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BUILDING MOMENTUM
FOR THE LONG-TERM CCS DEPLOYMENT
IN THE CEE REGION

Assessment of current state, past experiences and potential for CCS deployment in the CEE region

ROMANIA

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Acronyms and definitions

2D	two-dimensional
ACROPO	Regulatory Authority for Offshore Petroleum Operation in the Black Sea
ANRM	Agenția Națională pentru Resurse Minerale (the National Agency for Mineral Resources)
ANRE	Autoritatea Națională de Reglementare în Energie (the Romanian Energy Regulatory Authority)
ANPM	Agenția Națională pentru Protecția Mediului (the National Agency for Environmental Protection)
CCfD	carbon contracts for difference; a financing instrument by which governments guarantee investors in climate-friendly technologies and practices a fixed price which rewards CO_2 emissions reductions above the current price levels in the EU ETS
CC	carbon capture
CCU	carbon capture and utilization
CCUS	carbon capture, utilization and storage
CCS	carbon capture and storage
CEE	central and Eastern Europe
CIROM	Romania's national association of cement and lime producers
CO_2	carbon dioxide
coal seams	a banded deposit of coal visible within layers of rock
EC	European Commission
EOR	enhanced oil recovery; a class of techniques used to extract oil which could not have been extracted otherwise
EGR	enhanced gas recovery; a class of techniques used to extract natural gas which could not have been extracted otherwise
EU ETS	EU Emissions Trading System; an EU-wide system by which sources of GHG emissions are obliged to pay for a permit for each tonne of GHG they emit above a certain allocation level. Permits can be traded between emitters.
Eurobarometer	surveys on a variety of topics conducted by the European Union on Member State respondents
GEO	Government Emergency Ordinance

GHG	greenhouse gases
Gt	gigatonnes
hydrocarbon reservoirs	deposits of oil or natural gas
ISPE	Institute for Studies and Power Engineering
kt	kilotonnes
Mt	megatonnes
NGO	non-governmental organization
saline aquifers	geological formations characterised by the presence of water-permeable rocks which are saturated with salt water (brine)
SEE	South-Eastern Europe

Chapter 1. CCS and CCU: current state and past experiences in Romania

1. DESCRIPTION OF RELEVANT DOMESTIC ECONOMIC SECTORS

1.1. CARBON-INTENSIVE SECTORS OF THE ROMANIAN ECONOMY

To assess the potential market size for carbon capture and storage (CCS) and carbon capture and utilization (CCU)[1] in Romania, this section offers an overview of the evolution of domestic CO_2 emissions and their sources, as well as an indication of the size of the main economic sectors where CCS (and to some extent, CCU) could provide viable decarbonisation solutions.

Following a regime of carbon-intensive industrialisation under the communist system, Romania's greenhouse gas (GHG) emissions peaked in 1989. Ever since the end of the communist regime in 1989, the country has witnessed a steady decrease in emissions, especially following the closure of economically inefficient industrial facilities and the subsequent decrease in energy demand. As can be seen in Figure 1, GHG emissions in 2019[2] amounted to less than 50% of the 1990 levels. The steepest reductions occurred between 1990 and 2000. In 1991 alone, emissions suddenly dropped by 20% compared to the previous year.

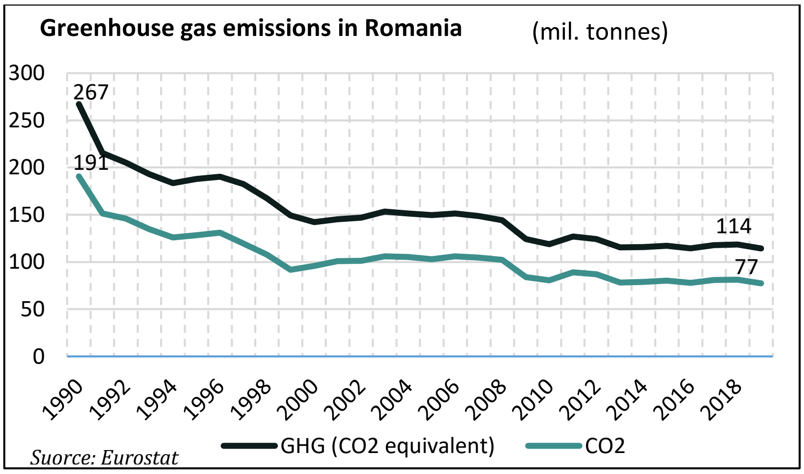

FIGURE 1. EVOLUTION OF GREENHOUSE GAS EMISSIONS IN ROMANIA

[1] The primary focus of this report is CCS, however CCU is mentioned in certain contexts as a potential route for carbon capture.

[2] 2019 figures were used for estimating CO_2 emissions, given the general fall in output caused by the COVID-19 pandemic in 2020.

In terms of emissions sources, out of the total of 77.4 million tonnes (Mt) of CO_2 emissions, the energy sector accounted for 66.2 Mt (85,5%), industry for 10.6 Mt (13.8%), and agriculture and other sectors for 0.6 mt (0.8%) in 2019 (Figure 2). This split has remained rather constant since 1990.

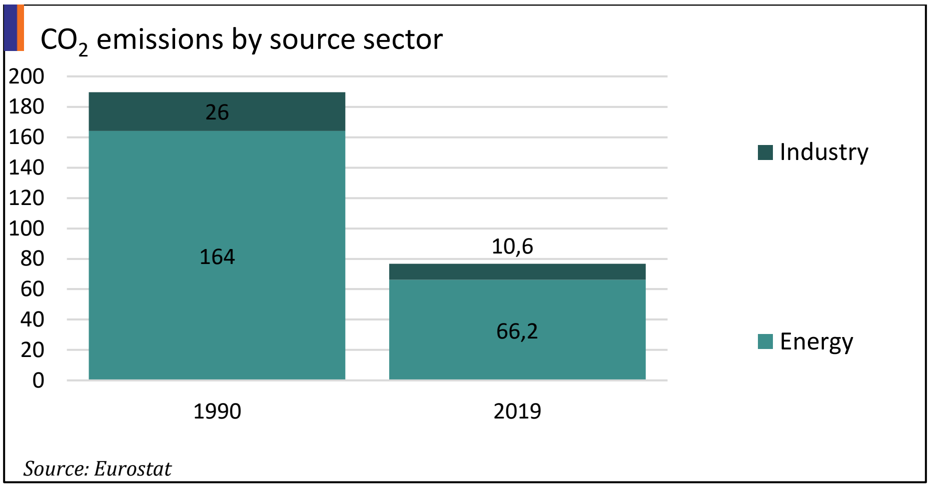

FIGURE 2. EMISSIONS OF CO2 BY SECTOR

Fuel combustion for energy

The 66.2 Mt CO_2 emitted by fuel combustion for energy are split as follows (Figure 3):

- energy industries (33%)
- transport (28%)
- manufacturing industries and construction (22%)
  - CRF1A2A - Fuel combustion in manufacture of iron and steel (1.3%)
  - CRF1A2B - Fuel combustion in manufacture of non-ferrous metals (0.5%)
  - CRF1A2C - Fuel combustion in manufacture of chemicals (3.3%)
  - CRF1A2D - Fuel combustion in manufacture of pulp, paper, and printing (0.3%)
  - CRF1A2E - Fuel combustion in manufacture of food, beverages, and tobacco (1.3%)
  - CRF1A2F - Fuel combustion in manufacture of non-metallic mineral products (4.8%)

    - CRF1A2G - Fuel combustion in other manufacturing industries and construction (10.3%)[3]

- other fuel combustion sectors (17%).

Fuel in the *energy industries* is mainly used for power generation and heating, which amounts for 18.4 Mt CO_2 annually. In *manufacturing industries and construction*, almost half of emissions (6.8 of 14.5 Mt) come from other manufacturing industries and construction, which include construction, transport equipment, machinery, mining and quarrying, wood and wood products, textile and leather, rubber and plastics products, medical, precision and optical instruments, watches and clocks, furniture and manufacturing n.e.c.[4], recycling. Another 3.2 Mt CO_2 come from fuel combustion in the manufacture of non-metallic mineral products, which includes glass, ceramic, cement, etc. Finally, 2.2 Mt are emitted by fuel combustion in manufacture of chemicals.

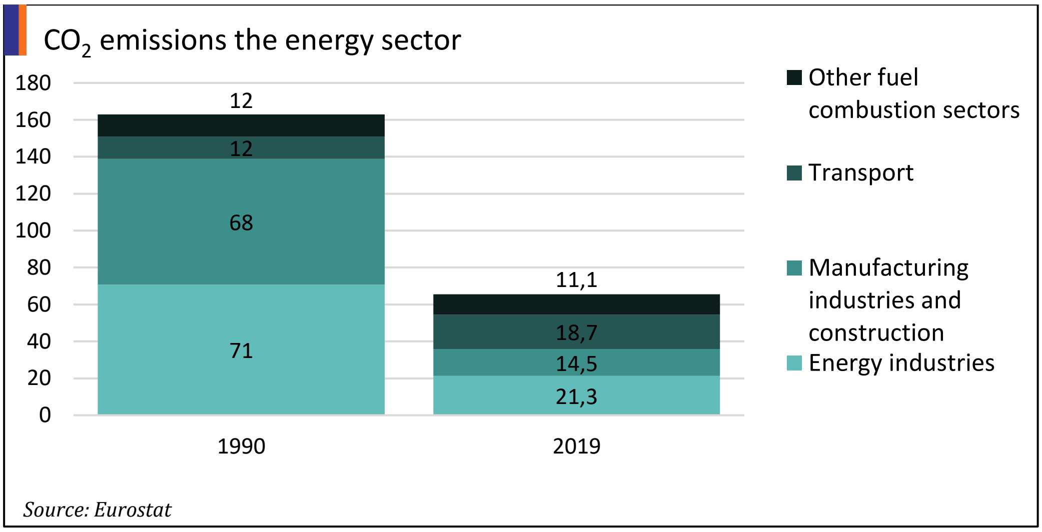

FIGURE 3. EMISSIONS OF CO2 FROM FUEL COMBUSTION FOR ENERGY, BY SECTOR

Industrial processes and product use

The CO_2 emissions from industrial processes and product use come mainly from the mineral industry and metal industry. Cement production releases in the atmosphere 3.8 Mt of CO_2

[3] The CRF codes listed here are part of the coding system used by Eurostat for statistics on fuel combustion in various economic sectors.
[4] Not elsewhere classified.

annually, while lime production releases 0.8 Mt. In metallurgy, almost all CO_2 is emitted by iron and steel production (3.8 Mt) and aluminium production (0.3 Mt). In the chemical industry, out of 1.0 Mt, 0.9 Mt are from ammonia production. To understand the CCS potential of these sectors, it should be mentioned that these figures represent just process emissions, and do not include emissions related to energy use in those industries, usually resulting from heat production.

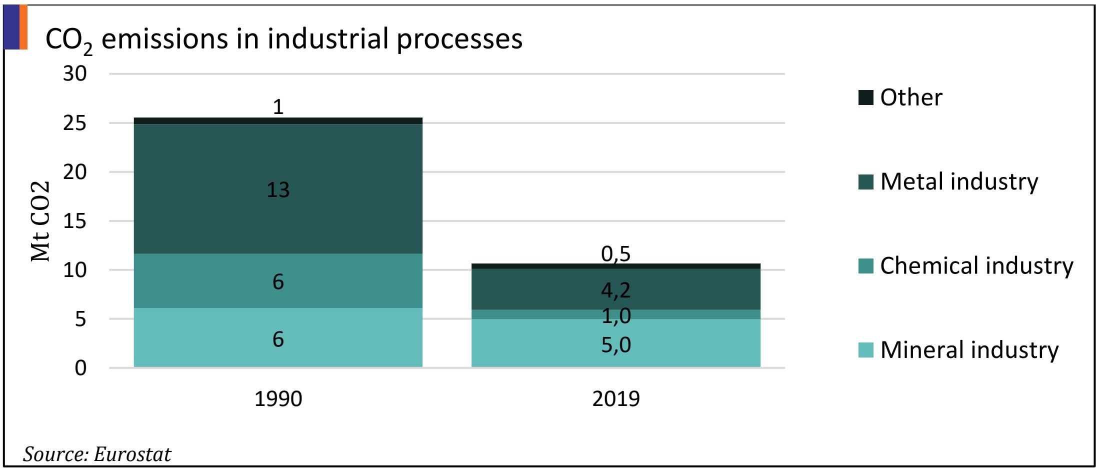

FIGURE 4. EMISSIONS OF CO2 FROM INDUSTRIAL PROCESSES AND PRODUCT USE, BY SECTOR

Table 1 also presents data on the economic size of domestic sectors with the highest and most concentrated CO_2 emissions. CCS technologies could provide decarbonisation solutions for these sectors, however the power sector could benefit from cheaper and more efficient alternatives, such as increased deployment of renewable energy sources or modernisation of infrastructure to reduce losses in the production, transmission, and distribution segments. Nevertheless, for the purpose of this report, we include the Romanian power sector as a potential CCS beneficiary.

TABLE 1. TURNOVER AND EMISSIONS OF A SELECTION OF SECTORS WITH HIGH CONCENTRATED CO2 EMISSIONS IN ROMANIA

Sector by NACE Rev. 2 code		CO_2 emissions (tonnes), 2019	CO_2 emissions (% in total CO_2 emissions including LULUCF), 2019	Turnover 2019 (EUR)	% of total national turnover
3511	Production of electricity	14,755,541	40%	3,201,528,270	0.91%
2351	Manufacture of cement	5,900,471	16%	823,854,006	0.23%
2410	Manufacture of basic iron and steel and of ferro-alloys	4,424,259	12%	1,938,538,578	0.55%
2015	Manufacture of fertilisers and nitrogen compounds	1,801,648	5%	407,185,857	0.12%
1920	Manufacture of refined petroleum products	1,689,037	5%	4,558,830,878	1.29%
2352	Manufacture of lime and plaster	511,179	1%	52,372,446	0.01%
2013	Manufacture of other inorganic basic chemicals	268,300	1%	395,291,631	0.11%
2332	Manufacture of bricks, tiles, and construction products, in baked clay	231,714	1%	186,741,435	0.05%
1712	Manufacture of paper and paperboard	148,984	0%	428,547,393	0.12%

2311	Manufacture of flat glass	70,662	0%	149,041,942	0.04%

Source: own work, based on data from EU Transactions Log

1.2. Major CO_2 emitters in Romania

Another important factor in evaluating the size of a potential CCS market is the geographical location of the CO_2 emission sources, given the costs of constructing and operating CO_2 transportation routes from sources to storage sites. Figure 5 shows the CO_2 emissions of companies covered by the EU Emissions Trading Scheme (ETS) aggregated at county level, indicating in which geographical area CO_2 emissions are concentrated. As it can be seen, Gorj, Dolj, Prahova, and Galați are the counties with the highest CO_2 concentrations. Based on geological considerations, the location of potential CO_2 storage sites should be as close as possible to the concentrated sources of emissions, to minimise the need for long-distance transport.

Figure 6 presents the CO_2 emissions from Romanian companies covered by ETS, aggregated at local level. This map points to potential industrial hubs where CCS technologies could be first implemented in Romania. Based on the industriesactive in those regions and their location, Galați, Ploiești, Râmnicu Vâlcea, and Constanța could become such hubs. [5] Finally, Table 2 shows the emissions aggregated at company level.

[5] Some potential clusters were excluded from this consideration given the fact that most local emissions are associated with electricity production from fossil fuels.

