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THE 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

LITHUANIA

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Glossary

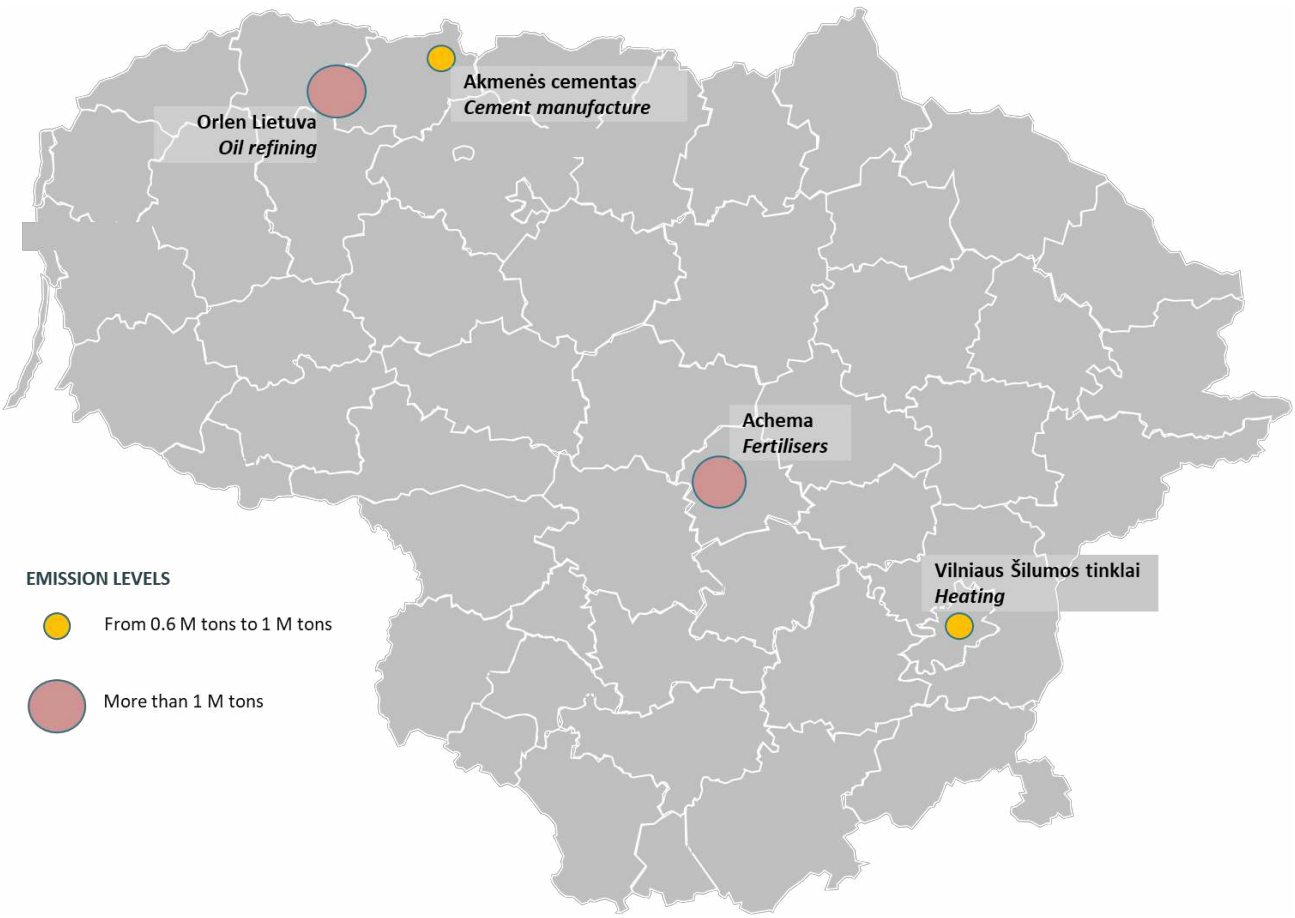
Term	Definition
AB	Joint stock company (LT: akcinė bendrovė)
CC	Carbon capture
CCS	Carbon capture and storage
CCU	Carbon capture and utilisation
CO_2	Carbon dioxide
DNA	Deoxyribonucleic acid
EC	European Commission
EU	European Union
EUR	Euro, the currency used in the European Union
Gt	Giga tonne (one billion tonnes)
KN	Klaipėdos nafta
KTU	Kaunas University of Technology (LT: Kauno technologijų universitetas)
LNG	Liquified natural gas
LS	Larvik Shipping
MOL	Mitsui O.S.K. Lines
MPa	Mega Pascal (one million Pascal units)
Mt	Mega tonne (one million tonnes)
PET	Polyethylene terephthalate
PET	Polyethylene terephthalate
SĮ	Municipality company (LT: savivaldybės įmonė)
UAB	Limited liability company (LT: uždaroji akcinė bendrovė)

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

1. Description of relevant domestic economic sectors

Lithuania's industry contribution to the gross domestic product is about 20%, and industrial goods account for more than 80% of Lithuania's exports. In terms of production volume, the country's industry is dominated by the manufacturing, chemical production, furniture and wood, clothing and textile, and electronics industries. Concerning CO_2 emissions, the main sectors of interest are fertiliser production, cement production, oil refining, and heating and electricity production.

