively low carbon price). While this figure will need to cover many different climate objectives, the decarbonisation of the energy sector is a prime candidate for strategic investments which will bear fruits in terms of the reduction of greenhouse gases and improving access to affordable, clean energy. However, in order to create a comprehensive financial envelope to support a strategic national investment plan over a period of 7-10 years, careful planning is required to determine how to best combine the different revenue streams to obtain optimal investment and avoid stranded assets. Failure to do so will not only prolong dependence on fossil fuels and pose obstacles to compliance with the EU's climate target, but also would put Romania on a backward footing in terms of securing the employment opportunities that are to come with the renewable transition.

The following two chapters will look into two renewable energy options, geothermal and bioenergy, to provide an overview of the potential and pitfalls of these two energy sources. Between 2014 and 2020, the Ministry of European Funds has a specific budget allocation covering biomass, biogas and geothermal energy (Large Infrastructure Operational Programme - Specific Objective 6.1 Increasing energy production from less exploited renewable resources). Bioenergy and geothermal are considered less exploited resources as their documented use makes up a very small share of Romania's energy mix. In 2019, 0.5 TWh of electricity production came from bioenergy (out of a total of almost 60 TWh) while of the total 61.4 PJ of heat energy sold, 3 PJ came from bioenergy and only 0.2 PJ from geothermal sources.[27] As a result of this low production, there is limited knowledge and experience of these energy sources. The next chapters aim to address these knowledge gaps and offer recommendations to ensure effective and strategic planning around these resources.

[27] European Commission (2020) Energy statistical country datasheets. https://ec.europa.eu/energy/data-analysis/energy-statistical-pocketbook_en

4. Geothermal energy

Geothermal energy refers to the heat inside the Earth, and it can be accessed over the Earth's entire surface. However, the form in which it can be exploited may differ from one location to another, and is also dependent on technological development in the field. Different types of geothermal resources and suitable exploitation methods are:

- Active geothermal regions: areas where geothermal sources, namely hot water, reach the surface.
- Hydro-thermal: geothermal sources found in permeable or fissured rock formations, which form natural hot aquifers at great depths.
- Hot dry rocks: geological formations that have a high temperature, and which are impermeable.
- Magma power: magma body heat source, close to the surface.

4.1 Uses of geothermal energy

Geothermal energy can be used to generate heat or electricity. However, the production of electricity from geothermal resources requires high temperatures, which cannot be easily accessed everywhere. Thus, there is a greater global potential for the geothermal resources to be used for heating purposes, where the required temperatures are lower, especially in the residential sector, agriculture and industry. However, geothermal resources can have multiple applications depending on the available temperature. The Líndal diagram below helps identify possible uses, and if practicable, its use in cascade.[28] The cascading use of geothermal energy means that the geothermal water used for the primary user is then used as an energy source for other, secondary users. In this way, its heat potential is maximised, reducing energy waste.

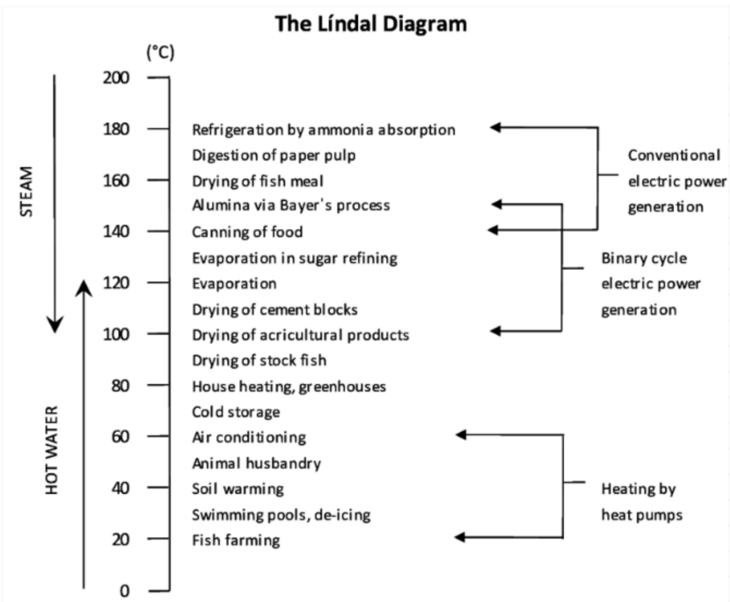


Figure 6 – Líndal Diagram

[28] J. S. Gudmundsson, D. H. Freeston, and P. J. Lienau (1985) The Lindal Diagram. GRC Transactions 9, 15–19 (1985).

Two principle uses of geothermal energy for heating are district heating and heat pumps. In district heating systems, two wells are drilled. Geothermal water is extracted from one well and directed into a geothermal heat exchanger before being reinjected into the second well (this re-injection ensures that the geothermal reservoir is adequately replenished). In the heat exchanger, the heat from the geothermal water is transferred to a clean water stream, which is then piped to individual buildings, where heat exchangers distribute hot water to taps and radiators throughout the building. Geothermal district heating systems can be built from scratch, but existing fossil fuel district heating systems can also be retrofitted for geothermal heat.[29]

Shallow geothermal resources can be used to provide heating and cooling through heat pumps, in a range of buildings from individual houses to large complexes. In these installations, geothermal heat is extracted either from ground water or a series of underground heat exchangers, and fed into the heat pump where it is converted to a suitable temperature before being fed into the building's heating system.[30]

The two forms of geothermal heating can also be used together, with heat pumps providing an extra boost to district heating systems relying on lower-temperature geothermal reservoirs.

4.2 Assessing geothermal energy potential

Status of geothermal energy

The IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (2011) estimates that geothermal sources are the renewable resource with the second highest technical potential for the production of electricity and heat, after direct solar. In 2019, the global installed capacity of geothermal power plants was 15.4 GW, which generated approximately 92 TWh, contributing both to electricity generation and to heating and cooling. The leading country was the USA, while in Europe, Turkey, Italy and Iceland were the countries with the highest use of geothermal resources. In 2019, Europe had 5.5GWh of geothermal heating and cooling capacity, alongside geothermal electricity production capacity of 3.3GW.

Sources: IPCC (2011), IEA (2020), IRENA (2017), EGEC (2019)

Geothermal energy potential is very dependent on local geologies, and therefore needs to be assessed on the basis of individual countries or regions. To identify geothermal resources, exploratory drilling projects are needed to establish what geothermal resources are available, at what temperature, and at what depths.