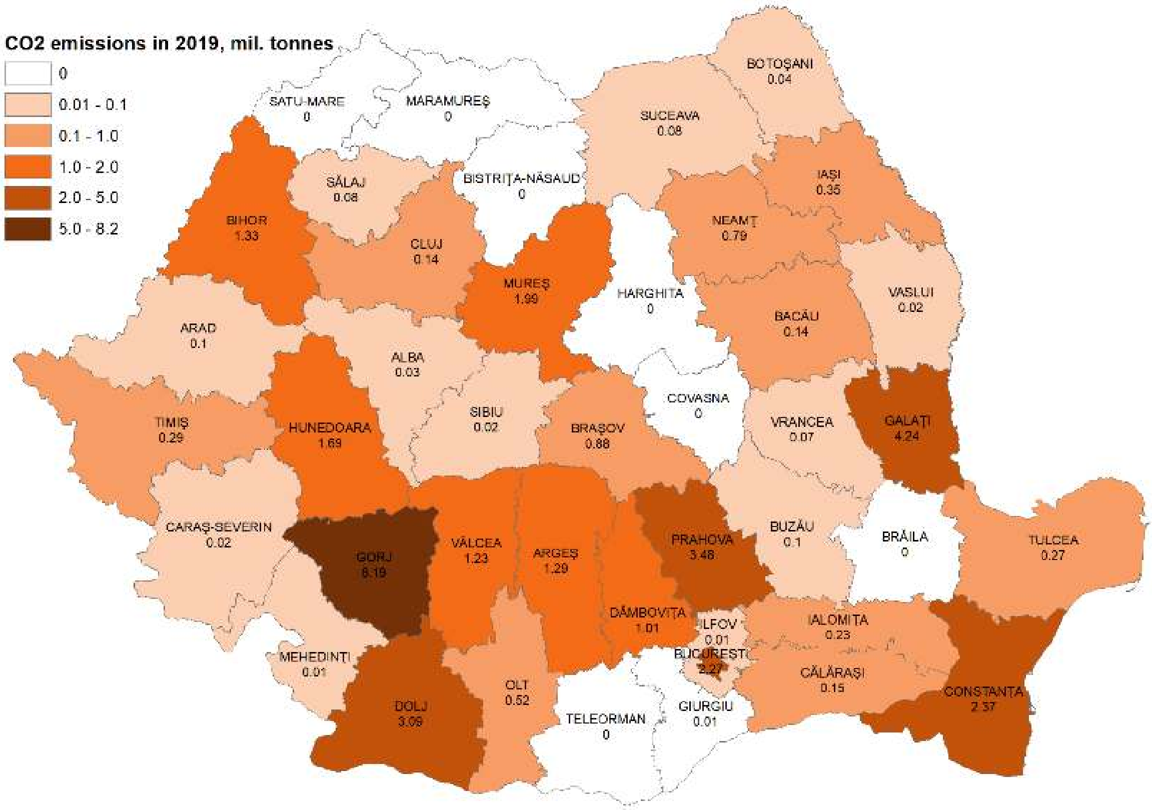

FIGURE 5. CO_2 EMISSIONS BY COMPANIES (EXCLUDING AIR TRANSPORT) IN 2019 AT COUNTY LEVEL

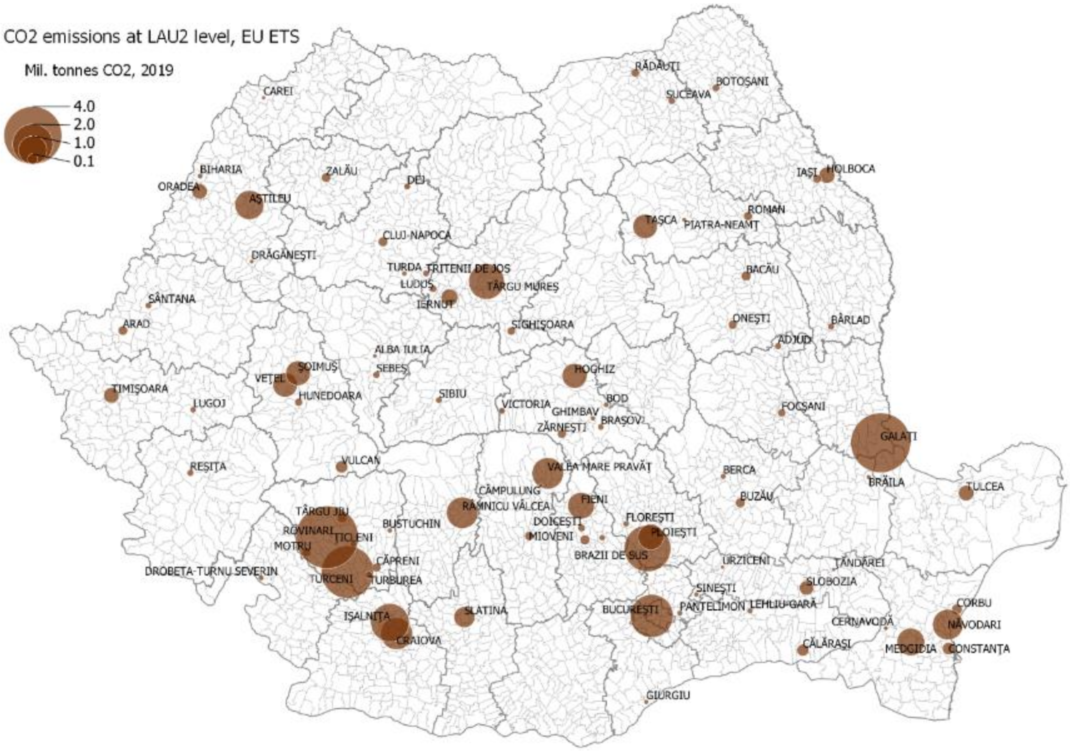

FIGURE 6. CO2 EMISSIONS BY COMPANIES (EXCLUDING AIR TRANSPORT) IN 2019 AT LOCAL LEVEL. LAU2 REFERS TO LOCAL ADMINISTRATIVE UNIT (LEVEL 2), A CODE USED TO DEFINE CITIES AND COMMUNITIES IN THE EU SYSTEM.

TABLE 2. LIST OF COMPANIES WITH CO_2 EMISSIONS OVER 100.000 TONNES IN 2019

Installation Name	Verified emissions (tonnes)	NACE code
SC C.E. Oltenia SA - SUC. Electrocentrale Rovinari	4,628,600	Production of electricity (35.11)
Liberty Galați SA	4,193,464	Manufacture of basic iron and steel and of ferro-alloys (24.10)
S Complexul Energetic Oltenia SA - SE Turceni	3,296,552	Production of electricity (35.11)
S Complexul Energetic Oltenia SA - SE Isalnita	1,818,205	Production of electricity (35.11)
SC Azomureș SA	1,578,627	Manufacture of fertilisers and nitrogen compounds (20.15)
SC Complexul Energetic Oltenia S.A. - SE Craiova II	1,268,134	Production of electricity (35.11)
Centrala de Cogenerare cu Ciclu Combinat - Brazi	1,256,180	Extraction of crude petroleum (06.10)
Petrobrazi	1,062,993	Extraction of crude petroleum (06.10)
SC Holcim (Romania) SA - Ciment Alesd	1,048,635	Manufacture of cement (23.51)
SC Holcim (Romania) SA - Ciment Câmpulung	1,039,764	Manufacture of cement (23.51)
SC CET Govora SA	1,028,701	Steam and air conditioning supply (35.30)
SC Rompetrol Rafinare SA	963,953	Manufacture of refined petroleum products (19.20)
CRH Ciment (RO) SA - Punct de lucru Medgidia	942,568	Manufacture of cement (23.51)
SC Electrocentrale București - CET București Sud	792,976	Production of electricity (35.11)

CRH Ciment (RO) SA - Punct de lucru Hoghiz	758,387	Manufacture of cement (23.51)
Electrocentrale Deva	733,306	Production of electricity (35.11)
Heidelbergcement Romania SA - fabrica de ciment Tașca	731,001	Manufacture of cement (23.51)
Heidelbergcement Romania SA - fabrica de ciment Fieni	715,632	Manufacture of cement (23.51)
Heidelbergcement Romania SA - fabrica de ciment Chișcădaga	664,484	Manufacture of cement (23.51)
SC Petrotel -Lukoil SA	645,532	Manufacture of refined petroleum products (19.20)
CTE București Vest	561,533	Production of electricity (35.11)
Blue Air Aviation S.A.	483,240	Passenger air transport (51.10)
CTE Progresu	435,267	Production of electricity (35.11)
SC ALRO SA - Sediul Social	383,641	Aluminium production (24.42)
S.N.G.N. Romgaz S.A. - SPEE Iernut - CTE Iernut	333,688	Production of electricity (35.11)
S.C. Tarom S.A.	311,340	Passenger air transport (51.10)
CET Iasi II	292,532	Steam and air conditioning supply (35.30)
Veolia Energie Prahova SRL- Punct de lucru Brazi	288,076	Steam and air conditioning supply (35.30)
Termoficare Oradea S.A.	265,943	Steam and air conditioning supply (35.30)
Sectia CET; Instalația CALCINAREA Al(OH)3	257,313	Aluminium production (24.42)
CTE Grozăvești	236,102	Production of electricity (35.11)
S.C. CHEMGAS HOLDING CORPORATION S.R.L.	223,021	Manufacture of fertilisers and nitrogen compounds (20.15)

SC Carm. Hold. SRL Brasov - Pdl Valea Mare Pravat	186,639	Manufacture of lime and plaster (23.52)
SC Carm. Hold. SRL Brasov - Pdl Fieni	162,116	Manufacture of lime and plaster (23.52)
Centrala Termică Palas	161,295	Production of electricity (35.11)
CT Timișoara Sud	159,612	Steam and air conditioning supply (35.30)
S.C. P.E.E.T. Electrocentrala Paroșeni S.A.	153,808	Production of electricity (35.11)
SC Uzina Termoelectrică Midia SA	123,223	Trade of electricity (35.14)
Ciech Soda România SA - Instalație obținere sodă calcinată	120,339	Manufacture of other inorganic basic chemicals (20.13)
S.C. Celco S.A.	106,429	Manufacture of concrete products for construction purposes (23.61)

2. Assessment of geological potential for CCS

Having reflected on the CO_2 emissions of Romania (and thus the potential for carbon capture), it is now useful to extend the discussion to the subsequent parts of the CCS chain - transport and storage.

2.1. General geological characteristics

Romania is part of the Southeast European general geological ensemble, mainly characterised by the Carpathian Mountains belt and surrounding depression and plain areas. The Carpathians flank to the east the Transylvanian Depression and an Eastern portion of the Pannonian Depression, and are surrounded by geological platforms of different ages, covered with sediments (the Moesian Platform and South Carpathians Foredeep and the Moldavian Platform and East Carpathians Foredeep).

Onshore geological storage options are generally bound to these sedimentary basins (Figure 7), whose layers can run several kilometres deep and act as potential reservoirs or sealing rock units.[6] Accordingly, an assessment of potential underground storage structures ought to be preceded by the identification of adequate sedimentary basins.[7] The most important regions in this respect are the Transylvanian Depression in north-western Romania, and the Moesian Platform and the South Carpathian Foredeep, in the Muntenia region of southern Romania. The Moesian Platform contains a Miocene-Pliocene subzone of geological structures of diapir origin, situated along alignments parallel with the Carpathian chain. This subzone is one of the most prolific accumulation zones in Romania, with numerous hydrocarbon deposits.[8]

[6] CGS Europe, 2013. State of play on CO2 geological storage in 28 European countries.

[7] CGS Europe, 2013. State of play on CO2 geological storage in 28 European countries.

[8] EU GeoCapacity, 2006.

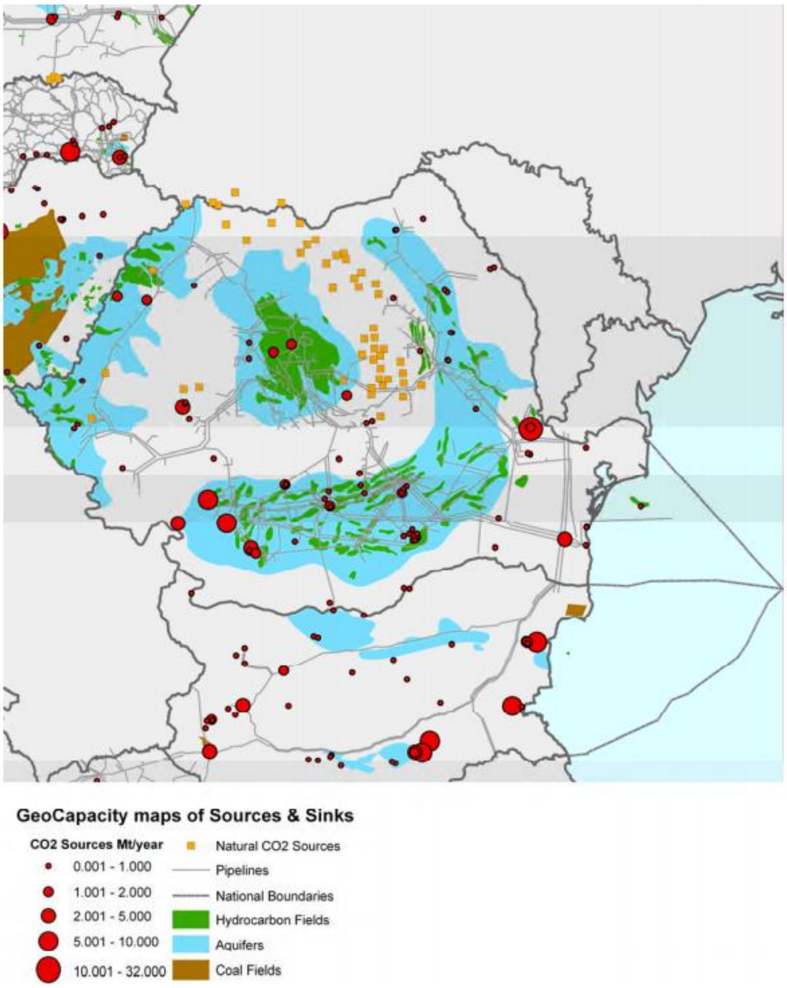

FIGURE 7. MAP OF CO_2 SOURCES AND SINKS IN ROMANIA (EU GEOCAPACITY, 2006)

2.2. Potential storage sites

Romania has significant theoretical CO_2 storage potential, highlighted in several studies and through stakeholder engagement in the CCS4CEE project. The bulk of storage capacity is in **deep saline aquifers**, with **depleted hydrocarbon reservoirs** (primarily onshore) contributing a smaller share. The most detailed estimate of Romania's storage capacity (EU GeoCapacity) found a total theoretical capacity of 22.6 Gt, with 18.6 Gt in deep saline aquifers and 4.0 Gt in depleted hydrocarbon fields – based on the assumption that most of Romania's remaining hydrocarbons will be extracted in 20-30 years and the resulting depleted fields will be available for CO_2 storage, and accounting for enhanced the oil recovery (EOR) and enhanced gas recovery (EGR) potential. A feasibility study for the Getica CCS Demonstration Project (Section 3.2.1), Romania's only existing CCS proposal (2011), found a storage capacity of about 100 Mt in each of two suitable sites identified in the Sarmatian reservoirs (Tertiary deposits) of the

Getica Depression, the sedimentary basin between the South Carpathians and the Moesian Platform. **Non-mineable coal seams** are not suitable for CO_2 storage in Romania.

With its 22.6 Gt of potential storage, Romania emerges as a significant CO_2 storage site, compared to the two neighbouring countries for which data is available – Bulgaria and Hungary. There are differences in the estimates of CO_2 storage potential in these two countries. In Bulgaria, deep saline aquifers could provide storage for 2.56-2.65 Gt, while hydrocarbon fields are estimated to store 3-6 Mt, and coal fields 27-27.4 Mt.[9] Hungary's estimates for CO_2 storage potential also vary: deep saline aquifers are estimated between 562 Mt and 2 Gt, hydrocarbon fields 150-389 Mt, and coal fields 87 Mt[10] (although some studies state the country has no potential at all), leading to a total storage potential of 1-2 Gt. These estimations are very basic and speculative, because of restricted access to data.

Significant effort is needed to estimate CO_2 geological storage capacity, which has been the subject of extensive geological research in Romania and the surrounding countries (Table 3). When estimating storage potential in deep saline aquifers, the EU GeoCapacity study (2006) had to use theoretical estimates for reservoir thickness and porosity. The feasibility study for the Getica CCS Demonstration Project (2011) faced a challenging data collection process in estimating storage potential in the Getica Depression. The data was based on existing 2D seismic lines (some in paper format) and 107 well profiles, sourced mostly from major Romanian oil and gas companies. There were practical challenges in liaising with O&G companies to collect data, largely due to a lack of centralized digital data and data transparency, as well as outdated well profile data.

TABLE 3. MAIN ACTORS IN RESEARCH OF CO2 STORAGE POTENTIAL IN SEVERAL EASTERN EUROPEAN COUNTRIES11

Country	Institution
Romania	• National Institute of Geology and Geo-ecology (GeoEcoMar) • University of Bucharest, Faculty of Geology and Geophysics • University of Ploiești
Bulgaria	• St. Kliment Ohridski University of Sofia, Department of Geology
Hungary	• Geological and Geophysical Institute of Hungary (formerly Eotvos Lorand Geophysical Institute) • Eotvos University, Budapest, Department for Petrology and Geochemistry • Technical University, Budapest, Department of Chemical and Environmental Process Engineering

[9] EU GeoCapacity (2006), State of play on CO_2 geological storage in 28 European countries (2013).
[10] EU GeoCapacity (2006), State of play on CO_2 geological storage in 28 European countries (2013).
[11] EU GeoCapacity (2006), State of play on CO_2 geological storage in 28 European countries (2013).

Serbia	None - There are no major research projects related to CO_2 storage. There is an ongoing PhD research at the Faculty of Ecology and Environmental Sciences, Belgrade, relating to CCS. All research is being done by the Association of Geophysicists and Environmentalists (AGES) through CGS Europe

As indicated in Table 3, for Romania and its neighbouring countries, research on CO_2 storage potential is not a prominent field, compared to Norway, for instance, where almost 16 entities focus on this area.

The following section outlines the CO_2 storage potential in different geological formation types in Romania (saline aquifers, depleted hydrocarbon reservoirs, including EOR potential, and non-mineable coal seams).