FIGURE 1: MAIN INDUSTRY CO_2 EMISSION SOURCES IN LITHUANIA



Source: Environment protection agency of Lithuania, 2019

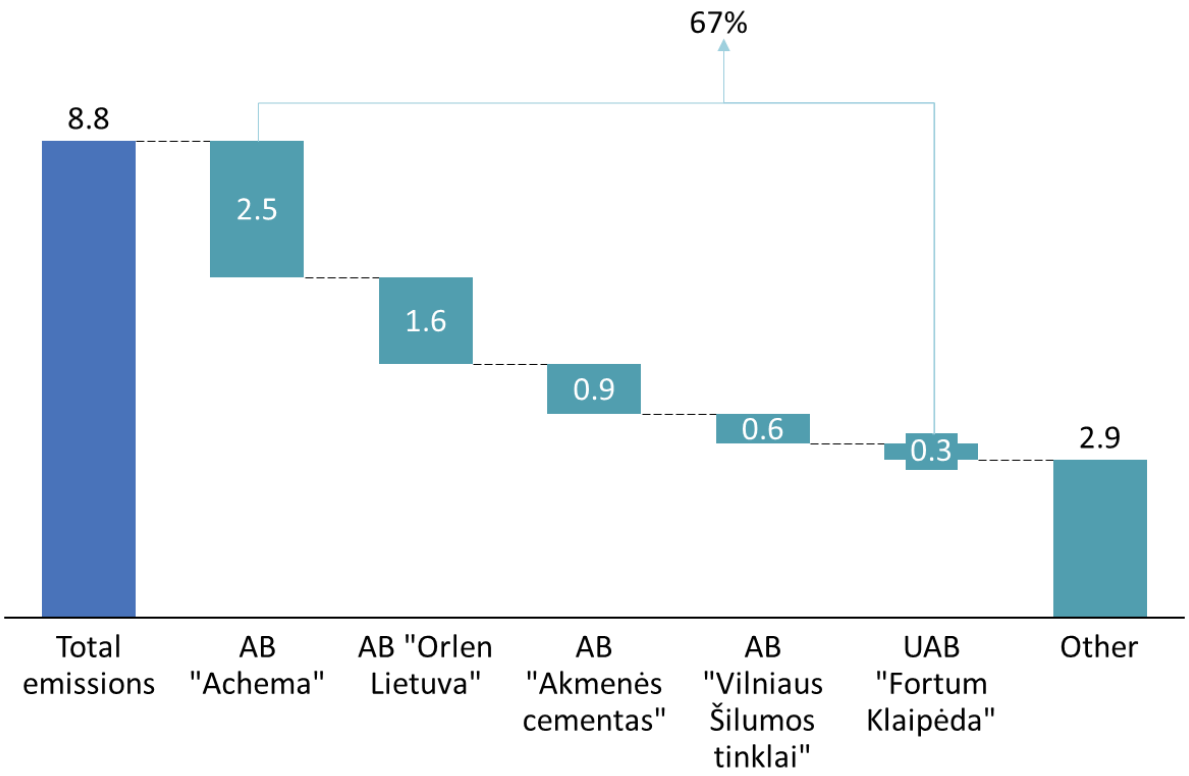
1.1. Carbon-intensive sectors of the Lithuanian economy

In addition to the main industry emitters, a significant part – 38% – of total emissions in Lithuania comes from heat and power generation. So, the main carbon-intensive sectors of the Lithuanian economy are:

- Fertiliser manufacturing and related chemical processes (1 plant in the central part of Lithuania, 250 km from Klaipėda port);
- Oil refinery and oil processing (north-west Lithuania, 60 km from the cement plant, 130 km from port of Klaipėda);
- Cement manufacturing (north-west Lithuania, 60 km from the cement plant, 160 km from port of Klaipėda);
- Heating and energy production (one emitter above 0.2 million tonnes per year in Klaipėda, 10 km from the port of Klaipėda).

Out of the industrial players, five companies emit the majority (67%) of CO_2.

FIGURE 2: INDUSTRY EMISSIONS BY COMPANY IN LITHUANIA, M TONNES, 2019



Source: Environment protection agency of Lithuania

Top 5 main CO_2 emitting entities - and major stakeholders withing the CCU/CCS context - are the following:

1. Achema - 2.5 M tonnes of CO_2. Achema is a producer of nitrogen fertiliser and other chemical products;
2. Orlen Lietuva - 1.6 M tonnes of CO_2. Orlen Lietuva is an oil refining company;
3. Akmenės cementas - 0.97 M tonnes of CO_2. Akmenės cementas is the largest cement manufacturer in Lithuania;
4. Vilniaus Šilumos tinklai - 0.62 M tonnes of CO_2. Vilniaus šilumos tinklai is Lithuania's largest provider of heating and hot water;

5. Fortum Klaipėda - 0.27 M tonnes of CO_2 [1]. Fortum Klaipėda generates heat and electricity using sorted municipal and industrial waste.

1.2. Major CO_2 emitters in Lithuania

Companies that emit more than 50 thousand tonnes of CO_2 are shown in Table 1.