[29] GEODH (2021). What is Geothermal District Heating? http://geodh.eu/about-geothermal-district-heating/
[30] Regeocities (2019) Factsheets on geothermal heat pumps: The Technology. https://www.egec.org/wp-content/uploads/2019/10/Factsheet-The-technology-print.pdf

Deep drilling projects

Worldwide, multiple deep drilling research projects have been carried out over the years. The most important ones are the Moho Project, Mexico (1962-1966), the Salton Sea Deep Drilling Program, USA (1984-1988), and the Kola Superdeep Borehole, Russia (1970 – 1992). The latter saw the deepest drilling carried out, reaching up to 12 km, where the geothermal gradient close to the surface was 1 °C/100 m, and 2.5 °C/100m at 3000 m depth. The measured temperature at the maximum depth was 205 °C, due to which drilling stopped in the year 1992, highlighting the technological limitations in this field. The Iceland Deep Drilling Project, ongoing since 2003, has reached depths of 5000m. The most recent deep drilling project, the DESCRAMBLE project in Italy, has test sites that have already reached a depth of 2.9km, with temperatures of over 350 °C.

Sources: Rezaie (2012), Iceland Deep Drilling Project (2021), DESCRAMBLE (2021)

Within the literature assessing geothermal potential in Romania, it is often only the potential of already known resources which are estimated.[31] To adequately assess the geothermal potential, all known hydro-geothermal reserves must be examined (not merely existing geothermal wells currently being exploited). With geothermal energy, the technical potential can come quite close to the theoretical potential, depending on the local conditions and available technologies. With the existence of adequate public policies, the final achievable potential can equal the technical potential.

4.3 Advantages and disadvantages of geothermal energy

Low greenhouse gas footprint

A major advantage of geothermal energy is its low greenhouse gas footprint. The IPCC specifies an emission factor for geothermal energy of 0 tCO_2/MWh in direct emissions and 0.060 to 0.062 tCO_2/MWh in life-cycle emissions, which is far below fossil fuels and even below other renewable sources.[32] Lifecycle emissions for geothermal district heating systems are particularly low and mostly stem from the transport of construction materials.[33]

[31] Schellschmidt, R., Hurter, S., Förster, A., and Huenges, E. (2002). Atlas of geothermal resources in Europe. Office for Official Publications of the European Communities, Brussels, Belgium. https://op.europa.eu/en/publication-detail/-/publication/9003d463-03ed-4b0e-87e8-61325a2d4456

[32] IPCC (2011) Special report on renewable energy sources and climate change mitigation. Renew. Energy 20 (2011).

[33] Geoenvi (2021). Compilation of Recommendations on Environmental Regulations. https://www.geoenvi.eu/resources/

High capital costs

Geothermal heating systems usually have high implementation costs and low operation costs. The costs of implementing geothermal projects for the supply of thermal energy in Romania are between €2 and 2.5 million per MW, depending on the available resources and the chosen technology. Between 40-60% of the implementation cost comes from the source of the geothermal energy, while the remainder comes from the transport and distribution of the energy. Drilling makes up a large part of a project's budget (deep drilling costs can be estimated between €750 – 1500 per metre). In the case of new projects for the use of geothermal resources, the cost of additional wells must be considered, as well as the cost of drilling a reinjection well for replenishing of the geothermal reserves. Because of this large capital cost, geothermal projects may not be economically feasible at a low installed capacity for a low number of final consumers. On the other hand, geothermal systems can have large economic benefits for high-density populated urban or industrial areas (although this depends heavily on the specificities of individual projects).[34] Additionally, geothermal heat pumps which use shallower geothermal resources can be competitive even in less densely populated areas.[35] The use of geothermal energy in a cascade can deliver important cost savings as well as gains in energy efficiency.

As well as these high investment costs, many geothermal projects gave very low internal rates of return and very long recovery periods for the initial capital costs. As most geothermal projects in Romania can only provide thermal energy, which must be provided at a price tenable for the general population, its sale cannot quickly recover the costs of deep drilling. As a result, most new projects depend on grants or other non-reimbursable financing sources. The majority of investments in geothermal energy have historically come from public funds, except for the period 1999-2004 when private investments made up 56% of geothermal funding. Figure 7 shows the centralisation of geothermal investments in Romania.

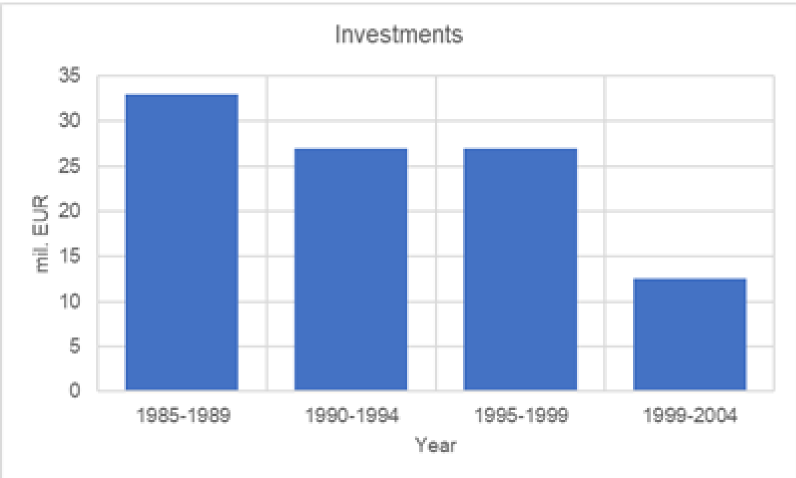


Figure 7 – Total investments in geothermal energy in Romania

[34] Rezaie, Behnaz, and Marc A. Rosen. "District heating and cooling: Review of technology and potential enhancements." Applied energy 93 (2012): 2-10.
[35] Exchange with EGEC, 12 March 2021.

Lower long-term and operational costs

However, costs of geothermal energy, while particularly high in developing markets, decrease rapidly in more mature markets.[36] As different countries have different geologies, projects are not directly transferable from one region to another, meaning that the first movers in a country have a quite high risk profile, as a large part of their efforts will consist of exploration. When the geothermal sector is more established in an area, with greater knowledge of the geology, costs decrease significantly. For example, in the Paris region (France) where half a million people are served by geothermal district heating, energy costs are between €15 and €50 per MWh – even the upper range being cheaper than the natural gas alternative.[37]

And while initial costs can be substantial, geothermal energy also has very low operational costs. This is particularly relevant for tackling energy poverty, as the fluctuating fuel prices which influence fossil fuel heating systems no longer apply. Geothermal energy is also important for the Just Transition, as a lot of the skills required in the sector are the same as those required in the gas industry. Professional reconversion is very possible, and jobs in the geothermal sector tend to be more localised than those in the fossil fuel sectors.[38]