2.2.1. Saline aquifers

The sedimentary basins containing deep saline aquifers are situated in four main geological areas: the Moesian platform and South Carpathian foredeep, Moldavian platform and East Carpathian foredeep, Transylvanian Basin and Pannonian Basin, as indicated in Table 4 below.[12] The total storage capacity of onshore saline aquifers is estimated at **18.6 Gt**, with the majority occurring in the Transylvanian Depression and Moesian Platform and South Carpathians Foredeep.[13]

TABLE 4. ESTIMATED CO_2 STORAGE CAPACITY IN DEEP SALINE AQUIFERS IN ROMANIA

Zone	Surface area (km^2)	Reservoir geological formations	Estimated reservoir thickness (m)	Estimated porosity	CO_2 storage capacity (Gt)
Moesian Platform and S. Carpathians Foredeep	38.000	Pontian, Meotian, Sarmatian, Cretaceous, Trisiac	70	0.2	5.2
Moldavian Platform and E. Carpathians Foredeep	24.000	Sarmatian, Tortonian	50	0.2	2.5

[12] Bossie-Codreanu, D., C. Car et al. (2009), WP2 – Storage Capacity. EU GeoCapacity project – Assessing European Capacity for Geological Storage of Carbon Dioxide, Geological Survey of Denmark and Greenland, Project Np. SES6-518318, p. 73

[13] EU GeoCapacity, 2006

Transylvanian Depression	22.000	Buglovian, Sarmatian, Tortonian	200	0.2	8.8
Pannonian Depression	15.000	Pannonian, Tortonian, Cretaceous	70	0.2	2.1
Total					**18.6**

Offshore saline aquifers do not present significant CO_2 storage potential, on account of their low capacities. However, research on these sites has so far only been incipient. In a 2020 study,[14] three deep offshore saline aquifer structures in the Albian reservoir (sandstones with limestone cement) were identified, with a combined storage capacity of 17 Mt: Iris (no. 23 in Figure 8, 6.6 Mt), Lotus (18, 4.8 Mt) and Tomis (17, 5.3 Mt).

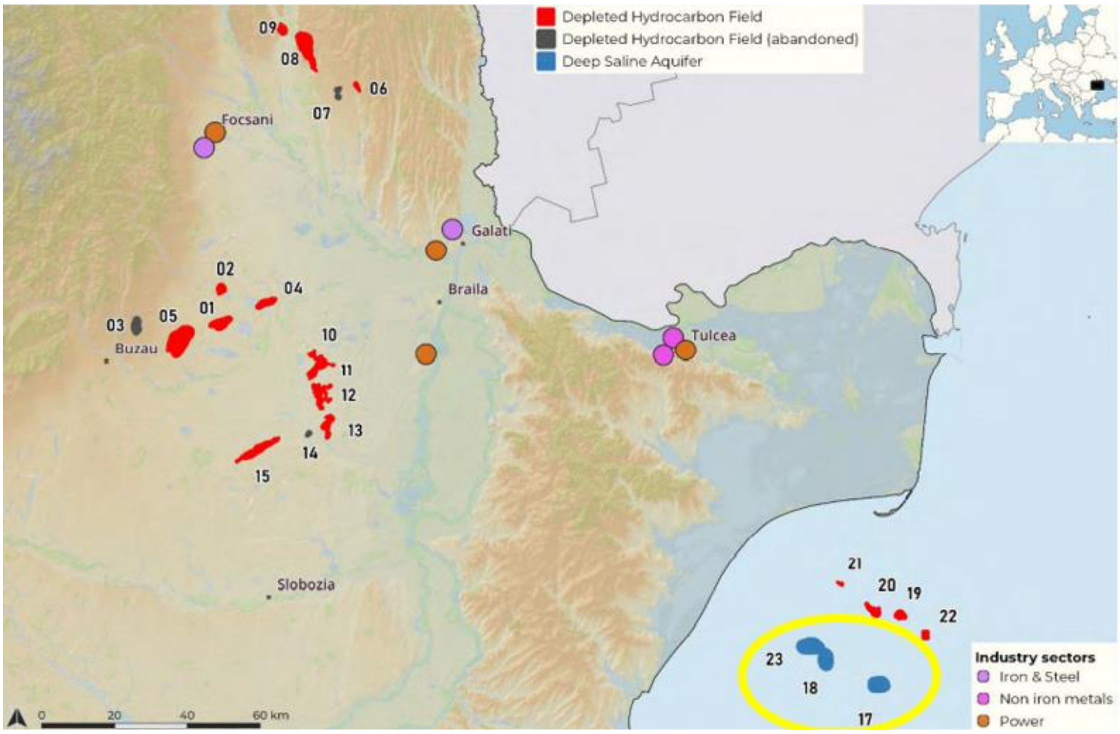

FIGURE 8. LOCATION OF OFFSHORE SALINE AQUIFERS IN ROMANIA

[14] Strategy CCUS, 2020.

2.2.2. Depleted hydrocarbon reservoirs

Romania's 150-year history of oil extraction means that it is considered a "mature" oil and gas province, with up to 80% of existing resources already exploited. The total CO_2 storage capacity from depleted reservoirs is 4 Gt, most of which comes from depleted gas reservoirs (3.41 Gt), as opposed to oil deposits (0.59 Gt).[15]

For depleted hydrocarbon fields, considering Romania's long history of oil and gas industry and its proved reserves per region, an estimated CO_2 storage capacity in oil and gas deposits in Romania is presented in Table 5. For coal seams, the scientific assessment is that Romania cannot offer appropriate conditions for CO_2 storage.[16]

TABLE 5. ESTIMATED CO_2 STORAGE CAPACITY IN OIL AND GAS DEPOSITS IN ROMANIA

Geological units	Produced		Produced estimated		Total estimated capacity		CO_2 storage capacity (Gt)	
	Mt Oil	Gm^3 Gas	% Oil	% Gas	Mt Oil	Gm^3 Gas	Oil	Gas
Pannonian Depression	47	25	80	85	57	29	0.03	0.07
Transylvanian Depression	-	772	-	85	-	908	-	2.27
Bârlad Depression	1	2	-	-	1	6	-	-
North Dobrogea	6	13	-	-	6	13	-	-
East Carpathians	377	90	85	90	560	100	0.34	0.25
Getic Depression	120	125	70	65	156	192	0.09	0.48
Moesian Platform	169	95	75	70	211	136	0.13	0.34
Total	720	1122			981	1384	0.59	3.41
						Total	4 .00	

[15] EU GeoCapacity, 2006.

[16] EU GeoCapacity, 2006.

Onshore fields

The EU GeoCapacity report (2006) includes two case studies for Romania in which the theoretical CO_2 storage capacity was assessed for hydrocarbon fields: Ghercești – Malu Mare (24.34 Mt) and Turnu (15 Mt). Strategy CCUS also assessed the CO_2 storage potential in the Galați region, identifying 11 hydrocarbon fields with storage potential (6 oil and 5 gas fields) in the southern Carpathian Basin, and 4 potential fields (2 oil and 2 gas fields) in the North Dobrogea Promontory. As part of this, the study includes storage capacity estimations for two geological storage units at Țepu (oil – 5 Mt, North Dobrogea Promontory) and Ghergheasa (gas – 50 Mt, southern Carpathian basin). Furthermore, the study identified three abandoned hydrocarbon fields that could be considered for CO_2 injection. There are no storage capacity estimations for these abandoned fields, but the Bobocu field has an area of 7.18 km^2 and is much larger than the other two fields. It is located 85 km west from the city of Galați in a rural setting, with very low population density. Assessing the capacity estimate for Bobocu is a priority, given its potential for CO_2 storage in the Galați Region.

Offshore fields

The Histria Depression, located in the western part of the Black Sea Basin, presents good possibilities for CO_2 storage and utilization (CO_2-EOR). This depression comprises five oilfields (discovered so far) located on a NW-SE alignment on its northern flank: Lebăda Est, Lebăda Vest, Sinoe, Delta, and Pescăruș. The fields are located in the Upper Cretaceous (Cenomian) reservoirs comprised of sandstones, limestones and marls, or in Albian reservoirs.

2.2.3. Enhanced oil recovery

Romania has had several CO_2 injection experiments in oil fields,[17] and short-term CO_2 injection has also been applied to a number of wells, mostly with positive results. There have been extensive laboratory research and field experiments on EOR methods (chemical, thermal, CO_2 injection, oil mining, microbiological, nitrogen injection and horizontal drilling). The best results were obtained by underground combustion (thermal EOR), which has been applied in 26 Romanian oil fields. However, the most efficient method of enhanced recovery that can be applied in Romanian oil fields is the technological injection of CO_2 (CO_2-EOR).

Several potential EOR sites located close to large CO_2 emitters (power plants, cement factories, chemical and steel plants and refineries have been proposed. From 130 identified fields with EOR potential, a total of 10 oil regions, consisting of 19 individual fields, were coupled

[17] Sava et al, 2017; Injection and Storage of CO2 – Efficient method for increasing oil recovery, Geo-Eco-Marina 24/2018

with 15 nearby emission sources, including three power plants in Bucharest and four units of the Oltenia Energy Complex, Romania's largest CO_2 emitter (Figure 9).[18] Another project (ECO-BASE) proposed a business case for the Brădești oilfield in the western Oltenia region.

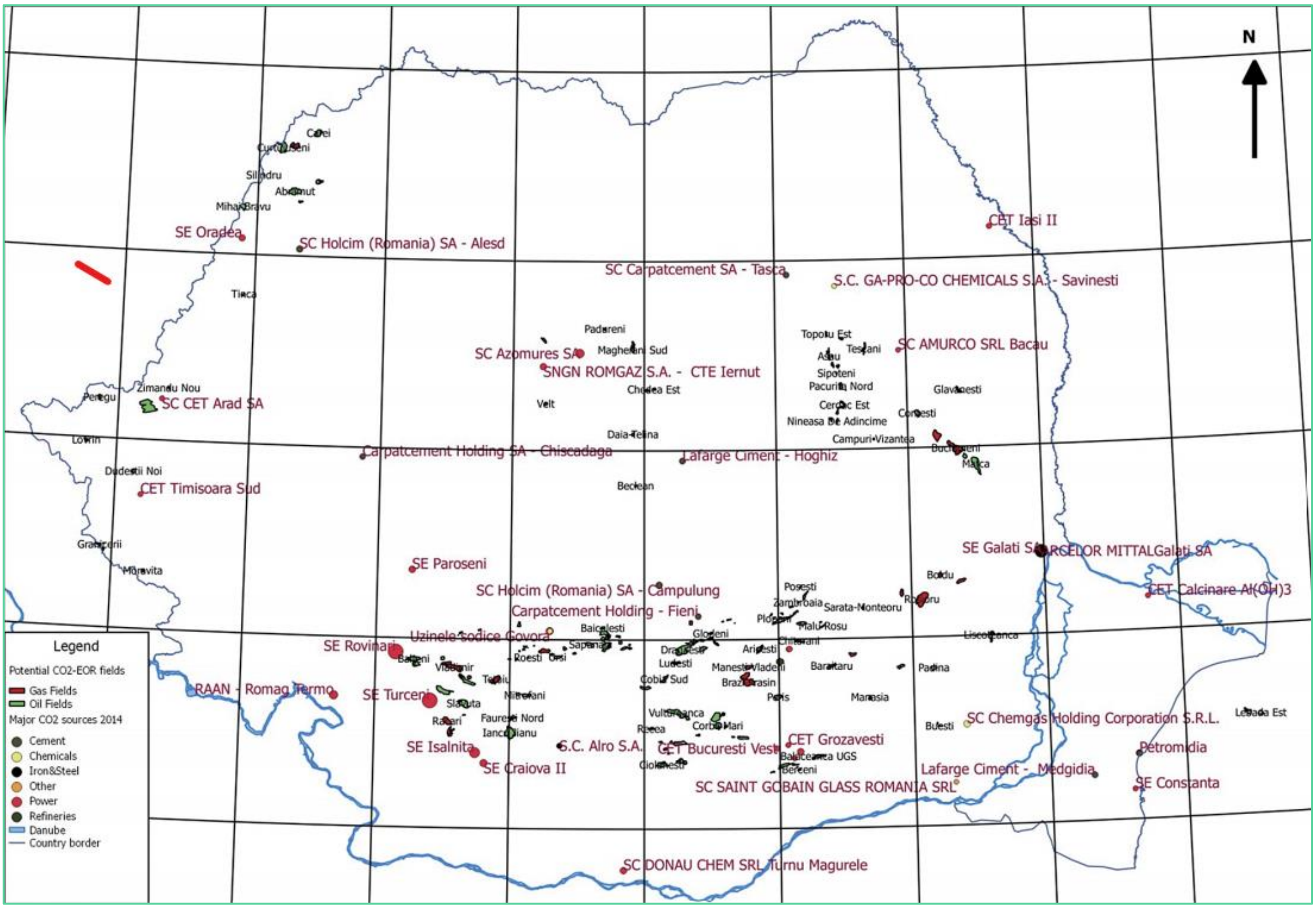

FIGURE 9. MAP OF POTENTIAL STORAGE SITES, COUPLED WITH EMITTERS. NOTE THAT SC AZOMURES IS A FERTILIZER PLANT, RATHER THAN A POWER PLANT AS INDICATED BY THE LEGEND. SOURCE: TRASCĂ-CHIRIȚĂ ET AL, 2017

The advantages of CO_2-EOR are that it can be applied on all types of oilfields and can increase oil production and commercial reserves by 20-30%. CO_2 injection can also be followed by a process of geological storage of CO_2 that ensures a sensible increase of technological injection efficiency. The difficulties of applying technological CO_2 injection in the Romanian oil fields include the neglect of this method for the last 20 years, with lack of practical field work

[18] Trască-Chiriță et al, 2017.

and management of injection, as well as lack of adequate infrastructure for most commercial oil fields.

The Strategy CCUS project (2011) estimated the CO_2 storage potential in several EOR sites. In the southern Carpathian Basin and the North Dobrogea Promontory, it identified 15 depleted hydrocarbon fields with a total storage capacity of 0.2 Gt. Other onshore hydrocarbon fields still under exploration also seem to have an interesting potential once they become depleted. For example, the Roșioru field, located in the same region as Bobocu in the Galați region, is a large hydrocarbon field of significant CO_2 storage potential.

For the offshore hydrocarbon fields, only Lebăda East and Lebăda West can be used for CO_2-EOR operations and CO_2 storage purposes. These fields already have injection wells that are used for EOR operations (not involving CO2).[19]

2.2.4. Non-mineable coal seams

According to the EU GeoCapacity study (2006), non-mineable coal seams are not suitable for CO_2 storage in Romania.

2.3. Transportation infrastructure

Romania transposed the EU CCS Directive[20] through the Government Emergency Ordinance (GEO) 64/2011, Art. 22. This Ordinance defines the implementing authorities of CCS regulation as the National Regulatory Authority for Energy (ANRE) and the National Agency for Mineral Resources (ANRM). Although ANRE's duty is to issue transportation licences, the procedure on transparent and non-discriminatory access of operators to the transport networks and storage sites has not been drafted or adopted to date. Indeed, following the adoption of GEO 64/2011, ANRE should have developed the procedures for third-party access to the CO_2 transport network within nine months; to this day, this has still not occurred.[21]

To enable CO_2 transportation infrastructure, the legal framework for the transport of natural gas should also be analysed, to assess its applicability for CO_2 transport. The following technical codes should be modified:

[19] Multimodal Transport of CO2 for implementing CCUS in Romania, GeoEcoMarina 2017

[20] Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006

[21] Permitting Report to the Global CCS Institute, Getica CCS Demo Project Romania, November 2011

- The code on the national network for transporting natural gas or liquefied petroleum gas should include details on the transport of dense-phase of CO_2 via pipelines;
- The technical standards for the design and construction of upstream pipelines and natural gas transport pipelines should include provisions on the design and construction of pipelines for the transport of dense-phase CO_2;
- The technical criteria on the areas of protection and safety of the National Transport System associated with crude oil, gasoline, condensate, and ethane should include provisions on the areas of protection and safety of dense-phase CO_2 pipeline.

Additionally, GEO 64/2011 does not address **transboundary cooperation for CO_2 transport**. Originally, the draft version of GEO 64/2011 contained a provision appointing ANRM and ANRE as counterparts of the competent authorities for transboundary transport of CO_2in other Member States, but this provision has not remained in the final version of the GEO.[22]

The following sections outline the potential and risks for pipeline and multimodal CO_2 transportation. Unfortunately, no studies have addressed the road, rail, or maritime transportation potential of CO_2 in Romania.