TABLE 1: INDUSTRY EMISSIONS BY COMPANY IN LITHUANIA, 2019

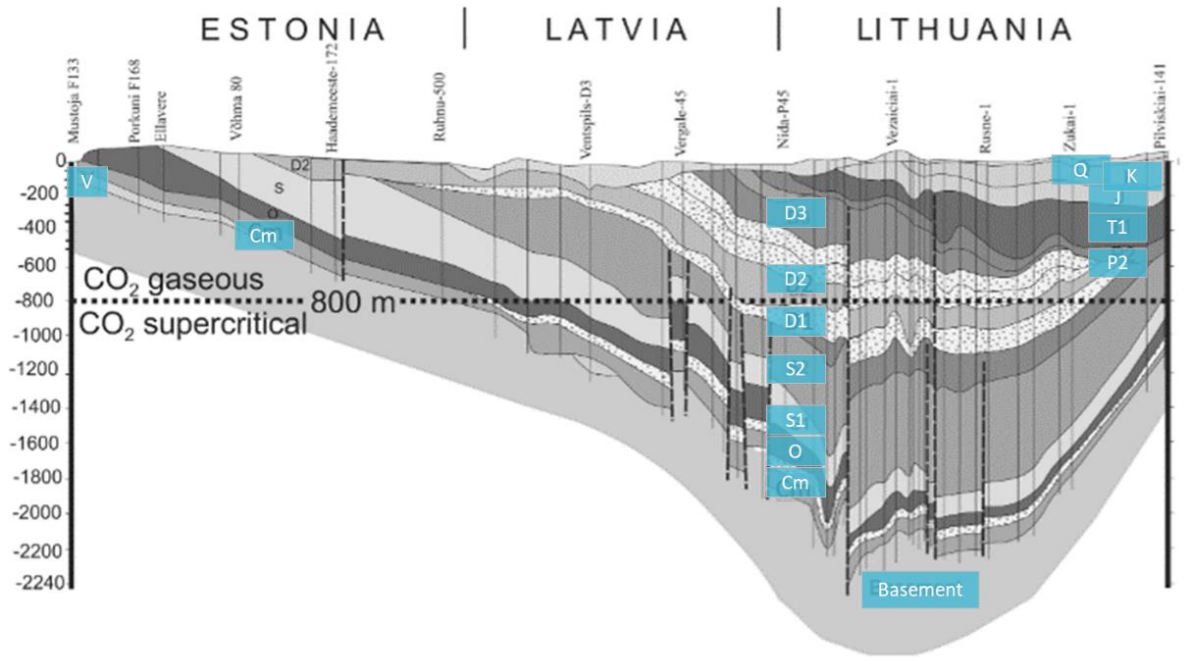
No.	COMPANY/OBJECT NAME	SECTOR	CO_2 EMISSIONS, 2019, '000
1.	AB "Achema"	Fertilisers	2,486
2.	AB "Orlen Lietuva"	Oil refining	1,599
3.	AB "Akmenės Cementas"	Cement	968
4.	AB "Vilniaus šilumos tinklai"	District heating	625
5.	UAB "Fortum Klaipėda"	District heating	271
6.	AB "Šiaulių energija" Šiaulių Pietinė katilinė	District heating	238
7.	AB "Grigeo Klaipėda"	Paper production	216
8.	UAB "Idex Paneriškės"	District heating	180
9.	UAB "Neo Group" katilinė	PET resins and polyol	159
10.	AB Roquette Amilina (buvusi UAB "Lignoterma")	Grain processing	142
11.	AB "Panevėžio energija" Panevėžio RK-1	District heating	124
12.	UAB "Utenos šilumos tinklai" Utenos rajononė katilinė	District heating	91
13.	UAB "Mažeikių šilumos tinklai" Mažeikių katilinė	District heating	89
14.	UAB "Litesko" filialas "Marijampolės šiluma" Marijampolės rajoninė katilinė	District heating	88
15.	UAB "Idex Biruliškės"	District heating	83
16.	AB "Kauno energija" Petrašiūnų elektrinė	Electricity production	80
17.	AB "Ignitis gamyba" Elektrėnų kompleksas	Electricity production	78
18.	AB "Klaipėdos energija" Klaipėdos rajoninė katilinė	District heating	70
19.	AB "Panevėžio energija" Rokiškio RK	District heating	66
20.	UAB "Paroc"	Building materials production (rockwool)	62
21.	AB "Jonavos šilumos tinklai" Girelės rajoninė katilinė	District heating	61
22.	UAB "Litesko" filialas "Druskininkų šiluma" Druskininkų katilinė	District heating	61
23.	SĮ "Visagino energija"	District heating	59
24.	UAB "IKEA Industry Lietuva"	Furniture production	59
25.	AB "Kauno energija" "Šilko" katilinė	District heating	55
26.	UAB "Hoegh LNG Klaipėda"	LNG terminal	50
27.	Other, smaller emissions (total - 61)	-	787

[1] Amount of CO_2 emissions shows total emissions from fossil fuels (0.14 M tonnes) and biomass (0.13 M tonnes).

2. Assessment of geological potential for CCS

Lithuania is located in the eastern and central parts of the Baltic sedimentation basin; the thickness of the sedimentary cover varies from 200 metres in the southeast of the country to 2.3 km on the Baltic Sea coast. The section is characterised by a variety of lithological composition and hydrogeological conditions. The upper part of the sedimentary cover is in the zone of active water exchange; deeper transition and stagnant zones are distinguished. Overall, the Baltic countries are situated within the Baltic sedimentary basin that contains a number of regional-scale aquifers. However, only two of these, the Lower-Middle Devonian (marked D1 and D2 respectively) and Middle Cambrian reservoirs (marked Cm), meet the basic requirements for CO_2 storage. Offshore options of CCS for Lithuania are limited, and their storage potential has low estimates[2].

FIGURE 3: INDUSTRIAL CARBON DIOXIDE EMISSIONS AND POTENTIAL GEOLOGICAL SINKS IN THE BALTIC STATES



Geological cross-section across Estonia, Latvia and Lithuania. Major aquifers are Indicated by dots. V - Vendian (Ediacaran), Cm - Cambrian, O - Ordovician, S - Silurian, D1, D2 and D3 - Lower, Middle and Upper Devonian, P2 - Middle Permian, T1 - Lower Triassic, J - Jurassic, K - Cretaceous, Q - Quaternary.

Source: Feasibility study. Carbon capture, transport and storage in geological formations, taking the provisions of the draft Directive, 2008, UAB Cowi Baltic and UAB Krige Investicija into account.

As a result of these conditions, two carbon capture and storage scenarios are suitable for Lithuanian conditions, which require different assessment strategies. The first group of potential objects consists of anticline-type structures, including oil fields. The second type includes monocular-type saline aquifers. Anticline-type structures are the safest, but their potential is limited compared

[2] Šliaupa S., Lojka R., Tasáryová Z., Kolejka V., Hladík V., Kotulová J., Kucharič L., Fejdi V., Wójcicki A., Tarkowski R., Uliasz-Misiak B., Šliaupienė R., Nulle I., Pomeranceva R., Ivanova O., Shogenova A. and Shogenov K. (2013) CO2 storage potential of sedimentary basins of Slovakia, the Czech Republic, Poland and the Baltic States. Geological Quarterly, 57 (2):219–232, doi: 10.7306/gq.1088

to monoclonal aquifers. As the experience of long-term research in Lithuania shows, higher closed elevations are only common in the Cambrian aquifer.