Environmental impacts

Although it has been shown that geothermal energy sources can have low greenhouse gas emissions, activities related to the exploitation of geothermal resources can have high environmental impacts. The initial deep drilling is the stage at which most environmental impacts can occur. The soil can be polluted by the chemical liquids used during the drilling, which can then migrate through porous formations or cracks. During the operation, if there are deficiencies in the construction of the wells, geothermal water, which can be contaminated with various substances and associated gases, can pollute the groundwater sources. A similar situation can happen if the geothermal water is reinjected through another well in the deep reservoirs. Even when the wastewater is treated, reinjecting warm water can impact the surface temperature and lead to algae formation, a source of methane emissions. Geothermal projects in the EU are covered under the Water Framework Directive and in theory contamination of water supplies can be avoided. However, this is dependent on no malpractice occurring, and technical prescriptions vary from country to country.[39]

Small earthquakes are another concern of geothermal drilling, and they are felt mostly during operation, caused by extracting or reinjecting liquids or gases, which can cause instability along fault or fracture lines.[40] Such seismic activity is rare and only occurs for certain forms of

[36] Georisk Project (2021). https://www.georisk-project.eu/about-us/
[37] GEODH (2021). What is Geothermal District Heating? http://geodh.eu/about-geothermal-district-heating/
[38] Exchange with EGEC, 11 March 2021.
[39] Geoenvi (2021). Compilation of Recommendations on Environmental Regulations. https://www.geoenvi.eu/resources/
[40] Harmon, Katherine (2009) How Does Geothermal Drilling Trigger Earthquakes. Scientific American, June 29 (2009).

geothermal exploitation; for district heating purposes, the risk of earthquakes is extremely marginal.[41]

Romanian hydro-geothermal resources are known to contain associated gases (waste gases), mostly high concentrations of methane. The volume of gases associated with geothermal water can reach in some situations 1-2.0 Nm3/m3 of water, with a methane concentration of 90%, comparable to natural gas.[42] Accidental leakage of these methane deposits can occur, which from existing wells could generate a maximum estimate of 0.9 Mt CO_2 equivalent emissions each year if left unchecked. However, changes to environmental legislation now require new wells to be equipped with liquid and gas separators to capture waste gases. Projects today tend to be closed loop projects, where waste gases are never released and reinjected directly back into the reservoir, avoiding this methane leakage.

Like any form of energy production, geothermal energy is not without its negative environmental impacts, and measures must be taken to ensure that these are monitored and minimised, through effective legislation and accountability mechanisms.

4.4 Geothermal energy in Romania today

Policy framework for geothermal energy

Romanian renewable energy legislation is harmonised with EU law, where geothermal energy is classed as a renewable energy source under RED II (Renewable Energy Directive). In Romania's national renewable energy support scheme, geothermal energy is mentioned and supported, but only for electricity production or the production of electricity and heat in cogeneration. This is in line with the fact that public policies in Romania in support of the transition to renewable energy have focused mostly on the production of electricity, and less on the production of thermal energy, although the latter makes up a significant share of national energy consumption. Considering that Romania's geothermal sources are mostly only suitable to produce thermal energy, the support scheme is not useful for the development of projects using this energy source. As a result, geothermal investments have remained low for the past 20-30 years, with other thermal energy sources such as natural gas receiving the bulk of state support.

In Romania, mineral resources (including geothermal resources) are owned by the State. Covered under the mining law, geothermal resources must go through well-established stages of research, exploration and experimental exploitation, before the final exploitation can take place. Poor coordination between local and national authorities often leads to administrative delays. As a result, it can take 3-5 years to reach the final licencing stage. The long duration of this licencing process may delay the implementation of geothermal projects which could be beneficial in terms of greenhouse gas emission reductions. As a result, while there are quite a few projects in the early planning stages, very few have reached

[41] Geoenvi (2021). Compilation of Recommendations on Environmental Regulations. https://www.geoenvi.eu/resources/

[42] Rosca, Marcel G., Kostas Karytsas, and Dimitrios Mendrinos (2010). Low enthalpy geothermal power generation in Romania. Proceedings World Geothermal Congress 2010.

implementation (see Figure 8).[43] Taxation costs for geothermal exploitation are also high, similarly to those for fossil fuel exploitation, but measures have begun to reduce this tax burden.

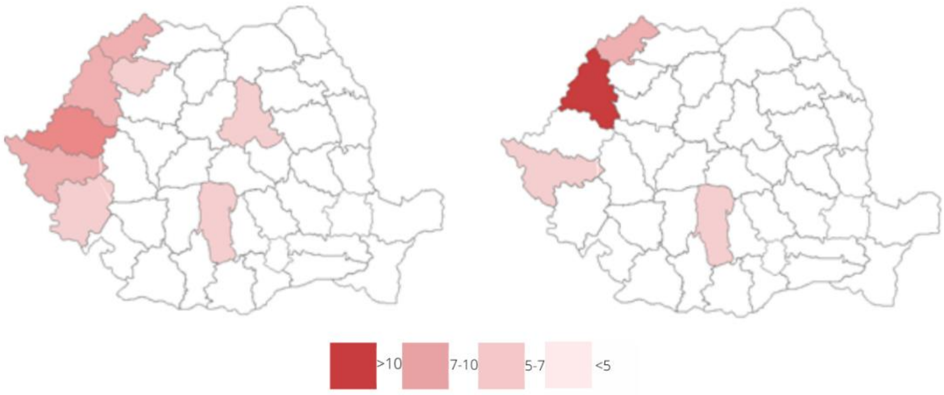


Figure 8 – The number of geothermal projects in Romania by licensing stage (right – exploration licences, left – exploitation licences)

Existing geothermal exploitation

Research into thermal aquifers in Romania began around 50 years ago, initially as a secondary objective of hydrocarbon exploration, then through drilling for hydrogeological research. More than 100 geothermal wells were put into production and experimental operation, which allowed the evaluation of the exploitable resources and heat reserves of the hydro-thermal systems in Romania. To date, significant geothermal resources, in the form of hydro-thermal reservoirs, have been identified in sedimentary basins located mainly in the southwest of the country. More than 250 wells with depths of between 800 and 3,500 m can be found, of which over 100 are currently exploited. The most used are those in the northwest of the country, with applications in space heating, agriculture, industry, and bathing. The estimated total installed capacity of the existing geothermal wells is 450 MW, of which only a total of 145 MW is currently used, with an energy utilization of 2900 TJ/year. Of the total energy used, approximately 30% is for bathing and recreation, and 70% for energy purposes.[44]

Case study: Beius

The city of Beius is one of the only cities in Romania to be fully heated by geothermal district heating systems. It is located in the western part of the country, where the geothermal water reserves are found at a depth of about 2500 m with a temperature of over 80 °C. Access to the geothermal reserves is made through two deep drillings, and one drill is used for the reinjection of the thermally used water back into the underground reservoir. The system provides thermal energy both for the general population and for public buildings. In 2019, geothermal sources supplied 22477 MWh of energy, displacing 4540 tonnes of CO_2 equivalent compared to the natural gas alternative. *Sources: National Institute of Statistics*

[43] Agentia Nationala pentru Resurse Minerale, Romania.
[44] Antal, Cornel, and Marcel Rosca. (2008) Current status of geothermal development in Romania. Proceedings of the 30th Anniversary Workshop, UN University, Reykjavık. 2008.