Pipeline transportation

So far, the transportation aspect of the Romanian CCS chain has been analysed only for the Oltenia region in the context of the GETICA CCS feasibility study, coordinated by the Institute for Power Systems and Engineering (ISPE)[23]. In this study, a 40 km onshore pipeline was projected to connect the Turceni power plant (CO_2 source) to two proposed storage sites (Global CCS Institute, 2013), with two respective CO_2 transport pipeline routes. Both pipeline routes would traverse areas with a population density of 50-250 persons/km^2. Based on a preliminary risk and safety assessment (part of the Feasibility Study), protection would be maximised primarily by installing the pipe underground, to reduce the likelihood of third-party intervention. As a rule, a minimum clearance of 500 m from the existing villages and buildings was considered when selecting the route. Possible risks generated by coal mining activities in the region(quarries and pits) were also considered, and surface subsidence would have a negative impact on the CO_2 transport pipeline. As a result, it is vital that these subsidence and mining areas are avoided when selecting the pipeline route, regardless of whether the mines are operational or decommissioned.

Another study identified that possible challenges of permitting construction of CO_2 transport pipelines may relate to the poor public evidence of ownership – local public authorities do not

[22] Case studies on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide Romania, Monika Jozon, November 2011

[23] Global CCS Institute, 2013. GETICA CCS Demo Project Romania: feasibility study overview report to the Global CCS Institute. Public report.

always have accurate information as to the ownership of the plots of land in their jurisdiction. Romania is still conducting cadastral surveys at the national level (originally planned for completion by 2023 but severely delayed), [24] which may introduce complications in the centralization of land ownership information, in view of developing multimodal transport masterplans.[25]

Multi-modal transportation

As the southern part of Romania is crossed by the Danube river, there is an opportunity to promote the concept of "multimodal transport of CO_2". Once the major industrial sources of CO_2 and potential storage or EOR sites have been identified, segments of CO_2 transport pipelines can be designed to or from the closest Danube ports. As a certain amount of CO_2 reaches its collection point in a Danube port, it can be transported by barges to another Danube port that is connected to a storage site. Similarly, CO_2 arriving at a Danube port can be transported through the Danube-Black Sea Channel to the Agigea Port on the Black Sea coast. From here, it can be shipped or transported through offshore pipelines to a storage site in the Black Sea. CO_2 storage operations, including EOR and EGR, could thus develop in the Western Black Sea Basin, similarly to the North Sea.[26]

3. Description of implemented and planned projects

3.1 Planned projects

Concrete discussions on CCS or CCU based on coherent strategies and detailed actions have not reached the Romanian governmental or public agenda for over a decade. As part of its National Recovery and Resilience Plan (NRRP), Romania has managed to revive discussions on carbon capture, but has failed to adopt a holistic or impactful approach.

In the pursuit of developing a favourable legislative and regulatory framework for future technologies, in particular hydrogen and storage solutions, two projects that include carbon capture installations are proposed in the NRRP. They propose the production of green hydrogen, subsequently mixed with natural gas and combusted in two respective 159-MW power plants equipped with CO_2 capture installations. The planned implementation date for the projects is 2024. The proposed project consortium was formed of the country's largest gas producer

[24] Europa Libera, 2021. Țară în service | Din 1,16 miliarde euro, bani de cadastru, s-au finalizat 110 localități. Au mai rămas 3064. Unde sunt timpul & banii.

[25] Permitting Report to the Global CCS Institute, Getica CCS Demo Project Romania, November 2011

[26] Multimodal Transport of CO2 for implementing CCUS in Romania, GeoEcoMarina 2017

Romgaz, Grup Servicii Petroliere (GSP) Power,[27] Siemens and the National Institute for Research on Cryogenic and Isotopic Technologies (ICSI). Some argue the consortium was arbitrarily put together,[28] and direct financing for these projects were subsequently removed from the NRRP after a discussion with the European Commission which expressed a preference for the competitive selection of projects rather than pre-established consortia and projects.[29] In any event, these projects are considered insufficient for accelerating emission reduction efforts, and could even pose a risk to the development of mature projects. In addition, the lack of public consultation or transparency[30] in selecting the project consortium can possibly lead to public opposition of carbon capture technologies.

In 2020, some operators announced their intention to develop CCS projects in Romania. The HeidelbergCement factory from Fieni (Dâmbovița County) may be an option for carbon utilisation and storage. At this point, no further information about the storage site or preferred technologies are available, but the discussion between the cement operator and ANRM (the competent authority for geological storage of CO_2) have started. The competent authority for CO_2 storage will assess and propose the suitable locations for CO_2 storage. The company also aims to develop the CCU and CCS project with European funding.

AIK Company, a natural gas trader and supplier, delivered a presentation to Oltenia Energy Complex's top management about a CCS project. One board member of the state-owned lignite company confirmed that they were evaluating the possibility of implementing such a project at Ișalnița steam power plant.[31] The cost related to the project development is still unclarified.

3.2 Past projects

3.2.1 Getica CCS Demonstration Project

[27] GSP Power LLC was established in 2020, as part of GSP Holding.

[28] Economedia, 2021. Magnate's Gabriel Comănescu company along with Romgaz will be the beneficiary of almost 600 mil. euro projects funded from PNRR. GSP is the only private company chosen without tender by the Ministry of Energy to receive European money.

[29] G4Media. The controversial 600-million euro project of Romgaz-GSP Power, removed from the RRP. Minister for Energy Virgil Popescu explains: We will replace direct projects from the RRP with competitive selections.

[30] Hotnews. C*oncordia about PNRR: Important sectors were not consulted. There is lack of energy related roadmap /The heavy traffic charging system must also receive incentives.* https://economie.hotnews.ro/stiri-finante_banci-24846976-concordia-pnrr-sectoare-consultate-energie-lipsa-foi-parcurs-sistemul-taxare-trafic-stimulente.htm . Accessed June 23, 2021.

[31] E-nergia. *Carbon capture and storage projects in Romania are increasing. AIK Energy proposed to CE Oltenia a CCS project for Ișalnița.* https://e-nergia.ro/se-inmultesc-proiectele-de-captare-si-stocare-a-carbonului-in-romania-aik-energy-a-propus-ce-oltenia-un-proiect-ccs-la-isalnita/. Accessed June 23, 2021

As the European Commission started to build the economic and legal framework for demonstrative CCS projects, Romania responded with its only proposal for a CCS demonstration to date – the Getica project (2011). Getica was the first national integrated CCS demonstrative project, covering the full CCS chain of capture, transport, and storage of CO_2. The project was planned to start operation during the 2016-2030 period, however it never materialized, being put on hold due to lack of funding following the completion of its financial report in 2013.[32]

A consortium of state-owned utilities, comprising Turceni Energy Complex SA (in charge of CO_2 capture), SNTGN Transgaz (the transport operator), and SNGN Romgaz (the CO_2 storage operator) were the key actors for development the proposal. The chosen region for implementation, Oltenia, is one of the most industrialized regions of the country, responsible for 40% of Romania's CO_2 emissions. At the time (2011), the lignite-fired Turceni Energy Complex was the largest electric power plant in the country, covering 12.5% of Romania's electricity demand.

The Institute for Studies and Power Engineering Romania (ISPE) together with the National Institute for Research and Development on Marine Geology and Geo-ecology (GeoEcoMar) provided input in the technical consortium. Both entities contributed to the feasibility study for the CCS chain (capture, transport, storage), with Geoecomar having expertise in the storage area while ISPE contributed mostly to developing communication programmes to boost public acceptance in the region. Financial and institutional support for the feasibility study were provided by the Ministry of Economy, Trade and the Business Environment (METBE) and the Global CCS Institute.

Unprecedently, the Getica project was at the intersection of government support, available funding, and cooperation among stakeholders. It was designed to capture up to 1.5 Mt CO_2/year from Turceni's unit 6 by retrofitting a carbon capture installation to the lignite-fired 330MW unit. As reports from the time attest, the amount of CO_2 would have been transported within 50 km of the capture site for storage at a depth of approx. 800 m in onshore saline aquifers.[33] The proposed capture technology was based on Alstom Power's Chilled Ammonia Process (CAP). The Global CCS Institute put forward a €2.5 million grant for the feasibility study for Getica. In addition to the feasibility study, a permitting report and a regulatory toolkit for authorities (workshop and matrix) were compiled and submitted to the Global CCS Institute. The toolkit was designed to allow a detailed evaluation of the adequacy of pre-existing regulatory practices to adjust the framework of the CCS chain, which in turn would enable government and regulators to address gaps and challenges encountered during technologies' deployment.

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[32] CCSDBA, 2010. Getica CCS Demonstration Project Details.

[33] Global CCS Institute (2011), Feasibility Study Report Getica CCS Demo Project, Public Report

Getica's inception took place in a high-trust climate, considering the political will and synergistic efforts of companies and research-oriented entities. Prior to Getica's application for funding under the EU NER300 Programme (2011), the government expressed its commitment to CCS through several important actions. First, key ministries co-initiated the "Action Plan to prepare for the Energy-Climate Change European Union (EU) legislative package implementation," endorsed by the Prime Minister. As part of this package, the Ministry of Economy, Trade and the Business Environment (METBE) released the "Action Plan for implementing a Demo Project regarding CCS in Romania", followed by a national call for proposals for CCS projects attached to emissions-intensive industries in Romania.

By November 2010, Getica had been selected, the feasibility study had commenced and the application for NER 300 was completed. In the attempt of meeting the necessary criteria for further development of the demonstrative project in Oltenia, Romania began to draft a national regulatory framework for CO_2 storage. For a timely approval, the transposition of the EU CCS Directive came into force through GEO 64/2011. However, as detailed in Section 3.2.2, the transposition lacked proper implementation procedures and responsibilities assigned for administration. As such, it was more a formality than an effective enacting piece of legislation, a formal framework to facilitate the Getica project rather than a comprehensive set of regulations for CO_2 storage.

The project's estimated cost was €1 billion, with 50% coming from financial support from the EU. The Getica project competed with 15 other projects that applied for the first call of NER300 Programme. It did not progress past the competition's technical and financial evaluation stage, because of lack of reconfirmation of government support, which was due to be sent to the Commission in 2012. This was primarily caused in a context of o political instability in the wake of the 2008 financial collapse, with the head of the government changing hands four times. Meanwhile, most of the stakeholders actively involved in the process appreciated that the Getica project had solid winning chances given its potential to become a future CCS hub.

Getica still remains Romania's flagship project, despite the fact that no facility was ultimately build for carbon capture, transport or storage. The CCS demonstration project opened the path for a regulatory framework that evinced the complexity of the process. In drafting the primary and secondary pieces of legislation, the attribution of responsibilities showed where hurdles may occur, such as permitting procedures. Involvement from national agencies was crucial for avoiding possible delays with the necessary documentation.

3.2.2. CCS STUDIES

In the years following the Getica proposal, the interest for CCS prospects in Romania has expanded. In the past decade, Romanian research entities have consistently been involved in

EU funded projects to explore the potential for CCS and CCU. Currently, two such projects are ongoing, with due dates in 2022 (Strategy CCUS and Rex-CO_2), which have already published relevant findings. These research studies have brought a deeper understanding of potential storage sites, transport options and available technologies for CCS and CCU. However, they cannot provide the sort of fundamental know-how that can only stem from pilot projects and their real-world demonstration capabilities.

In the remainder of this section, we cover studies from the last 10 years to ensure relevance, going project by project.

Strategy CCUS

The assumption of the Strategy CCUS project (2019-2022) is that eight specific regions from seven EU member states are promising for CCUS development. From Romania, the port area of Galați was selected, out of 174 identified industrial and power facilities with total CO_2 emissions over 121.5 Mt/year.[34] The area met several key criteria: the presence of an industrial cluster, possibilities for CO_2 storage and/or utilization, potential for coupling with hydrogen production and use, existing studies, and political will.

The study sets out the industry's downward trend in the region. As the main large CO_2 emitters in the Galați area have been identified, out of the eight facilities with a total amount of emissions up to 4.56 Mt/year, only five units are active (three power plants, an iron and steel mill and a non-ferrous metals plant). As the single largest GHG emitter (92%), Liberty Steel Galați SA provides the impetus for adopting CCUS in the region, potentially becoming an aggregator for smaller sources in neighbouring Vrancea and Tulcea counties. Liberty Steel has said that it aims to become the world's first carbon-neutral steel company by 2030.

According to the study, in terms of CO_2 utilisation technologies, carbon dioxide enhanced oil recovery (CO_2-EOR) holds better prospects for implementation and could be the main initial focus for CCUS deployment in Galați. The industrial profile of the region leaves little room for other opportunities, since there are no major refineries or chemical facilities that could use CO_2 in conversion processes, nor is there a cement sector that could use CO_2 to produce cured cements or aggregates for construction. Therefore, the prospects for CCUS in the region revolve mainly around CO_2-EOR rather than other forms of utilization. The volume of emissions at the Galați steel mill is very large and not adequate for transport by road, rail, or river. The Liberty Steel complex is connected to the natural gas pipeline network that connects, with the western gas fields in the west, in one branch, and with the offshore fields in another branch.

[34] K Carneiro, J.F. and Mesquita, P. 2020. Key data for characterising sources, transport options, storage and uses in promising regions. EU H2020 STRATEGY CCUS Project 837754, Report, pp 170,

As the gas fields are still operating, reusing the pipelines may not be practical, but the same corridor allows for a CO_2 pipeline to be built.

The extensive work for Strategy CCUS draws on the expertise of 17 partners from the studied countries (Spain, France, Greece, Croatia, Poland, Portugal and Romania), and in the supporting countries (UK, Norway and Germany). Romania is represented by the National School of Political Studies and Public Administration (SNSPA), and the National Institute for Research and Development on Marine Geology and Geo-ecology (GeoEcoMar). The ongoing project with due date in April 2022 is funded from EU's Horizon 2020 research and innovation programme.

Rex-CO_2: Re-use of existing wells for large-scale CO_2 storage

The Rex-CO_2 project started in September 2019, aiming to develop a specific procedure and tools for evaluating the re-use potential of existing hydrocarbon fields and wells. 32 project partners provide inputs on technical, environmental, economic, and social aspects for the assessment of the existing well infrastructure to potentially reuse it for CO_2 storage. The consortium comprises several research institutions, operators, and regulatory authorities from six countries (US, UK, NL, FR, NO, RO). From Romania, the participant institution is GeoEcoMar, the national institute for geology, ecology, and marine environment.

As the 2019 project report[35] has pointed out, the first selected case study for Romania is the Salonta depleted gas field in Oltenia, given existing analyses on the geological CO_2 storage potential for the region. The main components of the well screening tool have been successfully developed, and at the end of February 2021 the beta version of the REX-CO_2 screening tool was completed.

According to the 2020 project report, the case study was supported by the ANRM and coordinated by GeoEcoMar. The latter also conducted a thorough analysis of the national regulatory framework comprising 10 legislative acts (including the GEO 64/2011, described in Section 2.5 of this report),[36] as part of the assessment study of policy, legal and environmental framework in the participating countries.[37] The analysis conducted by GeoEcoMar encompasses a range of regulations, including petroleum laws.

The REX-CO_2 outcomes are expected to facilitate large-scale CCUS implementation by providing a tool to evaluate and rank the CO_2 re-use potential of hydrocarbon fields. The developed

[35] REX-CO_2, 2019. Database development and the preparation of the national study for Stage 1.

[37] REX-CO_2, 2020. Deliverable D6.1 Report on the assessment of policy, legal and environmental framework in participating countries.

technology is not limited to a particular sector of CO_2 storage, but will accelerate all types of CCS.

ECO-BASE: Establishing CO_2 enhanced oil recovery Business advantages in south-eastern Europe (SEE)

Between 2017 and 2020, the ECO-Base project assessed the potential for CCUS through CO_2-EOR using an inventory of CO_2 sources (potential capture projects) and sinks (potential sites for CCUS through CO_2-EOR) in Romania and Turkey. The project's 2019 deliverables included a techno-economic study for the development of a CO_2-EOR chain for Romania, an analysis of legislative aspects and the potential for financial incentives, best practice guides for the implementation of a project of CO_2-EOR and dissemination activities.

The selected site for studying CO_2-EOR development in Romania was the Ișalnița-Brădești site in Dolj County, Oltenia region. Two cases were defined and simulated: a business-as-usual reference case (unabated CO_2 emissions and water injection in the Brădești field), and a CO_2-EOR case involving CO_2 capture from the Ișalnița plant, pipeline transport and CO_2 injection for storage and enhanced oil recovery in the Triassic oilfield of the Brădești geological structure.

Unsurprisingly, it emerged that full support from national authorities, especially at Parliament and Government level, is needed for CCUS technology implementation. A very important role is also played by local authorities, which can act as mediators between industry and the population, both in terms of acceptance of CO_2 capture and the possible influence of this technology on the price of electricity. The Romanian ECO-Base partners were GeoEcoMar, CO_2Club, and Picoil Consult. The project was funded by the EU's Horizon 2020 research and innovation programme.

Align CCUS: Accelerating Low Carbon Industrial Growth through CCUS

The ALIGN-CCUS project, conducted between 2017 and 2020, was designed to support the timely delivery of CCUS in six of Europe's industrialised countries, including Romania (Oltenia region). The project focused on optimising CO_2 capture costs and developing a guideline for emissions control, including 11 capture technologies.