2.1. General Information

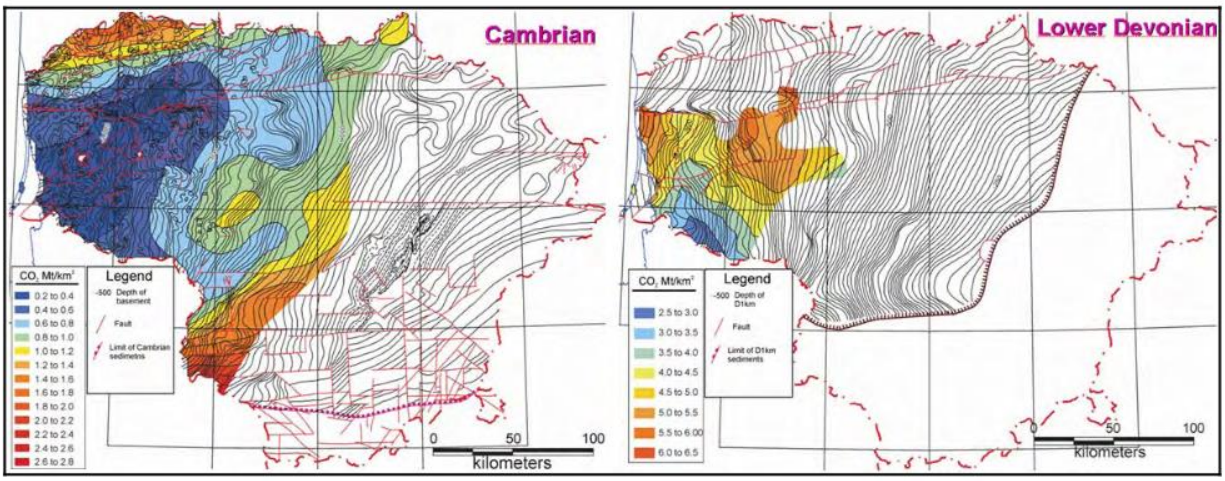
A number of parameters were evaluated when studying the CO_2 disposal potential of Lithuanian depths. Temperature measurement data of 160 deep wells were used to determine the temperature regime (Šliaupa, 2002), hydrostatic pressure information was reviewed. The reservoir porosity database consists of over 10,000 porosity and permeability measurements (Šliaupa et al., 2003), and the Devonian collector database contains several hundred measurements. The water mineralisation database consists of: Cambrian collector - 170 wells, Lower Devonian and Pärnu collector - 75 wells, Upninkai-Šventoji - 1300 wells. Other aquifers are not analysed because they are in unfavourable thermobaric conditions. Assessing the potential of local traps in the Cambrian collector, 72 structures on land and 30 structures in the Baltic Sea were inventoried.

2.2. Geological formations fit for CO_2 storage

According to the conditions of temperature and pressure, there are two promising saline aquifers in the territory of Lithuania - Cambrian and Pernu-Kemeriai (Lower Devonian and Lower Middle Devonian). Other aqueous layers common in the Lithuanian sedimentary section are lower in temperature and pressure than required, therefore CO_2 burial is not possible in them. According to the thermobaric characteristics, the Cambrian aquifer shows the most favourable conditions. The critical isotherm of 32 ^{o}C is in central Lithuania. In the west of the country the temperature reaches 70-85 ^{o}C. This high-temperature area roughly coincides with the pressure range higher than 7.8 MPa, and in western Lithuania it reaches up to 20 MPa. Thus, the entire western side of Lithuania is promising in this aspect - here the CO_2 will be in a supercritical state. In the eastern part of Lithuania, CO_2 is in the gas phase, and it will only reach liquid state (between the 32 ^{o}C isotherm and the 7.8 MPa isobar) in a small area. The Cambrian collector consists of Middle Cambrian Deimena regional floor sandstone, and in central Lithuania there is also suitable lower Cambrian sandstone[3]. The thickness varies from 20-30 to 60-70 m. Cambrian sandstone is characterised by decreasing porosity and permeability to the west, which is associated with greater depths of deposition. The open porosity varies from an average of 25% to 16% at a depth range of 400-1800 m.

[3] Ibid.

FIGURE 4: REGIONAL STORAGE CAPACITY OF CAMBRIAN AND LOWER DEVONIAN AQUIFERS, ONSHORE LITHUANIA.



Source: EU GeoCapacity, 2009

In the Pernu-Kemeri aquifer, CO_2 can be buried in western Lithuania, where the temperature and pressure exceed 32 °C and 7.8 MPa. The maximum temperature on the ridge reaches up to 45 °C, the pressure - 9 MPa, in some places (e.g. near Syderiai, along the lowered Telšiai fracture wing) it exceeds 10 MPa. CO_2 will be in a supercritical state here, while in central and eastern Lithuania it will be in a gaseous consistency. In the transition zone, CO_2 is in the liquid phase. The thickness of the aquifer reaches up to 190 metres in the northern part of western Lithuania (Paluknė-1 borehole). The Gargždai series below is characterised by poor collector properties, low-permeability siltstones predominate, abundant layers of clay and sandstone form a small part of the section. The aquifer of Pernu-Kemeri has good collector properties, the section is dominated by weakly cemented sandstone, the porosity of which is usually 25-30 percent. The permeability of sandstone is 0.5-4 millidarcy - these are very good collector properties. Sandstone makes up 62-67% of the aquifer section.

The largest structures in the territory of Lithuania are Syderiai and Vaškai. Another large structure stands out in the Baltic Sea near the coast (5 km). The CO_2 storage potential of these structures is shown in the table below.

TABLE 2: MAIN GEOLOGICAL STRUCTURES FIT FOR STORAGE IN LITHUANIA.

Aquifer structure	X coordinates (WGS-84)	Y coordinates (WGS-84)	Capacity ($MtCO_2$)
Syderiai	22.43	55.92	21.5
Vaškai	24.25	56.07	8.7
Baltic Sea structure (D11)	20.9	56.02	11.3

Source: Feasibility study. Carbon capture, transport and storage in geological formations, taking the provisions of the draft Directive, 2008, UAB Cowi Baltic and UAB Krige Investicija into account.

SYDERIAI

On the basis of seismic research, one Syderiai well was drilled in the centre of the structure. The amplitude of the structure reaches 80 m, the collector of the middle chamber is at a depth of 1458 m. The structure is oblong in shape, 8 by 11 km in size. From the south and east, it reaches fractures. The southern fracture is a part of the large Telšiai fracture zone, the eastern - an accompanying smaller fracture, the amplitude of which exceeds 75 m. The thickness of the collector is 57 m. It consists of Middle Cambrian Deimena series sand dunes with an average porosity of 16% and an effective water horizon of 0.75. A clay layer about 10 m thick divides the

collector into two parts. The average porosity of the upper sandstone is 18% (27 m thick), the lower - 15% (12 m thick). The temperature of the layer is 50 °C. Water mineralisation - 122.4 g / l (sodium-chloride type water).