Geothermal energy is mostly exploited in Romania through hydro-geothermal reserves, mostly low-temperature water reservoirs. The geothermal resources in Romania are characterised as low enthalpy. Low enthalpy deposits have temperatures lower than 150 °C, while the high enthalpy deposits reach temperatures higher than 150 °C.[45] The highest identified potential is in the western part of the country, where maximum wellhead temperatures of known reservoirs reach 125 – 130 °C.[46] In Figure 9, a distribution of geothermal water reserves according to temperature can be seen, and Figure 10 shows a distribution of geothermal water reserves used for energy purposes.[47] Thus, most of the known resources have temperatures between 20-29 °C, and the ones used for energy purposes have temperatures of over 70 °C.

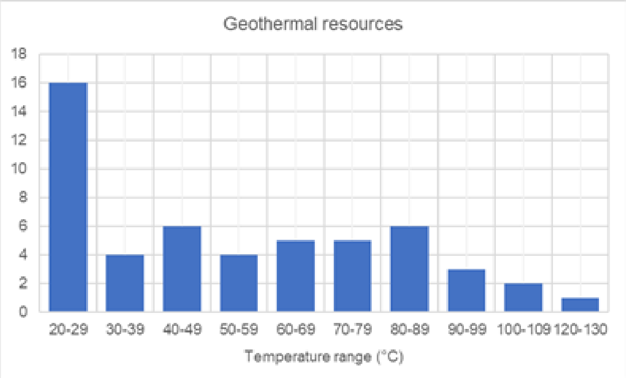


Figure 9 – Known geothermal resources

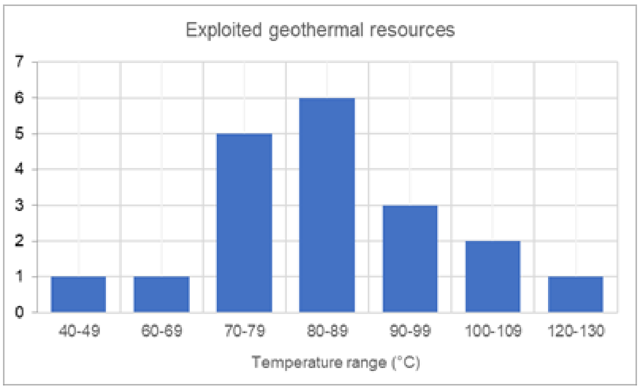


Figure 10 – exploited geothermal resources

Future potential of geothermal energy resources

As Romania's currently known geothermal resources are not used to their full potential (of the 450MW total installed capacity, only 145 MW are currently used)[48], the possibility to increase the geothermal technical potential is promising. The potential can be increased with the development of new drill-holes for the use of existing reservoirs, or by identifying new hydro-geothermal resources. With the former, great care must be taken not to over-exploit reserves, so that the water balance is maintained and resources do not reach exhaustion. For this reason, when new drilling projects are undertaken, geothermal wastewater reinjection wells must also be considered.

[45] I. M. Mihaela-Ana Roman (2009). Tratarea si utilizarea apelor geotermale.

[46] Schellschmidt, R., Hurter, S., Förster, A., and Huenges, E. (2002). Atlas of geothermal resources in Europe. Office for Official Publications of the European Communities, Brussels, Belgium. https://op.europa.eu/en/publication-detail/-/publication/9003d463-03ed-4b0e-87e8-61325a2d4456

[47] Schellschmidt, R., Hurter, S., Förster, A., and Huenges, E. (2002). Atlas of geothermal resources in Europe. Office for Official Publications of the European Communities, Brussels, Belgium. https://op.europa.eu/en/publication-detail/-/publication/9003d463-03ed-4b0e-87e8-61325a2d4456

[48] Antal, Cornel, and Marcel Rosca. (2008) Current status of geothermal development in Romania. Proceedings of the 30th Anniversary Workshop, UN University, Reykjavık. 2008.

On top of known but unused geothermal resources, the total theoretical potential is much broader. Even though hundreds of wells have been drilled in the last 50 years to research subsoil resources, some areas of the country have not been covered. Moreover, some of the drilling projects aimed to identify hydrocarbon resources and ignored the existence of geothermal ones. In multiple instances, geothermal resources were found during oil exploration drilling, but the boreholes were abandoned or closed. The existence of geothermal reserves in such situations is now only assumed and cannot be proven. Considering that now there are much more advanced technologies for identifying subsoil resources, more attention must be paid to this research.

Geothermal energy and district heating systems

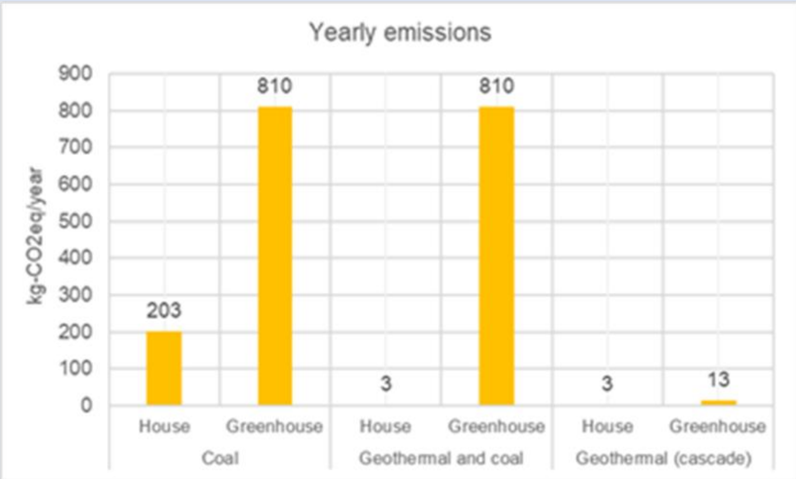
Romania’s declining, inefficient district heating systems may yet provide a solution to the country’s heating needs without perpetuating the expansion of the natural gas grid. The possibility of modernising and refurbishing these district heating systems has only recently entered into discussion, but there is significant potential to combine centralised systems with geothermal energy, alongside significant energy efficiency adaptations. The systems are suited to the use of multiple energy sources, and the energy source can easily be changed as the situation requires.

If appropriately set up, geothermal energy in district heating systems can generate less expensive heat compared to traditional fossil fuel systems. District heating systems with low heat losses, and which have the possibility for the consumer to monitor and control the amount of heat used, in combination with a primary geothermal energy source, can not only be a more economically feasible solution for the consumer, but also a less polluting way of meeting energy needs. Primary geothermal energy sources are much more reliable in terms of availability and long-term supply costs, and can improve energy independence compared to fossil sources.