The three-year project brought together experts from several research institutes and industrial companies to explore specific issues faced by the industry, in order to support quick and cost-effective deployment of CCUS. The project's technical research brought into focus real-life industrial clusters, where CCUS had been already considered a key technology for reducing the environmental footprint of operations.

The blueprint for Oltenia region in Romania will identify the most feasible CO_2 transport routes for future captured CO_2 from Oltenia's industrial cluster, and investigates suitable storage options, including the use of CO_2 in EOR. The report conducted for Romania also underlines that the use of captured CO_2 can be done in the oil tanks on the northern flank of Histria Depression.

The consortium of 34 entities included 4 partners from Romania. The provider of technical data was GeoEcoMar, while the SNSPA provided input for the public acceptance section of the report (see Chapter 3 for an overview of findings on public acceptance).

EU GeoCapacity: Assessing European Capacity for Geological Storage of Carbon Dioxide

26 partners (mainly geological research institutions) from 21 EU countries, including Romania, contributed to the three-year project, between 2006 and 2008. The project was co-funded by EU within the 6th Framework Programme of the European Community Research, Technological Development, and Demonstration Activities.

The EU GeoCapacity project produced an inventory of all storage locations across the EU with special focus on those countries not covered in previous projects, such as CASTOR[38]or Gestco.[39] A key objective of the project consists in building international cooperation between EU countries, China, and the members of the Carbon Sequestration Leadership Forum – European Commission, Romania, Ukraine, Germany, Poland, Norway, Serbia, Brazil, the United States and Australia.

All stationary CO_2 sources and potential sinks in Europe were mapped using GIS software. No estimation is available for coal fields storage capacity, while other previous studies outline that non-mineable coal seams are not the best candidate for CO_2 storage. Romania's contribution to the report consisted in two case studies for storage in depleted hydrocarbon reservoirs (Tătaru field and Ghercești-Malu Mare) conducted by GeoEcoMar.

3.3 Case studies

The following case studies, developed by international entities, bring into focus the Romanian landscape for CCU and CCS. Key aspects are tackled by each case study: geological storage potential, prospects for CCS development, and the regulatory framework.

[38] CO_2, from Capture to Storage (CASTOR).

[39] GETSCO Summary Report, 2004. Geological Storage of CO_2 from Combustion of Fossil Fuel.

State of Play on CO_2 geological storage in 28 European countries (CGS Europe) (2013)[40]

The report brings in forefront relevant details about storage options, potential and capacities across Europe, through research activities on CO_2 storage conducted by CGS Europe partners. It includes an assessment of demonstrative projects and of the transposition of CCS Directive in CGS Europe countries. The report was prepared in the framework of the FP7 EU-funded "Pan-European Coordination Action on CO_2 Geological Storage."

At the time of the report, 18 large-scale CCS projects were planned in the UK, the Netherlands, Poland, Italy, France, Spain, Romania, and Bulgaria. Most of these involved CO_2 capture from power plants. For Romania, the report only mentions the national funding for research related to CO_2 Storage, namely, "National Programme for Carbon Capture and Storage (CCS) time horizon 2020" (2010-2011) and "Optimal integration of CCS technology" (2012) supported by the Ministry of Economy, Trade and Business Affairs. Research on CO_2 storage was also budgeted in several commercial contracts between GeoEcoMar and ISPE (Institute for Studies and Power Engineering), including "Identification of storage possibilities for the CO_2 emitted by Rovinari and Ișalnița power plants" and "Feasibility Study for GETICA CCS."

Our future is carbon negative: A CCS roadmap for Romania (Bellona Foundation, 2012)

In this roadmap, the Bellona Foundation focused solely on CCS, as a climate change mitigation technology, and tenable strategies for its large-scale implementation. 19 primary actors and stakeholders for CCS were identified from the private sector, NGOs, and research and technical institutes, most of them being involved to some extent in the GETICA demonstration project.

The roadmap examines CCS implementation on two possible energy trajectories: the Romanian Energy Policy (ROEP Trajectory) and the High Coal Substitution (HCS Trajectory), using different fuels and technologies. The scenarios were designed as a tool to provide information on the efficient implementation of CCS and to describe as accurately as possible the cost and benefits of CCS in the Romanian energy generation sector. The roadmap is as a valuable resource to inform a future national CCS deployment plan.

The experts that conducted the assessment consider that by focusing on the expertise acquired in more than a century of industrial oil and gas activity, Romania could position itself as a key provider of CO_2 storage to other nations. Existing wells and redundant gas pipelines

[40] Rütters, H. and the CGS Europe partners (2013) - State of play on CO_2 geological storage in 28 European countries. CGS Europe report No. D2.10, June 2013

may be repurposed to transport and inject CO_2, so the necessary investments may be reduced while increasing the competitive advantage of the country.

Romania – Case Study on the implementation of Directive 2009/31/EC on the geological storage of CO_2 (2011)

The 2011 case study conducted by Professor Monika Jozon from University College London sets out that the Government Emergency Ordinance (GEO) 64/2011, Romania's transposition of EU CCS Directive,[41] was only a starting point in the process of implementing Directive 2009/31/EC (the EU CCS Directive). With no authorization, monitoring, control procedures and specific attributions and responsibilities drawn for central authorities or administrative bodies, GEO 64/2011 is rather a formal translation and not an enacting law. The GEO was issued as the framework law on geological capture and storage of CO_2, primarily to facilitate the necessary conditions for the implementation of the Getica project. The case study explores the policy objectives for CCS and the Getica demonstrative project and highlights that GEO 64/2011 lacks details on procedural rules and refers to a large set of other laws.

GEO 64/2011 empowered the National Agency for Mineral Resources (ANRM) as competent authority on geological storage of CO_2 and main issuer of geological storage licenses, with the National Environmental Guard (NEG) sharing monitoring and inspection responsibilities. Although the provisions of GEO 64/2011 designated ANRM as the main implementing authority, and an enlarged set of attributions should have followed, its current powers remain limited to issuing storage licenses.

The case study has highlighted as issues with GEO 64/2011 the long-term liability requirements, the transfer of responsibility, the conflicting uses of storage sites, the lack of differentiation between onshore and offshore storage, and the lack of regulation of financial CCS incentives. It has also pointed to the lack of public participation in decision making on CCS. There is no dedicated public body in Romania responsible for dealing with public engagement in CCS projects, and the opportunities for participation of local communities and non-governmental organisation are limited.

The Romanian case study dedicated to the implementation of Directive 2009/31/EC is part of the Carbon Capture Legal Programme work, initiated in 2010 to analyse the transposition of the CCS Directive in six European countries (UK, Germany, Norway, Spain, Poland and Romania).

[41] EU Directive 2009/31/EC on the geological storage of carbon dioxide

4. Legislation and regulation relevant for CCS deployment

4.1. Key laws and regulations for CO_2 geological storage

2011: GEO 64/2011 regarding the geological storage of CO_2

Romania's preparation for transposition of the EU's Directive 2009/31/EC on the geological storage of CO_2 (henceforth the CCS Directive) into national legislation started in early 2010. The Ministry of Environment and Forests was in charge and set up a Working Group that involved several authorities – four ministries, ANRE, ANRM, National Environmental Protection Agency (ANPM), National Environmental Guard, and Institute for Studies and Power Engineering Romania (ISPE).

The transposition of the CCS Directive in Romanian law took place by means of GEO 64/2011 regarding the geological storage of CO_2. As indicated by Jozon (2011),[42] GEO 64/2011 aimed to facilitate the implementation of the Getica CCS Demonstration Project, since full and effective transposition was imperative for the project's funding. However, this was not accompanied by the adoption of the needed regulatory framework for actual operation of the demonstration plants. In effect, GEO 64/2011 only provides a minimal institutional set-up and is lacking in procedures such as authorization, monitoring, and control. Notably, there is no mention of enhanced hydrocarbon recovery (EHR). The GEO's supporting note stated that ''within 12 months from the entry into force of the GEO, the Ministry of Economy, Trade and Business Environment will issue a Government Decision regarding the establishment and supporting schemes dedicated to carbon capture, transport and storage of CO_2 technologies." Despite this, no such support scheme has ever been introduced.

2013: Law 114/2013 for the approval of GEO 64/2011 regarding the geological storage of CO_2

GEO 64/2011 was finally approved two years later by Law 114/2013 in a rapid parliamentary procedure, with little debate. A few additional clarifications were brought regarding the conflicting use of geological formation for oil and gas operations and storage, and its regulation along the duration of the exploration licence.

2015: Procedure for granting the exploration permit for CO_2 geological storage (ANRM)

ANRM, the competent authority for CCS operations, set up a dedicated service for CO_2 geological storage in 2013, which coordinates the elaboration of procedures for granting

[42] Jozon, Monika (2011), Case studies on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide Romania, University College London

exploration and storage permits. According to Procedure 5 of April 30, 2015, operators may ask for ANRM an opportunity analysis for underground CO_2 storage in a selected perimeter. In case the analysis is favourable, ANRM issues a selection of offers for that perimeter. Alternatively, the agency can issue a list of opportune perimeters and call for exploration offers. The selection of offers is based on a set of criteria established by ANRM, with the winning bidder further negotiating for supplemental exploration works and a plan for environmental restoration. Once the final documents are agreed upon, ANRM issues the exploration permit and puts it up for 30 days for public consultations. The final exploration permit is issued by ANRM for the duration of works proposed in the offer, with a 2-year possible extension for additional works, if needed for evaluating the capacity of the storage complex.[43]

2017: Procedure for granting the CO_2 geological storage permit (ANRM)

The procedure for granting a CO_2 storage permit was established through Decision 16/2017 of the ANRM President. According to it, the holder of an exploration license can directly obtain the storage permit if they submit the application during the validity of the exploration license, and provided they have met all her exploration obligations (at a minimum, technical documentation on the planned storage site and its spatial delimitation). The owner of a petroleum agreement can also directly obtain a CO_2 storage permit if they submit the application before the end of the agreement, provided all the conditions specified in it were fulfilled. On the other hand, ANRM can grant storage permits competitively, by means of a bidding process (this process is detailed in ANRM Procedure 16/2017, yet no bid has taken place or been announced to date).

ANRM is obliged to notify the European Commission within 30 days of the tender completion by sending the request for storage permit, accompanied by all the related documents. In up to four months, the Commission shall issue a non-binding opinion. ANRM takes this into consideration, modifies the draft storage permit if necessary, and initiates public consultation (lasting 30 days). In 15 days from the end of public consultation, ANRM may include public proposals in the draft storage permit.[44]

2018: Guideline for preparing the documentation by operators/owners: Notification regarding the abandonment of offshore wells and disaffecting the facilities (ACROPO).[45]

[43] REX-CO2, *Report on the assessment of policy, legal and environmental framework in participating countries*, August 2020, p. 27 – project funded through the ACT program (Accelerating CCS Technologies) within Horizon 2020.

[44] Idem, p. 30

[45] ACROPO, 2018. Ghid de intocmire a documentatiei de catre operatori/proprietari.

The Regulatory Authority for Offshore Petroleum Operation in the Black Sea (ACROPO) was established in 2016 with the task of regulating and monitoring the safety of offshore petroleum operations, as well as to counsel ANRM on granting future of offshore petroleum licences in the Black Sea. The Guideline for the abandonment of offshore wells was issued by ACROPO in December 2018. Its application is mandatory for operators, owners, and subcontractors with activities in the Black Sea who must document any substantial changes brought to an offshore facility, as well as moving away from a fixed facility. Such operations bring an opportunity to reuse depleted offshore hydrocarbon wells in different ways, including CO_2 injection and storage.

It should be highlighted that CCS and CCU are notably absent from Romania's national energy strategy and National Energy and Climate Plan 2021-2030. Two carbon capture and utilization projects were proposed as part of Romania's Recovery and Resilience Plan, involving the injection of hydrogen into gas turbines, capturing CO_2 released from combustion, and transporting it to local greenhouses for use. The rationale behind these projects, proposed as hydrogen demonstrators, is unclear, and indeed they have been criticized for lack of transparency in establishing the implementing consortium.

4.2. Relevant institutions

In Romania, the central public authorities have sole legal competence for framing and implementing policies on geological storage of CO_2.

- **ANRM** is under the direct coordination of the Romanian Government. Given the similarities and notable experience in standardizing the oil and gas extraction activities, ANRM stands as the main implementing authority for capture and geological storage of CO_2, being responsible for issuing exploration and storage licenses, developing specific procedures, registering the granted storage permits, approving responsibility transfer and verifying compliance with the legal requirements during operation, closure, and post-closure periods. As a rule, ANRM also coordinates the assessment of the storage sites and the available storage capacity. According to the reasoning document for GEO 64/2011, ANRM's attributions and competencies shall be enlarged. However, to this date the CO_2 geological service is still underdeveloped, with no more than two persons running the office.
- **ANRE,** as per the legislation in force, is mandated to issue transport licences for CO_2 while ensuring a transparent and non-discriminatory access

to the CO_2 transport networks. To this date, no standing order has been the subject of public consultation or approval.

- **Local authorities (City Hall, County Council)** play an essential role, conducive to the issuance of building permits for transport pipelines or any plans for site construction under their jurisdiction.
- **The Ministry of Environment, Waters and Forests** has a rather supervisory role, with no substantial attributions.
- **The National Guard on Environment (NGE)** is responsible for monitoring sites through routine and impromptu inspections.
- **The National Environmental Protection Agency (ANPM)** approves the monitoring plans proposed by operators.
- **The Ministry of Energy** develops and implements the National Energy Strategy or any other strategic or programmatic document related to the energy sector.
- **The Ministry of Economy**'s role is underdetermined for CCS/CCU projects. Back in 2010, the Ministry of Economy, Trade and Business Environment was the main authority responsible for the GETICA CCS pilot project, and should have drafted and approved the support schemes for CCS technologies.

4.3. Regulatory hurdles

Lack of institutional capacity and unclear role for the responsible institutions

Following the transposition of the CCS Directive and subsequent legislative acts, no new central institution was set up for the implementation of the geological storage of CO_2 in Romania. The legislation in force and the existing governance structure appears very fragmented.[46] For every phase of the process, several hurdles must be overcome. Due to the novelty of the capture technology and lack of experience at institution level, various challenges are expected for the environmental impact assessment, which is critical to the issuance of the building permits.[47]

[46] Jozon, Monika (2011), Case studies on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide Romania, University College London

[47] Feasibility Study Overview Report to the Global CCS Institute, Getica CCS Demo Project, RO, 2011

For transport, Law 255/2010 on expropriation for public utility purposes should be amended to include CCS projects as projects of public utility, which would reduce the bureaucratic burden of the terms and procedures for obtaining required approvals. The provisions of this law do not apply to the environmental permitting procedures.[48] So far, no exploration permit for CO_2 storage has been issued, although the secondary legislation for granting exploration permits and storage permits has been established.

In case of leakage and non-compliance with the existing standards, ANRM is the empowered institution that can impose measures to the detriment of the Ministry of Environment, Waters and Forests. The National Environmental Guard (NEG) is in charge of routine investigation, whereas the ANRM will take any necessary measures following these investigations. The division of responsibilities between the National Environmental Guard and the ANRM is an unusual institutional arrangement and may affect the effectiveness of intervention in the case of harm caused to the environment or human health by storage projects.[49]

Regional and local authorities have no role in drafting legislation. However, the lack of additionally funds for the competent authorities to fulfil of their tasks as stipulated in GEO 64/2011 may prove problematic.

Absence of the regulatory framework for wells reuse (for enhanced oil recovery, CO_2-EOR)

Romania does not yet have specific regulations and standards for CO_2 wells or for the reuse of oil wells. Romanian regulatory acts only establish the conditions for temporary and permanent abandonment of wells, the lifting of abandonment and the transfer of assets between hydrocarbon license holders.

Technical projects for conservation and abandonment (including technical ones for lifting the abandonment/conservation of wells) drawn up by the holder, plus the approvals/agreements issued by the ANRM do not contain data about the geological resources and oil reserves within the commercial deposit.[50]

The transfer of rights is permitted only for hydrocarbon operations so far. The title holder of any oil agreement may transfer its acquired rights and obligations to another operator with the explicit approval of the competent authority (ANRM).

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[48] CCS regulatory test toolkit for Romania, Global CCS Institute, 2011

[49] Jozon, Monika (2011), Case studies on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide Romania, University College London

[50] REX-CO2, *Report Phase I, Data base and national study development, 2019*

Pipeline construction, at the junction of plentiful permits and local authorities' concerted actions

The main challenges in this area will likely occur for planning requirements, as well as for obtaining the building permits for the pipeline. Assuming the pipeline will cross several counties, multiple building permits must be issued for the respective sections. Therefore, the coordination between local public authorities will be essential.

Romania is still in the process of conducting cadastral surveys at the national level. Thus, it may be time-consuming to identify all the land-owners and obtain their approval for building the pipeline.[51]

Undifferentiated framework for onshore and offshore projects

Neither GEO 64/2011, nor Law 114/2013 contain any provisions for offshore storage projects. Such terms are not even mentioned in the content of the legislation. Most likely though, in practice, distinct regulations will have to be put in place for offshore projects.