The Syderiai elevation can hold 21.5 Mt CO_2. Syderiai elevation is close to the gas pipeline, which increases the potential of this structure. However, it should be emphasised that this structure is one of the most promising for the development of an underground gas storage facility in Lithuania, therefore a conflict of interest is possible here.

VAŠKAI

The structure in Vaškai is located in Pasvalys district, 10 km northwest of Pasvalys City. Between 1992 and 1999, seismic surveys were carried out in 168 km of the area and 5 wells were drilled based on its results. No significant geothermal studies have been carried out here, one can only guess from the general regional situation that the temperature of the chamber is about 30 °C, so it may be a bit too low to maintain a supercritical state in the reservoir. The carbon dioxide will be in the liquid phase, which is heavier than the pore water, so it will migrate downwards, erupting from the structure.

The Vaškai structure could store 8.7 Mt CO_2. The advantage of this structure is that it is close to gas pipelines and the simple geometric shape of the structure. Weaknesses of the Vaškai structure - 1) underground gas storage facilities are planned in the perspective, 2) unclear fracture closure; 3) there is a lack of temperature measurement data that would allow one to substantiate the supercritical state of CO_2 in the Cambrian aquifer.

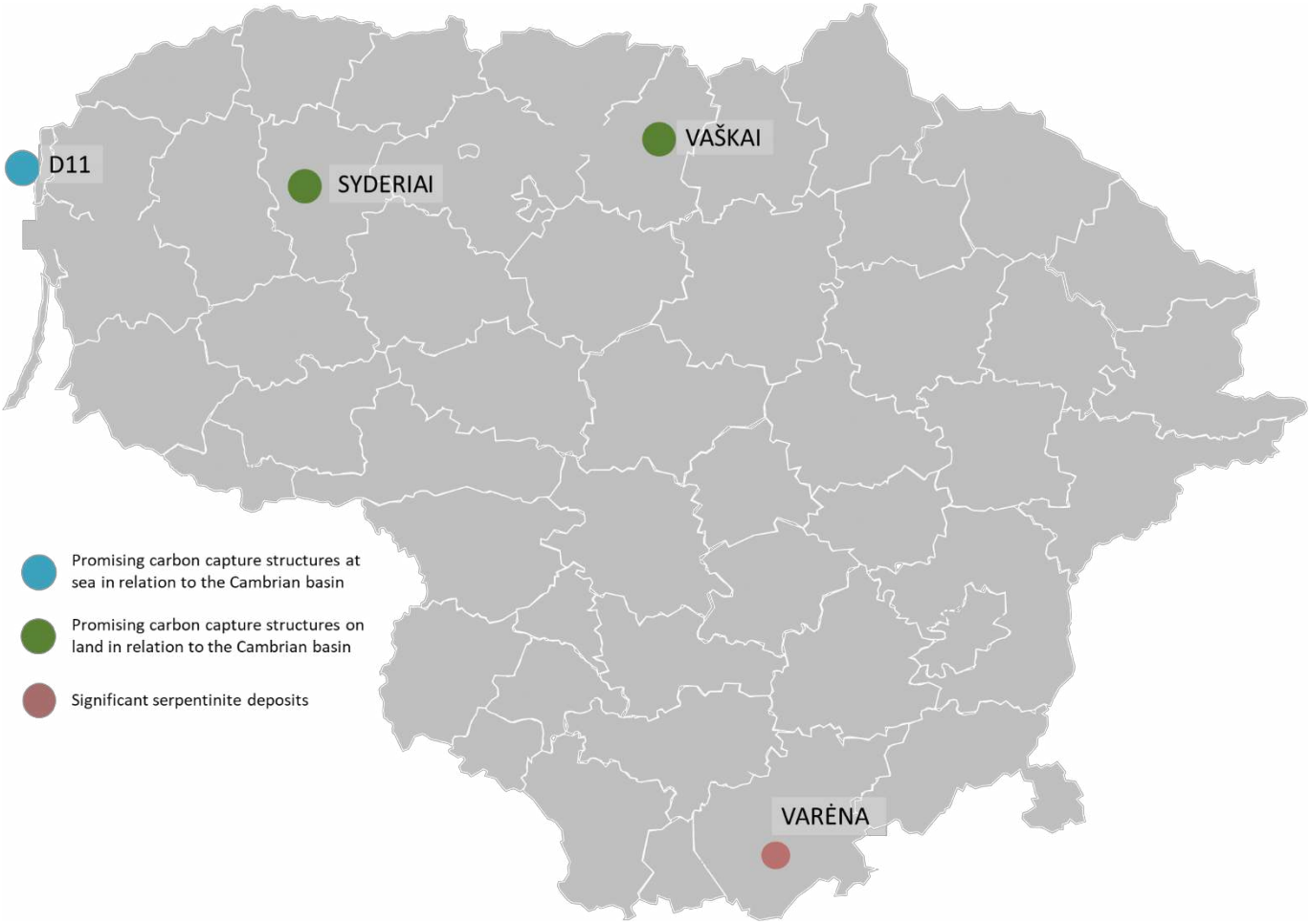
BALTIC SEA STRUCTURES

The aforementioned two promising salty aquifers extend into the Baltic Sea. Geological and geophysical surveys have also been carried out here in the past, mainly related to oil exploration. Seismic intelligence data identified 45 structures for which the CO_2 storage potential was calculated. The highest elevation highlighted is named D11, located 5 km from the shore. Its potential is estimated at 11 Mt. Other structures range from 100,000 tonnes to 7.8 Mt. No promising structures were found in the Devonian strata, as on land, so the prospects for this aquifer are virtually nil.