Heat losses in the distribution networks are very important in the context of the feasibility of centralised heating projects. If these heat losses are not addressed, they lead to an increase in the use of primary energy sources. However, where energy efficiency measures are undertaken to reduce and even eliminate heat losses, it can lead to lower energy and resource consumption of the entire system. Cascading use of geothermal energy can also contribute to more efficient energy use.

Cascading use of geothermal energy

An example of cascading use of geothermal energy is the use of geothermal water first for the heating of residential spaces, then for heating greenhouses in winter. In Romania, the total area of greenhouses is approximately 206 hectares, with a total land need of about 2000 hectares. These greenhouses currently source their heat from biomass, coal, electricity and natural gas, and are therefore a source of greenhouse gas emissions. When this fossil fuel use is replaced by geothermal energy used in a cascade, from domestic users to the greenhouse, associated greenhouse gas emissions can be considerably reduced (see Figure 11).



Sources: Ziarul Financiar (2020)

Geothermal resources can also be used in hybrid systems. Depending on the temperature of the geothermal water, they may need to be combined with heat pumps to provide adequate thermal energy to a centralised system. The use of geothermal sources together with biomass and solar sources is also of great importance and an increase of such systems is expected in the future.[49] Another hybrid use of geothermal energy is for underground thermal energy storage, which can be used to store solar thermal energy for seasonal storage, or store excess renewable electricity to provide balancing services to the grid.

[49] Dumas, P., et al. (2013) Developing geothermal district heating in Europe. Brussels: GeoDH (2013).

5. Bioenergy in Romania

Bioenergy is an energy carrier sourced from the biodegradable fraction of products, waste and residues of biological origin in agriculture, forestry and related industries, including fisheries and aquaculture, and the biodegradable fraction of industrial and municipal waste.[50] Bioenergy can be generated from solid biomass, biogas, and biofuels, used to produce electricity, heat, or liquid fuels. Historically, biomass was Europe's main source of energy until the early 20th Century, and it is still a major energy source in Romania today. About 48% of the population heat their homes by burning raw wood – while this is a form of bioenergy, it is unsustainable and poses many problems for the environment and human health.

There are several processes for the conversion of biomass into secondary energy:

- Thermal conversion can be defined as the process of using heat, with or without the presence of oxygen, to convert primary biomass energy into useful energy.
- Biochemical conversion is the use of bacteria and microorganisms for the decomposition of organic matter and the formation of energy carriers in gaseous and liquid form.
- Chemical conversion is the conversion of biomass primary energy into useful energy, mainly liquid fuels, using chemical agents.

5.1 Sources of bioenergy

The main sources of biomass and biogas are shown in the table below:[51]

Forestry residues	Forestry residues are defined as the biodegradable fraction of products resulting from the primary and secondary processing of wood: bark, sawdust, chips from processing, heads, shredding from profiling lines, wood scrap resulting from the processing or recycling of wood and/or wood products, as well as wood material declassified on site. Potentially harvested forest residues include both the amount of wood abandoned at the cutting site, about 40% of the total harvested wood, and the residues resulting from wood processing, about 15% of the total harvested wood. 55% of harvested wood can thus be considered as residues. However, because some of the residues must be left in place for soil conditioning, nutrient recycling, etc., only a total of 25% of the "potentially harvestable residues" are considered "recoverable residues".

[50] Directive 2009/28/EC of the European Parliament and of the Council. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009L0028-20151005

[51] Some sources of biomass, such as oilseeds, or algae are not assessed in detail in this report because they are primarily suitable to producing biofuels for transportation.

Agricultural crops and residues	Agricultural (energy) crops and residues represent the biodegradable fraction obtained from energy crops intended to produce biomass, and waste from agriculture, horticulture, aquaculture, fisheries and food preparation and processing.
Animal residues	Animal residues mainly refer to manure of animal origin. Most biogas plants worldwide use fermenting liquid manure, quite often combined with co-substrates to increase their efficiency.
Organic waste	Solid and liquid organic waste is waste generated by households. Waste from shops or from trade can also be considered as organic waste due to its similar composition. Solid and liquid organic waste represents about 30 - 45% of the total waste generated in households, which is about 50 - 100 kg/year for each EU inhabitant. Of this only about 50% is organic material suitable for use for biomass/ biogas production.

Technologies

Forest residues are suitable for use mainly in thermal conversion systems, such as combustion, pyrolysis, gasification, etc. Agricultural crops, plant residues, animal residues and organic waste are mainly suitable for use in anaerobic digestion systems, to produce biogas or for conversion to biomethane.

Bioenergy can be harnessed in both centralised and decentralised ways. Solid biomass can be burned in power plants, heat plants or Combined Heat and Power (CHP) plants, as well as in individual stoves using wood chips or pellets. Biogas with a methane content of more than 45% is flammable and suitable for use for energy purposes, and can produce heat and/or electricity in small, individual boilers or in CHP plants. Both biomass and biogas can be used in conjunction with district heating. Biogas can be upgraded to biomethane, which can be used in the same ways as natural gas and can be injected into the gas grid.

Bioenergy in Europe

In 2006, the European Environment Agency (EEA) estimated a primary energy requirement in the European Union of 1.8 btoe in 2020, of which 13%, or 230 - 250 mtoe, would be supplied from biomass. This represented a significant increase compared to 2003, when only 69 mtoe of primary energy consumption was represented by biomass. The achievable potential at the level of the European Union in 2020 was estimated at 235 mtoe, with countries such as Poland, Germany and France having the highest shares. In 2016, the primary energy consumption of biomass reached the threshold of 140 mtoe, with Germany, France and Italy having the highest share of gross inland biomass consumption.

Sources: EEA (2006), Scarlat (2019)

5.2 Evaluating bioenergy potential

At the level of theoretical potential, the potential of bioenergy is dependent on the available land area. This can be assessed in terms of land-use efficiency, i.e. the level of energy service that can be provided from an area of land.

The technical potential of bioenergy can fluctuate considerably depending on the level of technological development. Biomass usually requires preparation and pre-treatment before use, such as lowering the moisture content, bringing materials to a recommended shape and size, removing foreign substances, etc. All of these processes consume energy and resources which can lower the overall efficiency and therefore feasibility of bioenergy production.

Achievable potential of bioenergy is largely dependent on sustainability and biodiversity factors. In many circumstances, biomass cultivation and consumption can be damaging for biodiversity, food security and air quality. In the EU, for biomass to be considered a renewable energy source it must fulfil the requirements of Renewable Energy Directive 2018/2001/EU, which defines a series of sustainability criteria.[52] These criteria, necessary for ensuring that the overall environmental impact of biomass is a positive one, have the effect of significantly reducing the achievable potential of biomass compared to its theoretical and technical potential.