Lack of public participation and stakeholder engagement

The opportunities for public participation in decision-making on CCS are weak and unsatisfactory. There is no dedicated public body in Romania responsible for dealing with public engagement in CCS projects,[52] and the opportunities for participation of local communities and non-governmental organisations are rather limited.

4.4. Solutions and Incentives

The Romanian CCS Regulatory Framework Toolkit, developed in 2011, underlines that institutional capacity needs to be improved for the permitting process, with key local authorities and agencies to be involved from the early stages of the process. The environmental authorities must decide upon the divided or integrated approach of the CCS components. For a coherent approach, the recommendations included the creation of small inter-ministerial working groups, and the elaboration of action plans assigning responsibilities at ministerial level.

A special matrix was constructed with the aim to address and overcome the main challenges. Its purpose was to generate a comprehensive list of necessary approvals and authorizations for different stages of the CCS project (construction, operation, decommissioning), and to

[51] Permitting Report to the Global CCS Institute, Getica CCS Demo Project, RO, 2011

[52] Jozon, Monika (2011), Case studies on the implementation of Directive 2009/31/EC on the geological storage of carbon dioxide Romania, University College London

determine which procedures for permit approval could run simultaneously, to streamline the permitting timeframe. This process may include environmental approvals, building permits for transport pipelines and storage licenses, which were considered "show-stopper" permits.

Identified overlaps in permits or attributions of relevant authorities, to increase the management efficiency between public authorities and operators, were also included in the matrix. Furthermore, there is a need for improving data access on existing wells, carrying out hydrogeological assessments in respect of carbon storage and increasing institutional capacity for elaborating secondary legislation. In addition, the ANRM and ANPM should set out a methodology for their collaboration on GHG monitoring plans (a recommendation that was explicitly written in the toolkit for Getica, but that has not happened to this date).

According to GEO 64/2011, the development works of CO_2 transport and storage are of national interest, which may help reduce the permitting timeframe;[53] however, care must be taken in "fast-forwarding" projects of national interest and bypassing public engagement phases. An understanding of the legal framework related to full chain CCS technologies should be continuously enhanced through knowledge transfer workshops and conferences at international, EU and national level, including requirements for public consultation and social awareness. The aims of CCS knowledge-sharing and communication strategy are developing an appropriate legal framework through institutional capacity-building, and raising public awareness on to the role of CCS in mitigating climate change.

Prospects and opportunities for wells reuse may also come up after the identification of conserved and abandoned wells. As a rule, only title holders may start the work for well conservation or abandonment, based on the strength of the technical project of the well. The technical project for well conservation and abandonment must be executed by an engineer certified by ANRM. Such projects provide the necessary information (including technical, economic, and environmental) to identify and assess the well's reuse potential.[54]

4.5. Best practices

The Norwegian CCS projects were incentivised by a carbon tax introduced in 1991 as a mechanism to reduce CO_2 emissions from oil and gas activities on the Norwegian Continental Shelf

[53] Permitting Report to the Global CCS Institute, Getica CCS Demo Project, RO, 2011
[54] Idem, p. 7

(NCS). For Sleipner and Snøhvit projects, the CO_2 is separated from produced natural gas and re-injected into the subsurface in operation in the North Sea. The Norwegian Petroleum Directorate has done initial mapping of the entire Norwegian Continental Shelf for potential sites for CCS. In 2011, Gassnova[55] was given the mandate to explore the possibility for full-scale CCS on NCS. Thus the Northern Lights project was developed, with partners such as Equinor, Shell and Total. As outlined in the Norwegian model for re-using existing wells, if CO_2 injection is a part of a petroleum operation, the holder of a petroleum licence may re-use wells for CO_2 injection. Change of ownership of existing infrastructure is permitted, but the original owner will maintain secondary liability for decommissioning of the infrastructure at the change of ownership.

The Dutch government included CO_2 storage into its the national decarbonisation strategies. Previously, the Dutch Mining Act required the decommissioning of all infrastructure after use. This requirement was raised as a potential barrier to the deployment of CCS. The government's involvement in the decommissioning process and initiatives was fundamental. Established in 2017, NextStep is a joint initiative between EBN (the Dutch state participation in domestic exploration and production operations) and the Dutch oil and gas industry, which aims to stimulate and organize the reuse of oil and gas infrastructure in the Netherlands.[56]

The UK's Department for Business, Energy and Industrial Strategy (BEIS) is responsible for developing policies related to CCS across the board. BEIS conducted a consultation process to support the development of new policy relating to the re-use of existing oil and gas infrastructure for CCUS. Among the recommendations available since August 2020 for a timely ramp-up of CCS, the UK is committed to ensure regulatory coordination on CCS and hydrogen development (i.e., to provide a proactive regulatory support for CCS and hydrogen projects, ensuring guidance to permit the timely execution of pilots and subsequent ramp-up of these novel technologies in the 2020's). [57]

[55] Gassnova was established by the Norwegian authorities in 2005 to further the development of technologies and knowledge related to carbon capture and storage (CCS) and, in addition to this, serve as the adviser to the government on this issue.

[56] Idem, p. 10

[57] UKCS Energy Integration Final report, Annex 2. Carbon Capture and storage, August 2020

Chapter 2. Romania's outlook for CCS and CCU

This chapter presents the outlook for CCU and CCS in Romania. It is supported by the stakeholder engagement conducted as part of Work Package 3, focusing on the current status of CCU/CCS in Romania as perceived by stakeholders, as well as recommendations for accelerating deployment of CCU and CCS technologies in Romania and the CEE region.

1. Summary of stakeholder engagement

The main relevant stakeholders for CCU and CCS were engaged through interviews, written responses and an online workshop held on May 7th, 2021. In total, 19 stakeholders were engaged through interviews (18) or written responses to pre-set questions (1), and 22 participated in the online workshop. 13 of the 22 workshop participants had already been or were subsequently interviewed. As this section aims to assess in-depth stakeholder opinions, only stakeholders that participated in interviews are covered. Most stakeholders (11 out of 19) were private companies, including one industry association. 3 public institutions, 4 universities and 1 NGO were also engaged. Bar the industry associations, which represented the Romanian cement and lime producers, all stakeholders represented themselves (i.e., they represented either their personal opinions or the position of their company).

The stakeholders were selected for engagement based on their involvement with CCS/CCU projects and studies, and on their potential role in driving forward activities in this area. As such, private sector engagement focused on large emitters, including energy generation (1, Elcen), cement production (3, including CIROM, Romania's association of cement and lime producers, and Holcim Romania), chemicals production (2, Chimcomplex, the country's largest chemicals manufacturer, and AzoMureș, the main fertilizer producer), metallurgy (1) and gas production (1). Other private sector stakeholders were research institutions (1, Institute of Power Studies and Engineering, who played a central role in the technological and communication aspects of the Getica project) and a CCS expert working in the power generation industry but representing themselves as an individual (Dr Carmencita Constantin).

The engaged public institutions were the Ministry of Energy and the Ministry of Environment, as the main institutional actors key to CCU/CCS integration in national energy and climate strategies, and ANRM as the competent authority for issuing CO_2 storage permits. The academic stakeholders were selected based on their contribution to CCU/CCS research: GeoEcoMar, the main driver of CO_2 storage research, Babeș-Bolyai University, a leader in CO_2 capture research, an academic from the Polytechnic University of Timișoara, head of a pilot carbon capture plant, and two academics with experience in petroleum engineering and social aspects of CCS, respectively. The engaged NGO was Bankwatch Romania, with a firm anti-fossil fuels stance.

Notable absentees

A notable absentee in the stakeholder engagement was the Oltenia Energy Complex (OEC), Romania's largest CO_2 emitter and the planned site of the country's only CCS demonstrator proposal to date, the 2012 Getica project. The company turned down invitations to participate in interviews, and their absence from the workshop was remarked upon by participants. It is unclear as to the reason for their lack of participation. Meanwhile, a restructuring plan for the OEC is still in discussions with the European Commission and is likely to involve a transition to natural gas and renewables.

Several other key stakeholders turned down invitations to participate in the project, namely large operators from the primary steel production sector (including the steel producers' trade union) and one of Romania's largest petroleum companies. Their refusal for participation is unclear; it is known that steel manufacturers are focusing on other emissions reduction methods,[58] however it is unknown whether this was the motive behind their lack of participation. Another stakeholder which was not engaged at this stage of the project was the Ministry of Economy which, despite its key role in Romania's Getica Demonstrative CCS project, currently holds no identifiable knowledge of CCS.

Stakeholder representation concerns

Some stakeholders (all 3 institutions, 3 private sector companies and 2 academic stakeholders) did not wish to be associated with their organizations and addressed the interview questions from a personal perspective. This indicated a level of trepidation at publicly sharing views on CCU/CCS, which is likely due to the overall immaturity of the CCU/CCS discussion in Romania and the overall lack of concrete plans and strategies, resulting in a general unwillingness to make statements on behalf of an organization as to positions on or plans for CCU/CCS implementation. It should also be noted that 5 stakeholders also wished to be anonymized,

[58] Liberty Steel Group, 2021. Vision - LIBERTY Steel Romania.

including removal of any indication of their role. However, a few stakeholders were enthusiastic about being named, with one suggesting that given their history and expertise in the CCU/CCS area, this may help accelerate the debate on this topic in Romania.

2. Stakeholder positions on CCS and CCU

2.1. Position on CCS and CCU

Most stakeholders (12) were classified as pace-setters, given the inherent selection bias of stakeholder engagement. However, it should be noted that of these stakeholders, 3 responded with a personal view, and do not necessarily qualify their organization as a pace-setter. This is the case for Dr Carmencita Constantin, a long-standing CCS advocate and former head of Energy and Environment at the Institute for Power Studies and Engineering (ISPE), an research institute with significant involvement in the Getica demonstrative project proposal. Dr. Constantin currently works for General Electric, which cannot be classified as a pace-setter for CCS.[59] Similarly, academics are driving carbon capture research, but their universities cannot be said to be actively promoting CCU/CCS (fence-sitters), and engaged representatives of the Ministry of Energy are also promoting CCU/CCS, while the ministry itself lacks a coherent position on CCU/CCS.

Seven stakeholders were classified as fence-sitters, notably the representatives from the Ministry of Environment and ANRM, as well as a major natural gas producer (despite one expert stakeholder sharing that the demand for CCS has shifted from the power sector to oil and gas producers). This reinforces the image of a certain trepidation towards expressing strong views on CCS at organizational level, with some key stakeholders adopting a "wait and see" approach in the absence of official commitment to CCS.

Finally, two stakeholders were classified as foot-draggers, but interestingly not for CCU or CCS overall. Bankwatch, a leading environmental NGO firmly opposed to fossil fuel use, is classified as a foot-dragger for CCS applied to the energy industry (given its high-risk nature and support for business-as-usual energy use) but is ambivalent about CCS for heavy industry. Chimcomplex, Romania's largest chemicals manufacturer, is a pace-setter for CCU with a long history of CO_2 utilization in the production of plastics, but a foot-dragger for CCS, due to the unproven nature of storage technologies. The latter point also raises the issue of a

[59] Despite the global GE group having a positive position on CCS (including gas-fired power units with CCUS capabilities), GE Romania does not exhibit any significant activity in this sector.

possible dissonance among some stakeholders regarding the proper understanding of the entire CCU/CCS technology chain, for which the overwhelming volume of captured CO_2 will need a definitive storage solution.

Most stakeholders (12) argued for CCU/CCS primarily due to emissions reduction benefits, while others cited emissions reduction as a secondary benefit, focusing on economic benefits (lower expenditure on emissions certificates, potential for continued use of fossil fuel reserves). A highlight was the tendency of stakeholders to prefer CCU over CCS, which was shared in three interviews and was supported by most workshop participants. The primary reason cited for this tendency in the workshop was the idea that storing CO_2 underground is equivalent to leaving it for other generations to address, and that Romania cannot become a CO_2 storage hub as this will result in "bags of CO_2" accumulating underground. Other reasons cited in individual interviews are the unproven nature of storage technologies (Chimcomplex), the dependence of CCS on government action and the lower leakage risk of CCU given less time spent in storage. Connected to this reservation is the reticence expressed by some stakeholders regarding the prospect that Romania may become a regional hub for underground CO_2 storage.

2.2. Stakeholders' activity and influence on CCU/CCS

Most stakeholders had at least some activity or projected interest in CCU/CCS. Seven of them were classified as having high influence on CCU/CCS activity, while six were classified as having high influence on the subject matter given their prior expertise and knowledge.

Regarding influence on CCU/CCS activity, several key stakeholders emerged. GeoEcoMar, with its driving role in the Getica project, active participation in international CCS networks and projects, and plans to bid for funding for continued research in CO_2 storage and transportation, has emerged as a leader on CCS studies and projects in Romania. From the private sector, the cement industry was shown to have high influence on CCS activity, given the size of unavoidable emissions and important role in Romania's heavy industry, as well as the commitment of CIROM (Romania's association of cement and lime producers) for its members to become carbon-neutral by 2050 and Holcim's experience in pilot carbon capture projects in other countries, which they are evaluating for application in Romania. Similarly, gas and power producers, as well as chemicals manufacturers, have a potential high influence on CCS activity, depending on their interest in pursuing these technologies.

The steel industry could also have high influence on CCS activity. However, as highlighted above, it was not meaningfully engaged in this stage of the project, in general seeming to focus on other emission reduction methods for otherwise ambitious climate neutrality targets (e.g., Liberty Steel's GREENSTEEL strategy for steel recycling and commitment to reach carbon neutrality by 2030).[60]

On the research side, ISPE stood out as having high influence on CCS activity, given their role in technology and social acceptance surrounding CCS projects. From the institutions' side, the Ministry of Energy and ANRM have a high influence on CCS activity. Despite their lukewarm position as a fence-sitter, ANRM has supported Romania's contribution to the Rex-CO_2 project and is currently reviewing a CCS project proposal by HeidelbergCement, one of Romania's largest cement producers. Finally, Bankwatch, the single NGO engaged in this stage of the project, has a potential high influence on CCS activity given their history of activism, particularly in the context of Romania's 2010 anti-fracking protests.

An interesting note is that only four stakeholders were classified as having both high influence on the subject matter (expertise and knowledge) and high influence on CCS/CCU activity (strategic importance or investment capabilities). This indicates that actors who could potentially drive CCS activity may not yet be knowledgeable enough about the subject matter to exert influence in this respect.

3. In-depth stakeholder perceptions of the CCU and CCS landscape

Given the immaturity of the CCU/CCS discussion in Romania, very few stakeholders had explicit positions on the topic. However, the interviews and workshop highlighted several key messages across stakeholder groups.

3.1. Overall prospects for CCU/CCS in target country

Most stakeholders agreed that Romania has sizeable advantages in terms of geological storage of CO_2 in onshore saline aquifers.[61] Others highlighted good prospects for CCS given Romania's relevant industrial sectors, including upcoming oil and gas exploration activities in the Black Sea, the communist-legacy proximity of emitters to oil and gas reservoirs, and continuing reliance on fossil energy. They were split on the advantage posed by Romania's lengthy oil and gas history, with some (including GeoEcoMar) raising concerns over the "sieve-

[60] Liberty Steel Group, one of Romania's largest CO_2 emitters, is exploring the potential for using hydrogen to power steel production, which could involve carbon capture if "blue" hydrogen is employed.

[61] One expert stakeholder highlighted that, unfortunately, saline aquifers are less well-understood than depleted oil and gas reservoirs, which have a much lower total capacity.

like" nature of the numerous extraction wells, and others pointing out the advantages of technological and geological know-how associated with the extraction industry.

While most stakeholders' positive view of Romania's storage potential led to overall optimism of CCS prospects, some were doubtful, given the reliance on government support and the uncoordinated political narrative around this subject matter. Some actors were optimistic in their timeline for potential implementation of CCS projects, in particular chemical manufacturers, given their already-existing CO_2 utilization activities. Others were more pessimistic, envisaging CCS installations to only be implemented in several decades.

In terms of explicit positions on CCU/CCS, several stakeholders are actively involved in exploring the subject matter and potential action: Chimcomplex and Azomureș, the two chemical industry actors engaged in this stage of the project, are already capturing and utilizing carbon by binding it to chemical products such as plastics; academic stakeholders, particularly GeoEcoMar and Babeș-Bolyai University, are actively researching the subject; for its part, Bankwatch has publicly stated its position on CCS for the energy industry.[62]

3.2. The role of CCU/CCS in sector integration

All stakeholders who discussed this topic, including the cement and steel industries, were positive about the role of CCU/CCS in driving sector integration, in particular through industrial clusters, which could lead to the formation of new horizontal business opportunities, including CO_2 transportation and the valorisation of hydrogen. Indeed, it was a consortium that brought forward the proposal for the Getica project, outlining explicit commitment to sector integration from partners such as GeoEcoMar and ISPE. Other former consortium partners did not discuss the subject of CCU/CCS as part of this project.