VARĖNA SERPENTINITE

Geological formations provide prospective sinks for CO_2 sequestration - essentially the main storage options in Lithuania. Alternatively, mineral carbonation, which is a process of converting naturally occurring minerals such as magnesium- and calcium-based silicates into stable carbonate minerals, has great potential. Different minerals can be potentially used for the immobilisation of carbon dioxide. The ultramafic rocks have been identified as the most suitable rock media. However, they are rather rare and can only provide limited reserves for CO_2 sequestration. Alternatively, serpentinite rocks are abundant in the world and can serve for the immobilisation of CO_2. The large serpentinite province was mapped in the Palaeoproterozoic crystalline basement of southern Lithuania. Serpentinites associate with high-quality iron ore, which provides the opportunity for the cascade utilisation of these formations. The volume of the serpentinites in the largest Varena Iron Ore Deposit is estimated to be as large as 1-2 Gt. Consequently, the sequestration potential is evaluated to be as high as 0.5-1 Gt. It is equal to 200-500 years of CO_2 production by the major south-eastern Lithuanian carbon dioxide emission cluster. The other serpentinite bodies identified in south-eastern Lithuania are much smaller. Assuming the total capacity of the rest objects is roughly equal to the Varena Iron Ore Deposit, they provide large potential for the mineral sequestration of carbon dioxide. However, one of the major problems in using rock material for CO_2 immobilisation is related to the volume of resources used and waste created. Also, logistical Issues of transporting CO_2 to the location of serpentinite deposits can be a serious hurdle. As a result, these technologies, compared to e.g. hydrodynamic trapping in saline aquifers, are rather immature and need considerable development. The main prospective structures and serpentinite deposits are shown in Figure 5.

FIGURE 5: MAIN PROMISING GEOLOGICAL STRUCTURES AND SERPENTINITE DEPOSITS.



Source: Feasibility study. Carbon capture, transport and storage in geological formations, taking the provisions of the draft Directive, 2008, UAB Cowi Baltic and UAB Krige Investicija into account.

3. Description of implemented and planned projects

As of writing this report, the injection and storage of carbon dioxide in natural and artificial underground cavities and aquifers is prohibited within the depths of the earth in Lithuania (small-scale projects, up to 10 thousand tonnes of CO_2 are allowed). (See 4. Legislation and regulation relevant for CCS deployment). Because of this, key stakeholders are holding back on planning CCS-related projects. Transportation of carbon dioxide to storage locations outside of Lithuania is permitted, but logistical costs and geographical challenges exist as the major emitters would need transportation for large amounts of CO_2 and the only viable option is transporting by ship. So, hypothetical discussions are taking place concerning CCS, but without restoring the legal ability to develop the storage aspect of the CCS sector, these discussions will not be realised as active projects within Lithuania.

Currently, several companies have shown an interest or taken part in steps for pre-feasibility study evaluations. This allows for small-scale calculations and experiments which do not come at a large cost. One concrete example of this interest - Klaipedos nafta (KN), Larvik Shipping (LS), and Mitsui O.S.K. Lines (MOL) will carry out a feasibility study for a liquefied CO_2 and hydrogen project in Klaipeda, Lithuania. KN, LS and MOL acknowledge the potential of CCUS and have reached an agreement to develop liquefied CO_2 (LCO_2) loading facilities at KN's existing infrastructure in Klaipeda, Lithuania. The overall vision is to develop an LCO_2 logistics and value chain from Lithuania and potentially the Baltic region with the seaport of Klaipeda at the centre. The main task of the feasibility study will be to identify an optimal configuration to export CO_2 to one or more sequestration facilities within Europe. It also includes the possibility to produce blue hydrogen as an important and necessary solution to reach a zero emissions economy.

Full list of stakeholders and their positions can be found in section 2 of chapter 2 (see 2. Stakeholder positions on CCS and CCU).

4. Legislation and Regulation Relevant for CCS Deployment

Title of legislative document	**Relevance to CCS/CCU**
Law of Depths of the Earth and CO_2 Storage	The legal landscape of CCS deployment in Lithuania currently has a significant discrepancy. First, the Law on Geological Storage of Carbon[4] establishes the rights, duties and responsibilities of persons in the exploration, transportation of CO_2, use and closure of geological storage facilities for CO_2, state management of geological storage of carbon dioxide, selection of geological storage facilities for carbon dioxide, permits for the storage of carbon dioxide in the territory of the Republic of Lithuania. It also provides legal requirements for the conditions of issuance, renewal and cancellation in the Lithuanian exclusive economic zone and the continental shelf, obligations related to the operation, closure and post-closure of the geological storage of carbon dioxide, as well as dispute settlement and international cooperation procedures. Secondly, Chapter IV of the Law on the Depths of the Earth[5] provides guidelines for the use of the resources of the Earth's depths and cavities. However, the amendments to Article 14 of this Chapter, introduced in 2019, stipulate that the introduction and/or storage of carbon dioxide in natural and/or artificial subsoil cavities and/or aquifers is outright **prohibited**. In the same Article it is also prohibited to use natural underground cavities for the disposal and/or storage of waste, radioactive and hazardous to human health and the environment, waste from the extractive industries, except for the return of brine extracted during exploration and/or exploitation to the same hydrocarbon tank subsoil. This results in the Law on the Depths of the Earth effectively renouncing the possibility of geological storage of carbon.

[4] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.403288
[5] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.19879/asr

Title of legislative document	Relevance to CCS/CCU
National Climate Plan	Use of hydrogen in energy, industry and transport is an additional promising area for the development of energy innovations and the use of energy competencies, research and experimental development results in other areas of the economy, including the promotion of export growth and the development of new businesses in the country. The European Innovation Fund will provide more than € 10 billion in support in five strategic areas between 2020 and 2030, two of which are directly related to CO_2 storage.
Comprehensive Plan of the Territory of the Republic of Lithuania	In the context of the EU's climate change and energy policy set out in Directive 2009/31/EC on the implementation of geological storage of carbon dioxide, Lithuania should continue to assess the conditions and prospects for CO_2 capture, transport and geological storage, focussing on the supercritical site and alternative geological storage technologies and opportunities. The territory of the supercritical state is marked in the drawing Complex infrastructure and reservation of territories for the needs of the state. Despite this statement being in the Comprehensive plan, current research on the depths of the Earth is mostly prohibited, unless it does not intrude on the various cavities and formations underground.

Conclusions

The geological and legal landscape seems fitting for CCS, but certain articles in the Law on the Depths of the Earth have forbidden CO_2 storage underground. Experiments and tests in small amounts are permitted, but the results of these cannot provide relevant or useful results to stakeholders who would be interested in CCS. Transportation is legal and regulated by the law on CO_2 storage and other general transportation and safety requirements.