5.3 Advantages and disadvantages of bioenergy

Greenhouse gas impact

Bioenergy is often considered neutral in terms of CO_2 emissions. This is because plants absorb carbon dioxide during growth. At the time of conversion to secondary energy, an amount of CO_2 approximately equal to that which was absorbed is released back into the atmosphere. However, renewable energy sources also generate greenhouse gas emissions as a result of energy conversion processes, when the complete life cycle is taken into account.[53] According to the IPCC, the emission factor for biomass energy can vary between 0.013 tCO_2eq/MWh and 0.416 tCO_2eq/MWh, below fossil fuels. The emission factor depends firstly on the type of biomass used, wood or wood residues, and on the fulfilment of sustainability criteria.[54] Figure 12 shows a comparison of greenhouse gas emissions, considering the complete life cycle and the fulfilment of biomass sustainability criteria, for most common energy production sources (expressed in tonnes CO_2 equivalent i.e. considering all greenhouse gases).

[52] Directive 2009/28/EC of the European Parliament and of the Council. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009L0028-20151005

[53] Larson, Eric D. (2008) Biofuel production technologies: status, prospects and implications for trade and development. New York and Geneva.

[54] IPCC (2011) Special report on renewable energy sources and climate change mitigation. Renew. Energy 20 (2011).

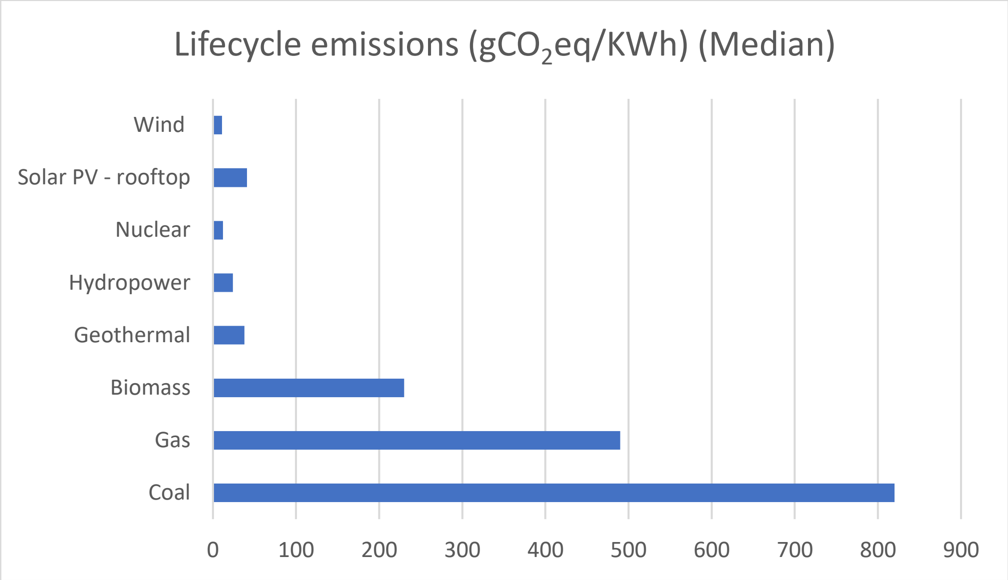


Figure 12 – Life-cycle greenhouse gas emission factors (IPCC 2014)

Reported emissions from bioenergy also depend on the methodologies used, which have posed problems for measuring emissions in Central and Eastern European countries. Discrepancies in reporting mean that it is difficult to get a clear view on greenhouse gas and particulate matter emissions from bioenergy. Romania has yet to submit the National Air Pollution Control Programme required by EU legislation.[55]

Environmental impacts

Environmental impacts are a major factor affecting the feasibility of bioenergy use, particularly the use of solid biomass. As renewable energy support schemes have often led to an increased biomass use with multiple negative effects, biomass has come under increased scrutiny at EU level. Overzealous support for biomass production raises concerns about deforestation and poor forest management. Another important aspect to consider is that land use can have direct and indirect environmental impacts such as biodiversity and ecosystem losses.

Depending on the source of biomass and the technologies used, the burning of biomass results in air pollutants such as sulphur dioxide (SO2), nitrogen oxides (NOx), particulate matters (PM - dust particles with very small diameters), and volatile organic compounds (VOCs). Since 2015, PM and VOCs increased on the territory of the European Union as a result of the increased use of biomass.[56]

The environmental impacts of bioenergy need to be evaluated on a source-by-source basis to determine whether their use can have a net positive impact on emissions and the

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[55] Boglarka, Vajda & Tihamer, Sebestyen (2020) National and European Framework Conditions, Part 7: National Framework Conditions – Romania as part of AgroBioHeat project, Promoting the penetration of agrobiomass in European Rural Areas.

[56] European Environment Agency (2019) Renewable energy in Europe: key for climate objectives, but air pollution needs attention. https://www.eea.europa.eu/publications/renewable-energy-in-europe-key

environment. In general, Europe will have limited use of sustainable bioenergy by 2050 compared to today, principally for industrial needs rather than for energy production.[57] However, in the case of Romania, up to 48% of the population currently get their heating from the burning of raw wood, which is an unsustainable form of biomass with the highest air pollution impact. Carefully managed and targeted use of sustainable bioenergy, with the latest technology standards, could reduce this dependency on illicit wood burning, particularly in rural areas, without relying on a switch to natural gas use.

Competitiveness and availability

Whether biomass or biogas is a preferable use of bioenergy will often depend on location. Solid biomass can potentially be used everywhere, as even most urban areas will have access to pellets and wood chips. However, particulate matter pollution means that biomass is better in rural environments.[58] Heat from solid biomass is cost competitive at current market conditions, unlike biogas and other forms of renewable heat generation.[59]

Biogas from anaerobic digestion and syngas from gasification can be used locally to the source, which is usually in rural areas where a large heat demand is not always present. For this reason, local biogas installations are often highly subsidised. To provide energy to more distant users, both gases can be upgraded to biomethane, which can be injected into the existing gas grid. However, there are large costs associated with adapting the existing grid to allow feed-in from decentralised biomethane production.[60] Biogas production also faces strong competition from the lower price of natural gas.[61]

5.4 Bioenergy in Romania today

Policy framework

Biomass is considered a renewable energy source under RED II. In the Romanian legislation, biomass is supported as a renewable energy source, by allocating green certificates for the electricity produced. Despite the multiple changes in legislation, the number of green certificates allocated to bioenergy projects have been constantly maintained (unlike for other renewable sources). Bioenergy crops are supported for electricity generation and cogeneration, but use of biomass for only thermal energy is not supported by the renewable

[57] PAC Scenario (2020). Scenario Development. https://www.pac-scenarios.eu/scenario-development.html
[58] Exchange with Bioenergy Europe, 12 March 2021.
[59] European Commission (2019) Competitiveness of the heating and cooling industry and services: Part 1 of the Study on the competitiveness of the renewable energy sector. https://op.europa.eu/en/publication-detail/-/publication/b23af898-c48e-11e9-9d01-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search
[60] Exchange with Bioenergy Europe, 12 March 2021.
[61] European Commission (2019) Competitiveness of the heating and cooling industry and services: Part 1 of the Study on the competitiveness of the renewable energy sector. https://op.europa.eu/en/publication-detail/-/publication/b23af898-c48e-11e9-9d01-01aa75ed71a1/language-en?WT.mc_id=Searchresult&WT.ria_c=37085&WT.ria_f=3608&WT.ria_ev=search

energy support scheme. The legislation also lays down environmental requirements for the source of bioenergy. In the case of forestry, only residues are accepted as biomass sources.