One academic stakeholder stated that although industrial clusters would benefit CCS development, Romania's economy is not ready to set them up. In terms of who should take the lead on these clusters, GeoEcoMar said the government would be required to coordinate it, while another expert pointed out that the investment lead must be taken by oil and gas companies, who should be forming these hubs alongside emitters. Two stakeholders, one from the gas production sector and the other from ANRM, suggested that Romania could become

[62] Bankwatch, 2020. Just Transition Fund needs stronger safeguards on inclusion and decarbonisation.

a CO_2 storage hub for neighbouring countries' emissions – however, this idea was met with considerable resistance in the stakeholder workshop.

3.3. Awareness of EU policy and regulation for CCU/CCS

Most stakeholders were aware of the EU CCS Directive and its transposition into Romanian law and highlighted the role of rising carbon prices in the EU ETS as a major incentive for future interest in CCS. ISPE also envisaged future EU CO_2 transportation regulations covering Romania. However, several stakeholders perceived a lack of clear regulation and targets at EU level, with the major focus being instead on renewable energy.

3.4. Perceived deployment barriers and risks

Most stakeholders identified a suite of barriers to the deployment of CCS/CCU in Romania. These can be broadly categorized into institutional, regulatory, cost, financial, technology, infrastructure, social, knowledge and other barriers. Overall, the lack of government involvement and high costs of CCS were of concern to most stakeholders, primarily to academic and private sector stakeholders. The lack of state involvement was also manifested in the lack of transportation and storage infrastructure, which stakeholders believed are the state's responsibility for funding and constructing – although some highlighted potential business opportunities for new CO_2 transportation companies.

<u>Institutional barriers</u>

- Lack of government involvement. This was the most-referenced barrier by stakeholders (7 of them explicitly mentioning it) who called for more coordination at government level to accelerate CCU/CCS deployment. One academic stakeholder highlighted the attitude of "shutting down fossil fuel use" rather than exploring CCU/CCS options, which could cause job losses and social challenges (however, this comment ties CCS with fossil fuel use, a potentially narrower view of CCS potential than the debate at EU level, which speaks of the need for CCS for process emissions in the heavy industry). The lack of government coordination was exemplified by one stakeholderȘ the re-assignment of responsibility for emissions certificates from the Ministry of Economy to the Ministry of Energy, without an associated transfer of knowledge and qualified personnel.

- Lack of industry involvement. Although most stakeholders criticized the lack of government involvement, some also highlighted the lack of initiative from industry, with ISPE noticing that, for example, cement companies are already undertaking significant activity on environmental issues in other areas, and that the initiative should come from the oil and gas industry.
- Changing political attitudes towards CCU/CCS.
- Lack of enthusiasm for CCU/CCS.

Regulatory barriers

- Lack of an appropriate regulatory framework. It was interesting to note the split of stakeholders on this topic, with some stating that all necessary regulation for CCS deployment exists in Romania, and ANRM itself criticizing the lack of legislative updates and absence of CO_2 injection from key regulatory frameworks, such as petroleum law.
- Lack of targets and obligations related to CCU/CCS, with one stakeholder pointing to the EU as well as Romania as falling short in this respect.

Cost

- High costs and long investment timeframes. This barrier was the most-referenced one (7 stakeholders), with a stakeholder from the cement industry highlighting potential impact on final product prices. Other associated concerns were the lack of a protection mechanism for end products with lower embodied emissions, cost uncertainty and the lack of ability to invest alone.

Financial

- Lack of funding, including research funding, which can drive out young researchers, the lack of financial frameworks for CCS at EU level, and inefficient subsidy mechanisms.
- Lack of state aid. In particular, funding from state actors was highlighted as a concern, both at EU and state level. One stakeholder also pointed out the lack of clarity on EU financing (e.g., the inclusion or exclusion of natural gas from European Investment Bank funding).

Technology

- Low technological maturity. This barrier was highlighted by 5 stakeholders, in parallel with others identifying a low number of ongoing projects. Azomureș pointed to low maturity as an issue for CO_2 transportation, whereas CC technologies are seen as mature enough. Other stakeholders referred generally to a low maturity of technologies related to CCS/CCU.

Social

- Public opposition. Stakeholders highlighted past negative experiences with public opposition to fracking; Babeș-Bolyai university stated that in Western Europe, social acceptance for onshore CO_2 storage is so low that it is not even communicated anymore.
- Opposition from the press, particularly from local media.
- Low level of understanding, both from public and local authorities.
- Low priority of environmental issues amongst members of the public.
- Reticence towards underground CO_2 storage.
- Susceptibility of public to exaggerated claims or react to fake news.

Infrastructure

- Lack of storage and transportation infrastructure, highlighted by 3 and 2 stakeholders, respectively, and one identifying both as an issue at EU and Romania level alike.
- Old age of power generation capacities, resulting in very low efficiency of capture.

Knowledge

- Lack of knowledge and resources. Six stakeholders identified this barrier, including issues such as missing digitalization of information, lack of CCS specialists and institutional capacity and absence of CCS specialized companies, as well as lack of effort to exploit existing knowledge. Two of them identified a lack of in-depth studies on geological storage capacity, and another a lack of specific studies on using the gas network for CO_2 transport.

<u>Other</u>

- Safety risks from geological storage. This barrier was only highlighted by two stakeholders in interviews, but supported by most workshop participants. It was also related to the "sieve"-like nature of Romania's surface geology, given the extensive history of oil and gas drilling.
- Reticence towards future investments in natural gas at EU level, coupled with the lack of a narrative around gas as a transition fuel in Romania.
- The disparate nature of depleted oil and gas reservoirs, highlighted by an academic oil expert.
- Invasiveness of capture technology (need to retrofit sometimes sizable capture units, particularly for cement plants) and associated energy penalty (50-125%, according to a stakeholder from the cement industry).
- The administrative burden of obtaining storage exploration licences

4. Stakeholder recommendations for CCU/CCS

The stakeholders engaged in this stage of the project offered recommendations for taking forward CCU and CCS projects in Romania, which will serve as a foundation for formulating a CCU/CCS roadmap as part of the next Work Package of the CCS4CEE project.

4.1. Regulation

A majority of stakeholders (even those who believed that Romanian regulation on CCS is sufficient) stressed that CCU and/or CCS should be the subject of a coherent national strategy, with some outlining the need for it to be supported by an inter-ministerial effort, involving the Ministry of Economy, the Ministry of Energy, and the Ministry of Environment. Several highlighted specific regulatory mechanisms that could be employed: the National Recovery and Resilience Plan (AzoMureș) and the Carbon Border Adjustment Mechanism (CBAM), to protect products with lower embodied emissions, such as steel produced with carbon capture (steel producer).

Some stakeholders also suggested changes at the level of EU regulation, such as extending the ETS scheme to include CO_2 capture (cement producer); national targets for the Member States regarding CCU/CCS targets. Some stakeholders felt that the private industry is not being acknowledged in plans and regulations for CCS: CIROM, the industry association for lime and cement producers, highlighted the need for an integrated approach. Two stakeholders from the cement industry also showed interest in "simulating" or mapping the regulatory approval process to identify potential bottlenecks.

4.2. Technology

Relatively few stakeholders (7 out of 19) mentioned technology-related recommendations for deploying CCU/CCS. Some believe that CCU/CCS technology still requires development, while others suggest it is mature enough and there is no need to "reinvent the wheel" (GeoEcoMar, ISPE). The representative of Babeș-Bolyai outlined a differentiation between mature technologies, such as liquid gas absorption, which only require optimisation based on the industry they are applied to, and less mature technologies, such as chemical looping, which need demonstration at larger capacities than the current 1-10 MW installations, for which private sector involvement would be required to attract innovation funding. A stakeholder from the cement industry suggested that the number of European carbon capture pilots must increase 100-fold to achieve 2050 climate targets. Elcen, Romania's largest thermal energy producer, suggested an interest in this type of involvement in R&D for new technologies.

4.3. Infrastructure

In terms of storage infrastructure, some stakeholders suggested that advanced mapping of potential sites is required, with ISPE also recommending that existing depleted reservoirs be sealed to prevent CO_2 leakage.

In terms of transport infrastructure, most stakeholders indicated that it requires development, with GeoEcoMar suggesting the investigation of multi-modal transport, in the aspiration of making the Black Sea a storage site similar to the North Sea. Concern around potential leakage from pipeline CO_2 transport was highlighted by the stakeholder from the Ministry of Environment, suggesting that transport should occur over short distances to avoid this, and that stored CO_2 should be linked to potential utilization, reflecting the general concern about geological storage observed in the workshop. Some stakeholders outlined that CO_2 transport is the responsibility of the state (financing and operation alike), while stakeholders at ANRM suggested that the existing gas network be used for CO_2 transport, given the high costs of constructing a new transport network. Holcim Romania was also optimistic about reusing the gas networks for hydrogen transport.

In terms of capture infrastructure, one stakeholder suggested that CC should target newer energy generation units, including for natural gas. Another went further to recommend the reconfiguration and modernisation of power stations to be capture-ready (Elcen).

4.4. Market

Few stakeholders indicated recommendations for market development to facilitate the deployment of CCU/CCS technologies. A stakeholder from the secondary steel industry suggested that CCU/CCS should capitalize on potential business opportunities for transportation providers and equipment manufacturers. The Ministry of Environment outlined simply that CO_2 users must exist in order for the market to develop. Conversely, another stakeholder posited that the lead for CCS will come from the oil and gas industry; however, they need a sustainable and certain source of CO_2. A stakeholder at a cement company indicated that the final product (including CCS) must be sellable, touching on the issue identified earlier regarding the protection of products with low emissions against cheaper products from regions with looser regulations on carbon emissions.

4.5. Financial frameworks

Most stakeholders cited the price of ETS certificates as being a driver for CCU/CCS activity, and several across academia, private sector and public sector further mentioned the necessity of EU funding, with one recommending that a national financing framework be set up to draw down EU structural innovation funding for CCS, as well as identify suitable financial instruments. Stakeholders from the steel industry mentioned the possibility of accessing EU funding through instruments such as the Just Transition Fund and the Innovation Fund.

Targeted project financing was identified by several stakeholders, including the Ministry of Environment, as suitable for CCU/CCS. Furthermore, the potential for general financial frameworks was also recognized, indeed as part of a mix of financing. For example, a well-known CCS expert, Dr Carmencita Constantin, outlined the difference between investment costs, which should be supported through targeted public funding, and operation and maintenance costs, which should be funded through a Carbon Contracts for Difference (CCfD) scheme. A stakeholder from a cement company also recommended CCfDs to create long-term certainty on the price of carbon.

A similar mix of financing was envisaged in the personal views of stakeholders from the natural gas sector, who stated that the costs of injection and storage must be supported through public funding, as well as from the steel sector, who outlined that a general financial framework and public funding should support transport and storage of CO_2, while private, project-specific funding should support capture investments. The only stakeholders to not quote public funding as necessary were Bankwatch, who believe that, at least in the energy sector, CCS should not be supported by public money, and Chimcomplex, who nevertheless recommended that any public funding should be accompanied by mechanisms for the valorisation of CO_2.

4.6. Inter-sectoral and regional collaboration

Several stakeholders highlighted the need for industrial clusters and inter-sectoral collaboration (including, in some cases, the state and research partners) to apply CCU/CCS technologies, although most did not make specific recommendations. Elcen also highlighted the need for regional cooperation, with Romania as a recipient of know-how from other countries and a collaborator with other post-communist countries, who face similar issues for deployment of CCS technologies. They also stressed that collaboration should be catalysed by professional and industry associations, and envisaged a partnership with a research institution whereby they could provide the infrastructure for demonstrating capture technologies. An institutional stakeholder also highlighted the potential for regional collaboration, with Romania being integrated into an EU network for CO_2 transport.

4.7. Social acceptance

Many stakeholders highlighted the need for promoting a better understanding of CCU/CCS, through dedicated channels and campaigns. Several stakeholders suggested that public discussions should not be overly technical, but indeed should acknowledge the emotional aspects related to CCU and CCS. However, several stakeholders from the private sector highlighted the need for a scientific backing of the public message on CCS risks, to avoid manipulation of potential fears, particularly based on past experiences with fracking. ISPE, which coordinated public communication around the Getica project, suggested that communications should focus on job creation and environmental benefits, a suggestion echoed by the stakeholder from the competent authority on CO_2 storage. In terms of the "messengers" of CCU/CCS, ISPE recommended that this be done by NGOs rather than ministries, while the stakeholder from the competent authority on CO_2 storage suggested that professors and teachers be the main deliverers of the messages. Similarly, another stakeholder suggested that public education should begin with schoolchildren.

Transparency in communication was also highlighted by several stakeholders. An academic stakeholder warned that transparency about any potential price increases (e.g., in the cost of energy) will be key in public communication. One institutional stakeholder highlighted further that public consultation and transparency in decision-making will be key across stages of project implementation. ISPE recommended that campaigns always communicate benefits, risks, and mitigation measures. Linked to these risks, one stakeholder suggested compensation strategies to increase social acceptance in project areas.

Other stakeholders did not perceive risks of low social acceptance. A stakeholder from the natural gas sector did not believe social acceptance would be an issue, and the cost of storing CO_2 offshore to avoid public concerns would be better put towards public information campaigns. Several stakeholders also suggested that, whether or not public acceptance is an issue, acceptance from public authorities and company managers must be increased. Indeed, some suggested that authorities should be the starting point for addressing issues of social acceptance.

Finally, other recommendations were for a national plan for education and improved education on climate change, with awareness in this area still being relatively low.

4.8. Knowledge and capacity-building

Although not explicitly asked, many stakeholders recommended actions for increasing knowledge and capacity for the deployment of CCU/CCS projects. A systemic mapping of potential sites and sources was suggested by several stakeholders, as well as mapping macro-areas of economic interest and existing transport infrastructure. Other recommendations included a strengthening of know-how transfer, creating a national CCS roadmap or strategy, and studies to improve understanding of potential profitability for power production.

Chapter 3. CCS and CCU: Public acceptance in Romania

1. Public perception on environmental issues and curbing carbon emissions

According to the 2019 Special Eurobarometer survey on attitudes towards the environment,[63] Romanians consider air and freshwater pollution to be the most stringent environmental issues facing the country. To tackle them, the most effective ways are deemed to be the provision of more information and education (e.g., on energy consumption, waste separation), the introduction of stricter environmental legislation, and the introduction of heavier fines for breaches of environmental regulations. Most respondents believe that decisions concerning environmental protection should be made jointly within the EU, but many also believe that such decisions should be the responsibility of the national government. Romanians inform themselves about the environment primarily from TV (via news, documentaries, films) and to a smaller extent from family and their social and professional networks. Newspapers are the lowest-ranked information sources, and environment-related content is moderately consumed via internet and online social networks.

In 2021, the Special Eurobarometer survey on climate change[64] revealed a significant gap in climate change attitudes between Romanian citizens and the EU average. Consideration of climate change as a serious problem was lower than the EU average, as was the sense of personal responsibility for tackling climate change and the likelihood of having taken action to fight climate change recently. Even more telling is the tendency of Romanian respondents to agree less than the EU average with efforts for GHG emission to achieve climate neutrality, as well as that to agree more with investing economic recovery funds in the fossil-fuelled economy at the expense of the green economy. A decade after significantly more Romanians than the EU average declared themselves in favour of coal use (Special Eurobarometer on awareness of CO_2 capture and storage technologies, Section 3.2), these attitudes seem to continue to echo throughout the Romanian population.

According to the 2021 INSCOP survey,[65] while 34.6% of respondents consider that Black Sea natural gas reserves should be exploited and used to expand the gas network, only 19%

[63] European Commission (2019), Special Eurobarometer 501, Attitudes of European citizens towards the environment

[64] European Commission (2021), Special Eurobarometer 512, Climate Change

[65] Inscop (2021), Barometrul Securității Energetice, ediția a III-a

believe that Romania should reduce the pollution caused by the combustion of fossil fuels. In view of the pandemic crisis, almost 75% of Romanians consider that companies' large investment projects must be encouraged by the Romanian state.

2. Public perception of CCUS

In the 2011 Special Eurobarometer survey on awareness on CCS technology, Romanians were broadly similar to the EU average. However, a lower proportion of respondents than the EU average actually had an opinion on whether CCS could be effective for fighting climate change or whether it would benefit them if installed in their region – in both cases, around half of respondents did not know. Interestingly, significantly more Romanians than the EU average believed that CCS in their region would lower the price of electricity and reduce water pollution in their local areas, while fewer thought it would create jobs or have a positive impact on the environment or local economy. Nearly 60% of respondents expressed concern at the idea of a CO_2 storage site being located within 5 km of their home. However, the significantly higher support for the continued use of coal compared to the EU average sets the scene for potential difficulties in a smooth energy transition without CCS projects.