Chapter 2. Lithuania's outlook for CCS and CCU

This chapter will capture the CCU and CCS landscape in the target country, as per the Country Template guidance document (Theme 2, section 1). It will be informed by background research and expert insights from targeted stakeholders.

1. Summary of stakeholder engagement

14 stakeholder representatives were approached and engaged mainly through interviews and also seminars and workshops. Two academic (a), three public (b) and nine industry (c) representatives were engaged. These were chosen based on: their impact on (a) research done in theory and in practice, their current emissions, relevance and interest in reducing CO_2 emissions (b) and, finally, on the impact of (c) the approached institutions on discourse concerning CCS/CCU. The full list of engaged stakeholders:

- Achema - one of the top 5 companies by industry emissions. Produces nitrogen fertilisers and assorted chemical products;
- Akmenės cementas - one of the top 5 companies by industry emissions. Produces cement and related products;
- District heating association - a voluntary public organisation that represents the interests and rights of the Lithuanian District Heat utilities, organisations and other associated energy structures in the district heating sector;
- Fortum Lietuva - one of the top 5 companies by industry emissions. Generates heat and electricity using sorted municipal and industrial waste;
- Ignitis - Ignitis is the largest supplier of electricity and gas in Lithuania;
- Klaipėdos nafta is an oil and liquefied natural gas terminal operator based in Klaipėda, Lithuania;
- Kaunas university of Technology is one of the leading universities in Lithuania, with specialisations primarily in engineering, technologies and physical sciences;
- Lithuanian Geology Survey - this institution, which organisationally is under the Ministry of Environment, is a state institution intended for the investigation of underground regulation, its use and protection;
- Minijos nafta - the primary activity of the Lithuanian and Danish joint venture Minijos Nafta is oil extraction;
- Ministry of energy oversees government policy in fuel, electricity, thermo-energy production and supply for Lithuania's economy;
- Ministry of environment oversees the environment and natural resources in Lithuania;
- The State Scientific Institute Nature Research Centre is a public legal entity operating as a state budget institution and performing long-term research and experimental (social and cultural) development activities according to research trends established in the Articles of Association of the Nature Research Centre and significant for the state, society, international communication and business;
- Orlen Lietuva is one of the top 5 companies by industry emissions. Orlen Lietuva is an oil refining company;
- VIlniaus šilumos tinklai is one of the top 5 companies by industry emissions. This company is Lithuania's largest provider of heating and hot water.

2. Stakeholder positions on CCS and CCU

The aforementioned stakeholders were engaged in interviews, asking them about CCS/CCU. All stakeholders acknowledged that CCS in Lithuania is underdeveloped due to the restrictions on storing carbon dioxide underground. Companies that are the largest emitters or whose technological processes cannot forgo emitting CO_2 (like cement manufacturing) noted that they would be highly interested if the financial conditions permitted continuing with CCS development. There is also academic interest in CCS from a governmental research organisation (Nature research centre) and from a university (Kaunas Technology university). Detailed stakeholder positions can be found in Table 3 (See Table 3: Positions of stakeholders in Lithuania on ccs and ccu).

TABLE 3: POSITIONS OF STAKEHOLDERS IN LITHUANIA ON CCS AND CCU

STAKEHOLDER	POSITION	ROLE
ACADEMIC INSTITUTIONS		
Nature research centre	Experts from the research centre see their role as an advisory and informational partner to other institutions as at the current moment they are unable to perform scale-relevant research due to restrictions on CCS. The research centre has had experience in the past collaborating with scientists from other companies and various institutions in Europe - they noticed interest from large companies such as Klaipėdos Nafta with regard to the possibilities of developing the CCS sector in Lithuania.	Fence-sitter
Kaunas Technology university (KTU)	While KTU does not have extensive research into CCS/CCU, previous research not only shows potential for geological storage, but also for combining CO_2 with serpentinite, which could produce a carbonate that can be used for road infrastructure. The feasibility of this option, as with other relevant options in Lithuania, depends highly on the infrastructure for CO_2 transportation.	Fence-sitter
INDUSTRY REPRESENTATION		
Achema	Being the largest emitter in Lithuania, Achema has always analysed and looked at the possibilities of reducing their carbon footprint. Currently, Achema seeks this by offsetting activities and providing a part of CO_2 emissions to the local beverage industry. Around 3.3% of Achema's yearly emissions (1.5 M tonnes of CO_2) are turned over to beverage producers. Current ETS carbon prices (EUR 50 per tonne) are not sufficient (based on their previous calculations) to push Achema into developing CCS and CCU solutions. Despite this, Achema is collaborating with KTU and are looking into CCU options - creating products to be used in construction or related sectors. Achema is more inclined to possibly create new products with CCU, but CCS abroad is also a possibility they are willing to investigate.	Pace-setter
Akmenės cementas	The main cement producer in Lithuania does not currently see an opportunity for CCS for several reasons. First, current capture technologies are not well-established in Akmenės cementas and they require more information and best practice examples. Secondly, transportation and storage costs outside of Lithuania might be too much of a financial burden. Finally, as storing CO_2 in Lithuania is forbidden, the best option would be utilising it to create new products, but they are not yet sure of CCU potential.	Fence-sitter
Orlen Lietuva	Orlen group has prepared a strategy that foresees becoming climate neutral by 2050 through CO_2 capture or offsetting measures. Orlen Lietuva are currently looking at the financial and logistic opportunities of CO_2 capture and transportation offshore, with the most likely destination being Norway. Taking the amount of time needed for large-scale changes in their industrial line into consideration, Orlen Lietuva would install carbon capture technologies in around 2027 when their machinery is under general repair.	Fence-sitter