Romanian legislation on energy efficiency in buildings now requires that all new buildings must receive 30% of their primary energy consumption from local energy sources, an amount that becomes difficult to achieve if the house is connected to the gas grid. If this law is properly implemented (while the framework exists, specific implementation rules are yet to be published), renewable heating solutions will become substantially more attractive.[62] Particularly for rural areas, biomass or biogas could serve as a local energy source.

Current uses of bioenergy

The majority of bioenergy use in Romania today is unmonitored, as almost half of the population heats their homes through burning raw wood. This can be sourced through illegal logging or the re-use of waste wood, which may be tainted with chemicals. This informal biomass use, and the significant air pollution it generates, is difficult to monitor and therefore to regulate.

On top of this large informal use of bioenergy, there is a small amount of energy production from biomass and biogas. According to the National Energy Regulatory Agency, 13 biomass electricity generation units are currently authorised in Romania, with a total installed capacity of 104 MW, and 19 biogas energy production units, with a total installed capacity of 19 MW.[63] The state of development of bioenergy is very low compared to the potential of this renewable source.

Currently, the production of bioenergy from municipal waste is limited in Romania. Waste separation schemes have only recently been developed and proper waste treatment is not yet in place.[64]

Biomass and biogas potential

Forestry is the main source of biomass for energy in the European Union. According to the National Forest Inventory, 29% of Romania's surface is forested.[65] "Forested area" contains not only the area covered with trees, but also the area intended for afforestation, including land which is temporarily empty as a result of land clearing, illegal logging, natural disasters, etc. In Romania, illegal logging activities have become significant in recent years.

The main group of trees found in Romania are hardwood trees, making up approximately 74% of the forest stock, followed by softwood with 24%. The energy content of forestry residues depends on the species and the amount of moisture present. The Romanian Ministry of Environment assigns the following values to the main species found nationally:[66]

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[62] Exchange with Romanian Renewable Energy Producers' Association, 11 March 2021.
[63] ANRE, Autoritatea Nationala de Reglementare in domeniul Energiei.
[64] Interview with Romanian Renewable Energy Producers' Association, 11 March 2021.
[65] Ministerul Mediului Romania, Informatii rezultate din primul ciclu (2008 - 2012) al inventarului forestier national
[66] Ministerul Mediului Romania (2012) Procedura de emitere a certificatelor de origine pentru biomasa provenită din silvicultură și industriile conexe.

Forest species	Moisture [%]	Calorific Value [MJ/kg]
Softwood	0	16.9 – 21.2
	15	14.8 – 16.9
	30	13.4 – 15.3
Hardwood	0	17.1 – 19.4
	15	13.3 – 15.4
	30	12.5 – 13.6

This forest cover is not evenly distributed, but varies according to region. The Western area has the greatest potential with over 53% of the country's forests, a total of 3.6 million hectares, followed by the Southern area with 26%, (1.8 million hectares), and the Eastern area, with a total of 1.4 million hectares.[67]

Figure 13 – Romania Forest Map [67]

According to Romanian legislation, a quantity of 3 cubic meters/ha/year can be legally harvested from the forest stock. Considering that wood can have multiple uses, ideally only residues should be used for energy purposes. Therefore, potentially harvestable residues from the primary forest biomass include on-site forestry residues (40% of the total cut wood),

[67] Ministerul Mediului Romania, Informatii rezultate din primul ciclul (2008 - 2012) al inventarului forestier national

and secondary forest residues, (waste generated during processing at timber mills, which represents 50% of the processed wood). The result is that only 30% of the total amount of harvested wood is transformed into wood products, while the remaining 70% are residues. However, because some of the residues must be left for soil conditioning, only 25% of the potentially harvestable residues will be considered recoverable, representing 17.5% of the total harvested wood. Out of the total 3m3/ha/year that can legally be harvested, up to 0.5m3/ha/year can be recoverable residues.[68]

Another component that must be considered in evaluating the energy potential is the bulk density, which also depends on the humidity of the wood. Thus, we will consider a bulk density of 750 kg for each m3 of wood, at a moisture of 20%.

Not only does Romania have a significant percentage of forest cover, but it also has a large agricultural area. The agricultural area is the totality of productive lands used for agricultural purposes. These include arable land, permanent meadows, and permanent crops. The non-agricultural surface represents the non-productive lands or productive lands which are not used for agricultural purposes. More than 14 million hectares are defined as agricultural land, representing 61% of the total country's surface.[69]

The most popular types of crops are cereals such as wheat and corn, and oily plants, especially sunflower and rapeseed. They can both be used for energy purposes: cereal crop residues can especially be used for thermal energy production, and oily plants for the production of biofuels. The following table shows the energy potential of the main crops that can be cultivated on Romanian territory, as well as the production related to the surface area:

Crop	Production [t/ha]	Biogas [m^3/ha]
Corn	9 – 30	3.500 – 18.500
Grass	12 – 14	3.500 – 6.500
Clover	5 – 19	1.500 – 6.500

Due to potential competition between the use of crops for energy and food purposes, it is advisable to only use agricultural residues for energy purposes, or green and woody plants grown on otherwise unused agricultural land. For this reason, only unused arable land will be evaluated here. From a total of 9 million hectares of arable land, approximately 2% are annually declared as unused. Based on the situation of the lands available on the different regions, and the possible energy production potential, an achievable biogas potential can be estimated (assuming a methane concentration of 55%, with yearly corn as feedstock).

One possible way to evaluate the achievable potential of biogas using animal residues as feedstock is by assessing the size of herds across different regions. However, because the use of these substrates has several advantages in co-digestion systems, they will not be considered independently, but only as an additional energy source where agricultural crops

[68] Frank, R. C., et al. (2006) The biomass assessment handbook: bioenergy for a sustainable environment.
[69] National Institute of Statistics. https://insse.ro/

digestion systems are used. The below table shows the energy potential from animal residues, organic waste and wastewater sludge.