Closer to the present date, the 2020 Align-CCUS project uncovered public attitudes towards CCUS.[66] Results of the survey showed that most respondents believed the main benefits of CCUS in Romania are the reduction of CO_2 emissions in line with international agreements and the continuation of industrial or fossil-based energy production activities. The survey also showed that CO_2 utilization has attracted little media coverage so far. It also showed that similar arguments are used for and against CCS by proponents and opponents, respectively: proponents state that CCS is a sustainable and proven technology, whereas opponents present CCS as not sustainable and unproven. This potentially makes it difficult for the public to articulate an opinion on CCU/CCS,[67] particularly given the low overall knowledge of the technologies.

As part of the Align-CCUS study, further results from two focus groups showed that respondents in the 'industrial area' of Craiova (Oltenia region, south-western Romania) considered both environmental and economic benefits important and saw these as interconnected, whereas participants in the 'non-industrial area' of Bucharest considered environmental benefits to be more important. Findings on costs and risks overlapped between the two focus groups: most of the participants in both focus groups expressed concerns on the safety of storage and transport. Most participants in both focus groups also agreed that there is a need

[66] Align CCUS (2020) - Accelerating Low Carbon Industrial Growth through CCUS Deliverable Nr.D6.3.1: Stakeholder Perceptions of CCUS in Germany and Romania

[67] Align CCUS (2020), Accelerating Low Carbon Industrial Growth through CCUS Deliverable Nr. D6.3.2: Developing and testing new core messages

to prevent further climate change (but proposed different measures to achieve this) and that the alternatives to produce sustainable energy need further research and development.

Within the Align-CCUS study, the main risks discussed were pipeline and storage site leakage, the funds required for CCUS projects (which were considered insufficient), and conflicts among partners during project implementation. The main identified challenges for CCUS development surrounded the limited involvement of industrial and institutional actors who could play a leading role in CCUS development in Romania, i.e., the management of industrial companies and public institutions.

The CCUS implementation issue most frequently identified by respondents from Romanian companies was the lack of funding. As a result, industrial companies (including energy companies) postpone the implementation of CCUS projects, despite the drastic increase in emissions certificate prices. In contrast, interviewees from Romanian universities showed interest and involvement in CCUS development and had participated in recent research projects. These findings align with those of our own stakeholder engagement as part of the CCS4CEE project.

Finally, in a survey conducted as part of the ECO-BASE project, the reduction of CO_2 emissions was mentioned as a priority by the majority of Romanian respondents (80% of a total of 98 responses submitted during spring – summer 2020).[68] 38% of respondents also knew what CCUS is and an additional 22% had at least heard about it. It should be noted that the survey was disseminated through the ECO-BASE project website, and as such is likely to have attracted a more expert audience than surveys of local communities in the Getica project.

3. Issues of social acceptance in national discourse and at local project level

The main source of information for local narratives on CCUS comes from the 24 educational and information activities organized for the Getica Demonstrative CCS project between 2008 and 2012.[69] Various stakeholders from national authorities, the business sector, national and regional mass-media, the diplomatic environment, NGOs, universities, elementary school and the international CCS community were engaged in different activities (roundtables, conferences, workshops, educational and open-door events). Public acceptance was not perceived as an insurmountable barrier to CCS deployment, due to the sustained communication efforts

[68] ECOBASE (2020), Establishing CO2 enhanced oil recovery Business advantages in South Eastern Europe – Final Report
[69] Getica CCS Demo Project (2011) Feasibility Study Overview Report to the Global CCS Institute, Romania

preceding the Getica project – 1% of Getica's total investment costs (est. €1 billion), had been assigned to public awareness, communication and knowledge sharing activities.

As part of the Getica project, a first-of-a-kind sociological study conducted in 2012 in the Gorj, Dolj, and Mehedinți counties of south-western Romania, aimed to reflect perception both on climate change and CCS technologies. The quantitative research implied a questionnaire distributed to 1,200 people and one focus group of 9 people aged between 25-55 y.o. The study revealed a low level of understanding and knowledge of climate change and its effects amongst respondents. Although the need for reducing CO_2 emissions was acknowledged by almost half of respondents, and main CO_2 sources were broadly correctly identified, at the time respondents were inclined to believe that greenhouse gases do not play a crucial role in climate warming. Indeed, over 30% of respondents assumed that CO_2 is actually responsible for water pollution. As observed in the Eurobarometer survey, TV was respondents' primary information channel (85%), followed by the internet (20%), radio (18%), acquaintances (family and friends) (15%). At the time, however, newspapers still accounted for 24% of information conveyed to respondents. The least effective information providers were schools and universities (3%).

On the other hand, respondents knew very little about CCS itself. 15% of respondents had only heard about CCS, without knowing what it implies. Air quality improvement (22%) and new jobs being available (14%) were seen as the main benefits for society. On risks, more than half of respondents did not identify any substantial risk associated to CCS deployment. Most people identified potential storage and transport risks such as CO_2 leakage, which was perceived to negatively impact the environment and people' health.

Crucially, nearly two-thirds of respondents asserted that they would be concerned if the CO_2 storage site was located at a distance of less than 5 km from their properties. This is similar to, though slightly higher than, the findings of the 2011 Special Eurobarometer survey on CO_2 storage (see Section 3.2). This indicates a widespread reticence towards CO_2 storage in populated areas, raising the question of how local communities may need to be engaged in a timely and effective manner in future CO_2 projects.

Though Getica may have represented a positive example in terms of public acceptance of new technologies such as CCS, Romania has sufficient counterexamples to suggest caution in assuming social acceptance. Although neither relate directly to CCUS, parallels can be drawn to root out potential social issues to be faced by the deployment of CCUS technologies. In 2013, a resistance movement was formed at the village of Pungești, which vehemently objected to the planned shale gas exploitation by Chevron in eastern Romania. Almost 500 hundred people (village residents and environmental activists from Bucharest and Bârlad) occupied the road leading to the extraction site and, at least once, tore down the fence and entered the perimeter, which required the intervention of the Gendarmerie.

There was no prominent discourse based on scientific evidence, and all protests had an emotional driver fuelled by key people in the community, namely priests[70] and environmental NGOs. Despite geologists arguing that hydraulic fracturing was already a common practice also for natural gas exploitation in Romania, people feared that Chevron's exploitation will destroy the groundwater.[71] Following extensive Romanian media coverage, including a streaming channel – TV Pungești,[72] Chevron announced the suspension of its activities in the area and started to withdraw its operations – although this is not posited in the present study as the primary cause of Chevron's withdrawal. The Local Council considered organising two referendums,[73] one for the dismissal of the mayor and another for ending the exploration project.

The protests at Pungești did turn violent, but without significant injuries. Support and sympathy poured in from across the country, marking disapproval for the political will to continue Chevron's exploration. Spontaneous protests spread across Romania's biggest cities. As fears mounted, disapproval towards the national government grew, including the claim of abuses of protestors by the Romanian Gendarmerie. High-level governmental representatives also considered that the treatment faced by Pungești protesters was anti-democratic.[74] Eventually, the toppling of the Ungureanu Government took place following a censorship motion of the Social Democratic Party that drew heavily on criticism against the government's support for shale gas extraction.

The Romanian fight against fracking was part of a bigger environmental movement that includes opposition to the controversial Roșia Montană gold mining project in Western Romania, which also took place in 2013. Thousands of protesters gathered weekly to march, mainly in Bucharest and Cluj-Napoca, to manifest their disapproval towards plans by a Romanian-Canadian firm to mine gold and silver in the Roșia Montană village. The mining process would have included the use of cyanide, which caused an immense uproar at national level, partially due to negative experience with a cyanide accident in the northern Romanian city of Baia Mare, in 2000. The accident, considered one of the most severe environmental disasters in European history, caused almost 100,000 tons of mud polluted with cyanide and heavy metals to flow into the Tisza and Danube rivers. Furthermore, Roșia Montană is the oldest

[70] RFI Romania, 2013. Liviu Dragnea: Preotul din Pungeşti, capul răutăţilor.

[71] Digi24, 2013. Protest faţă de gazele de şist. Locuitorii din Pungeşti au televiziune online.

[72] The Guardian, 2013. Chevron suspends shale gas exploration plan in Romanian village after protest

[73] Digi24, 2013. Utilajele Chevron de la Pungeşti au fost ridicate de pe câmp şi duse în afara localităţii. Circa 100 de oameni protestează încă.

[74] RFI Romania, 2013. Sulfina Barbu: Măsurile luate la Pungeşti sunt exagerate şi antidemocratice.

documented Romanian settlement and has been considered for inclusion on the UNESCO World Heritage list for its cultural and natural riches. There is local pride for the cultural value of the houses, churches and ancient mining galleries hosted in the village and nearby areas.

Initially, the Roșia Montană protests were conducted by youth, but were later amplified across all age groups, fuelled by environmental activists. They were considered as symbolic fight of a generation.[75] In Roșia Montană, disputes intensified between those residents who accepted the company's compensation and those who decided to stay, putting up signs which said "This property is NOT for sale." The controversy and heated discussions about Roșia Montană still continue in 2021,[76] mostly led by environmental NGOs.

4. Institutional positioning on CCUS and coverage in the media

Aside from the public perception of CCUS, it is important to consider the positioning of Romanian institutions. Although CCUS is still an immature domain, Romania has shared its enthusiasm towards CCS, and for a brief period (2009-2011) CCS was high on the governmental agenda. This prioritization of CCS emerged from the potential financing under NER 300, rather than from environmental concerns. The following section aims to present both the last decade's stance of different stakeholders, as well as the present institutional positioning towards CCS. Focusing on content rather than quantity, public declarations as well as several relevant media articles have been consulted to coalesce opinions from state officials, key decision-makers from companies, NGOs, and expert researchers.

In 2011, high-level officials, such as state secretaries and advisors, officially announced that the Getica CCS Project was a priority for Romania and the most important program run by the Ministry of Economy, Trade and Business.[77,78] However, in its present configuration, the Ministry of Economy does not have a leading role in such projects and hence no positioning on the matter, deferring to the Ministry of Energy. In 2021, CCUS discussions reopened in the context of Romania's post-Covid National Recovery and Resilience Plan (NRRP), which includes carbon capture projects proposed as innovative and easy replicable.[79] In the same year, the Ministry of Energy was asked by a Member of Parliament whether CCS had been

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[75] The Guardian, 2013. Protests continue in Bucharest against gold mine plan in Rosia Montana.

[76] Adevarul, 2021. Protest al Greenpeace în Piaţa Victoriei, faţă de o eventuală retragere a dosarului de înscriere în patrimoniul UNESCO a sitului Roşia Montană.

[77] Consulate General of Romania in Bălți. Getica CCS project, a priority for Romania.

[78] Focus Energetic, 2021. Getica CCS la Mediaş | Focus Energetic.

[79] G4Media, 2021. INTERVIU Ministrul Energiei: Facturile la electricitate sunt mari din cauza comportamentului speculativ al furnizorilor / Despre finanțarea GSP prin PNRR: S-a asociat cu Romgaz, întrebați la ei cum s-a întâmplat.

considered for the Oltenia Energy Complex, Romania's largest CO_2 emitter. The inquiry was met with a relatively evasive response, referring to the upcoming decarbonization plan of the Complex.

The Ministry of Environment also has no positioning on CCUS, which has not changed since the heyday of CCUS in Romania – the time of the Getica project. Save for a vague response to an inquiry by a Member of Parliament in 2011, the Ministry has not mentioned CCUS. The same can be said about ANRM, Romania's competent authority for CCS, with no statements or comments available so far. Overall, between 2011 and 2021, out of over 1,000 inquiries by MPs to all government departments, only two referred to CCS, reflecting the low interest by Parliament in the subject.

In the continuation of the long-disputed development of gas reserves in the Black Sea, in 2021 the Minister of Energy officially announced a potential collaboration between Romgaz, Romania's largest and primarily state-owned gas producer, and Exxon Mobilin the field of carbon storage;[80] no further details or reactions have surfaced. OMV Petrom, Romania's second-largest gas producer, is also assessing CCS technologies as part of its future development, focusing mostly on pilot or experimental projects.[81]

Aside from gas producers, only a few private entities have announced their appetite for CCS/CCU, most recently HeidelbergCement,[82] a newcomer in the Romanian cement industry. Compared to the Getica-era discussions around CCS, led by energy companies, other industry sectors are now approaching with concrete proposals for CCUS, such as the cement and chemical industries (Azomureș,[83] Chimcomplex[84]). The Oltenia Energy Complex, despite having been a consortium partner in the Getica demonstrative project,[85] currently considers CCS development to be expensive, and that before making any decision they must be sure that future incomes will exceed expenditures.[86] Environmental benefits related to CCUS have only been touched upon by ISPE, focusing on the future use of coal in a sustainable way.[87]

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[80] Agerpres, 2021. Ministrul Energiei a discutat cu reprezentanţii Exxon despre colaborarea cu Romgaz pentru stocarea de carbon.

[81] Ziarul Financiar, 2021. Paşi în direcţia unui viitor fără emisii de carbon.

[82] Economica.net, 2020. Prima intenție comercială din România pentru un proiect de stocare a carbonului.

[83] Agrepres, 2021. Mureş: Decarbonizarea economiei şi măsurile pentru producătorii de îngrăşăminte din UE, discutate de conducerea Azomureş cu Timmermans.

[84] Ziarul Financiar, 2021. Tivadar Runtag, Chimcomplex, cu afaceri de 1,71 mld. lei: Industria chimică consumă foarte multă energie. Creşterea drastică a preţurilor la energie este o preocupare majoră.

[85] Bursa.ro, 2011. Investiţia Romgaz în proiectul Getica CCS este de 500 milioane euro

[86] Economica.net, 2020. Se înmulțesc proiectele de captare și stocare a carbonului în România. AIK Energy a propus CE Oltenia un proiect CCS la Ișalnița.

[87] Focus Energetic, 2011. Getica CCS la Mediaş.

In 2011, environmental protection-oriented NGOs were either absent or silent regarding CCS. Currently, in contrast, there is more movement amongst NGOs on this topic. In a recent analysis,[88] Bankwatch claims that further investments from NRRP funds cannot be considered green if part of them are attributed to fossil fuels projects, such as the proposed carbon capture projects on gas power plants.

Overall, no institution is against CCS, many of them acknowledging the benefits (emission reduction) of the technology. However, no adamant supporter as CCS can be identified either. Other benefits, such as job opportunities or climate change mitigation and the associated risks have not reached the CCS narrative in Romania.

When it comes to media coverage, the analysis done by the Align CCUS project shows that media coverage of CCUS is low in Romania, compared to Netherlands and Germany. The overall tone of the identified media articles was relatively critical in Germany (68.2% of the arguments identified were arguments against CCUS), somewhat more mixed/balanced in the Netherlands (59% of the arguments identified were arguments against CCUS) and relatively positive in Romania.[89] Very few media recent articles mention CCS and are mostly related to interest expressed by various private actors in engaging in carbon capture projects (see above).

5. The need for public awareness campaigns

As noted in the ECO-BASE project report,[90] education campaigns are essential for CCUS cluster development, even though no significant resistance to establishing these clusters is expected in areas where communities are familiar with industrial operations (for example, Dolj county in SW Romania). Consequently, stakeholders from the industrial field are considered of particular interest, as having a decisive role in the implementation of CCUS projects in Romania.[91]

Respondents to the ECO-BASE survey consider the level of CCUS awareness to be very low (both on a local and national level), an aspect also identified in the interviews conducted for the CCS4CEE project. Most respondents believed that public information campaigns should

[88] Bankwatch, declic.ro, 2021. Planul Național de Redresare și Reziliență: Investiții și reforme contrare procesului de decarbonizare a sectorului energetic.

[89] Align CCUS (2020), Accelerating Low Carbon Industrial Growth through CCUS Deliverable Nr. D6.3.2: Developing and testing new core messages

[90] ECOBASE (2020), Establishing CO2 enhanced oil recovery Business advantages in South Eastern Europe – Final Report

[91] Align CCUS (2020) - Accelerating Low Carbon Industrial Growth through CCUS Deliverable D6.3.1: Stakeholder Perceptions of CCUS in Germany and Romania

be launched to coalesce an informed public opinion on CCUS and prevent negative attitudes which could persist long-term. For a better understanding and diminished risk for public opposition, messages related to CCS should be clear, accessible, and appeal to citizens' personal interests.[92] In recent years, the media and local authorities have demonstrated little awareness of or interest in CCUS, but at the same time expect the public to have a positive attitude towards CCUS, if it is to be developed in connection with local economic interests.

One thing is for certain, though: the public debate on CCUS must be based on strong scientific evidence. In this respect, the relatively high level of trust in national scientific institutions (the Romanian Academy ranks third after the Army and the Orthodox Church) may support science-based dialogue on and public receptiveness to CCUS. The role of international institutions should also be considered: 51.1% of Romanians trust the EU, while only 17.2% trust the Romanian Government and 12.2% the Parliament.[93]

[92] Align CCUS (2020), Accelerating Low carboN Industrial Growth through CCUS Deliverable Nr. D6.3.2: Developing and testing new core messages

[93] Inscop (2021), Barometrul Securității Energetice, editiția a III-a

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