Substrate	**DM [%] DMo from DM [%]**	**Biogas [m^3/kg DMo]**
Cattle manure	6 - 11	0.1 – 0.8
Pig manure	3 – 10	0.3 – 0.8
Chicken manure	10 – 29	0.3 – 0.8
Kitchen / canteen leftovers	9 – 37	0.4 - 1
Wastewater sludge	-	0.2 – 0.75

Based on this assessment of the different bioenergy sources available in Romania, Figure 14 compares current production to the annual technical potential of bioenergy (considering an average capacity factor of 0.6 and 0.9):

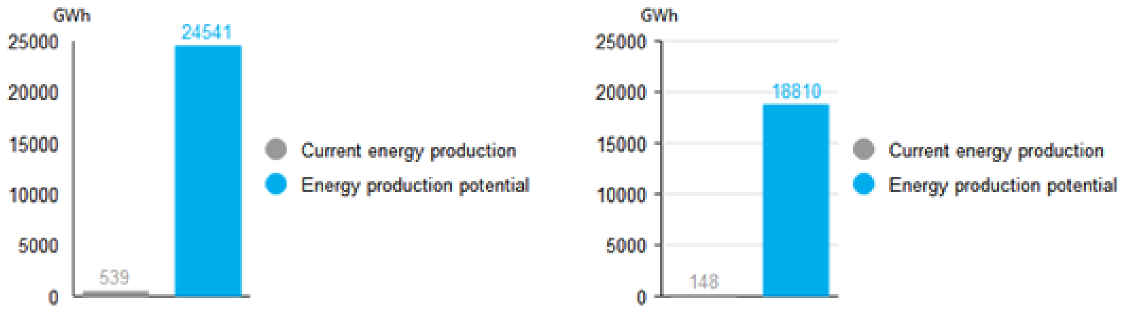

Figure 14 – Current production levels and potential of biomass (left) and biogas (right) energy

While any use of biomass and biogas must be carefully assessed in terms of its overall climate and environmental impact, there is more scope for the production of sustainable bioenergy, especially where it can replace unsustainable biomass use which is currently widespread in Romania. This is particularly relevant for rural areas which are close to sources of bioenergy and distant from more centralised energy infrastructure.

6. Conclusion and policy recommendations

The EU's 2030 and 2050 climate ambitions, while necessary for limiting global climate change, pose a large challenge to many Member States. A broad range of solutions are required to meet this challenge, ranging from the technical to the regulatory to the behavioural. For the decarbonisation of the energy sector, the central pillars are demand reduction, energy efficiency measures and renewable technologies. Romania has significant renewable energy potential and has made sizeable progress in the decarbonisation of its electricity mix (although recent policy changes have slowed this progress). At the same time, little policy support has been granted to the decarbonisation of heating, a major consumer of energy.

Romania's energy sector is still highly dependent on fossil fuels. On top of this, large swathes of the population do not have access to clean, affordable energy. In recent decades, natural gas has been seen as the solution to both of these problems, as a "transition fuel" that can help alleviate energy poverty. However, with only thirty years left to achieve climate neutrality, the time for transition fuels is long past. Gas is a fossil fuel that emits both carbon dioxide and potent methane emissions, and as such does not have a role in a carbon-neutral Europe. Any investments made in natural gas expansion and transportation in the coming decades risk becoming stranded assets, wasting any public funds invested in such projects.

However, there is currently an unprecedented amount of EU funding available for decarbonisation investments, coupled with the possibility to recycle EU ETS revenues for climate purposes. This represents a unique opportunity to scale up planning and investments in renewable solutions, not only for the more established renewable technologies of wind and solar power, but also for less exploited renewable resources. This report has outlined the possibilities and pitfalls around two of these less exploited resources: geothermal and bioenergy. While not without their disadvantages, these renewable energies have the potential to respond to targeted needs, taking into account the specificities and challenges of the Romanian energy system.

Romania is at a crossroads. Decarbonising the energy sector by 2050 is a long-term process which needs to begin now. The EU funds available over the next ten years can be channelled into natural gas in a business-as-usual approach, or they can be invested in renewable energy solutions. Only the latter has long-term viability, but it needs policy support. Based on the findings of this report, we can suggest the policy recommendations overleaf.

Policy area	Policy recommendation
Framework for Investment	➢ Romania should seek to recycle its revenues from auctioning under the EU ETS towards supporting further investments in decarbonisation and the Just Transition. ➢ Romania should aim to maximise its investment attractivity by creating a strategic investment plan to span over a period of 7-10 years, remaining resilient to further political changes. The NECP could be revised to properly encompass this and serve as an investment portfolio.
EU Funding	➢ Romania's spending under the RRF should support energy projects which are compatible with the EU's 2050 climate goals. The recovery package should be viewed as an opportunity to further expand investment in renewable energy beyond that which had been previously planned. Funding for gas projects should be seriously re-examined in light of their irrelevance for the energy transition. ➢ Local authorities and other actors responsible for the disbursement of EU funds must be better informed of the possibilities for renewable energy, including geothermal and bioenergy, and enabled to promote such projects under national and EU funding programmes where relevant.
Energy Poverty	➢ Reduce dependence on the burning of raw wood by funding and providing other renewable energy options, as best suit the needs and local circumstances of end users. Improve education around the health impacts of raw wood burning in open fires, and of alternative options for home heating. ➢ To tackle energy poverty, focus on eliminating dependence on costly fossil fuels, replacing existing heating with systems with low operational costs like renewables-based district heating. Phase out fossil fuel use in heating through energy efficiency measures, economic disincentives (e.g. ending fossil fuel subsidies) and setting requirements for new buildings that exclude the use of fossil heating systems.

National Energy Policy	➢ Regular changes to policy supports for renewable energies creates uncertainty for potential investors. Renewable energy support schemes should be predictable and stable, while allowing for the inclusion of new technologies as they become available. ➢ Official estimates on the potential of geothermal and bioenergy sources are vague and out-of-date. The achievable potential of these resources should be properly assessed, in line with strict sustainability criteria, and the results used to inform energy policy. ➢ Romania needs specific legislation covering geothermal and bioenergy as part of a broader national energy policy aligned with the EU's 2030 and 2050 climate objectives. ➢ Long licencing processes can help ensure the environmental integrity of geothermal projects, but can also act as deterrents. The licencing process for geothermal projects could be reassessed to determine whether the process can be streamlined without compromising on environmental protection. ➢ Renewable options for heating and cooling, such as geothermal heat pumps and renewables-powered district heating, can bring significant advantages in terms of energy efficiency and environmental protection. A national strategy for the development of renewable heating and cooling systems should be elaborated, which could include specific regulations, incentives at local and state level, and the establishment of a national association for renewable heating solutions. ➢ Renewable energy projects that generate only thermal energy should be included under renewable energy support schemes, alongside power generation and cogeneration. Targeted funding streams could be allocated to heat decarbonisation options.

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