Vilniaus Šilumos tinklai (Vilnius heating networks)	Vilnius heating networks does not have a direct interest in CCS/CCU as by 2030 the company is planning to phase out gas through switching to biofuel and lowering of temperature (from 110 °C to 65 °C or so) in the system, harvesting excess heat from industrial users in Vilnius, and introducing heat accumulation devices and heat pumps. The prerequisite for this transformation is a significant renovation of apartment housing. Worst-insulated houses require large temperatures and consume disproportionally large amounts of energy during the coldest days. By 2040 the company foresees that biomass will be phased out in favour of electricity for two reasons. The first one - EU taxonomy directive, that will potentially remove CO_2 exception for biomass. Second reason - use of electricity will lower the temperature in the system even more and electricity (heat pumps) can be equivalently efficient and even easier to maintain the energy source. Criteria for success in this scenario is LT implementing its climate goals and a fully renovated housing stock.	Fence-sitter
Fortum Lietuva	Fortum Lietuva has gained insight from their group counterparts in Norway, Oslo, who have enacted pilot projects capturing CO_2. Based on those projects, Fortum Lietuva would be inclined to conduct their own pilot projects and they would help determine the most appropriate CO_2 capture technology, since the waste produced in Lithuania is quite different from Norway. Overall, Fortum Lietuva would be inclined to be a first mover in the CC market, but they do not see this as financially feasible in the current situation. Their pilot project would require extensive investments, so they will either receive governmental support or wait for the price of carbon to reach $ 100 per tonne.	Pace-setter
Ignitis	Ignitis has two main options for becoming carbon neutral: to stop burning fuels that emit GHG, or to catch the CO_2 that their fuel emits. Currently, the ETS price of carbon is not high enough to merit large-scale actions, so they are considering small pilot projects with specific power stations and collecting data about the costs of carbon capture, evaluating the costs of carbon transportation and possible shipment to CO_2 storage sites.	Pace-setter
District heating association	In Lithuania most of the heat is produced from biomass, and if renovation will move forward, there will be far less consumption peaks and it is reasonable to expect gas usage (main $C0_2$ emission source) to be below 5% of total heating energy, and below 10% if conservative predictions are made. CO_2 from biomass is only relevant as the transportation of biomass consumes non-renewable fuels, but the actual burning of wood is not a problem as it is considered CO_2 neutral and will remain as such. District heating companies will not do anything about capturing this CO_2. The only municipality that currently has any significant emissions is Vilnius.	Fence-sitter
Minijos nafta	The company is interested in conducting research into carbon storage, but the current legal regulations do not allow one to use volumes of CO_2 that would provide meaningful results for this company. Minijos nafta also evaluates that their oil reserves are depleting and having the possibility to use CO_2 for enhanced oil recovery could help in prolonging their activity.	Pace-setter
Klaipėdos nafta	The company is interested in CO_2 capture, storage and utilisation and actively seeks opportunities to use its terminal infrastructure to diversify their portfolio and load more liquid energy-related products, including liquified CO_2. They have been talking with main CO_2 emitters, which are Orlen Lietuva, Akmenės cementas, and Achema, about collaboration in the CO_2 transporting topic. Klaipėdos nafta has an active feasibility study that looks into transporting CO_2, with a partner company that is “one of the main CO_2 emitters in the country”. Based on current CO_2 emissions, there are probably 3 potential clients that they could feasibly cater to. Does not see any breakthroughs regarding allowing CO_2 storage underground in Lithuania, mainly looking into the stance of government	Pace-setter

	institutions. Also interested in hydrogen transportation, which for them will likely be a more lucrative business.	
PUBLIC INSTITUTIONS		
Ministry of environment	Representatives from the ministry stated that the current legal base determines their low involvement in CCS. Considering changes in the relevant laws, the ministry does not see themselves as agenda setters and are not proactive in raising the discussion about CCS.	Foot-dragger
Ministry of energy	Representatives from the ministry stated an interest in hydrogen, which is reiterated In the National Climate Action plan and National Energy Independence strategy. Considering hydrogen as a prospective resource, the ministry sees the need of CCS as a key component in delivering clean hydrogen, which Is seen as a 'green' fuel. CCS can help to reduce the carbon emissions of processes that manufacture hydrogen as a usable resource, i.e. store the CO_2 from the reforming process of natural gas. The ministry is willing to start discussions among key stakeholders in small-scale discussions, workshops and seminars.	Pace-setter
Lithuanian geology service	The geology service sees the ban on CCS as a disservice to their research and possibilities for business to reduce their CO_2 emissions. If the possibility were to return, they would conduct research projects on the prospects and capabilities of CCS in Lithuania. Concerning the safety and risks of CCS, the representatives from the service see them as minimal taking the geological structure in Lithuania into account.	Pace-setter

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

3.1. Overall prospects for CCU/CCS in target country

Overall prospects for CCU/CCS are high in Lithuania, as the main emitters have shown confidence that they could transform their main activities and both capture and store the CO_2. CCS is viewed with hesitance by main actors in Lithuania due to the legal situation and a lack of commercial business cases. CCU is less known and accentuated during the interviews.

3.2. The role of CCU/CCS in sector integration

CCU/CCS has the potential to integrate a qualified majority of companies that emit the highest amounts of CO_2. This integration can be realised through common projects storing, transporting or utilising captured CO_2.

3.3. Awareness of EU policy and financial instruments for CCU/CCS

Several stakeholders commented about foreign companies or public institutions who relayed that there are various financing possibilities, especially considering the European Green Deal and projects related to carbon neutrality. Certain aspects in EU policy are not fully understood or disclosed (EU Taxonomy), so their final effect on CCU/CCS is to be determined.

3.4. Perceived deployment barriers and risks

The largest hurdle is the transportation cost of CO_2, which also has the additional issue of requiring a substantial amount of local storage. Another challenge is for each company to decide on and choose specific carbon capture technologies for each specific sector - currently some companies can draw from knowledge that their counterparts in other countries have gained (Fortum) and others can look at sectoral examples that are essentially identical in terms of industrial processes (Akmenės cementas).

4. Stakeholder recommendations for CCU/CCS

4.1. Regulation

The first and most important aspect for change in the legal landscape is the backtracking of the 2019 prohibition of CO_2 storage. Besides this one redaction, other laws and regulations are equipped to handle CCS and CCU developments. For this reason, several stakeholders did not see much need for enabling storage in Lithuania, as there are enough possibilities to store CO_2 outside Lithuania or propagating CCU solutions.

4.2. Technology

Two main technologies need development or government support: specific CO_2 capture devices and chain of transportation for CO_2. Different emissions structures within different industries require in-depth knowledge concerning different methods of capturing carbon. While some companies may just wait and see what others use, the major industry companies will be more inclined to perform small-scale pilot projects and find the best technology for their own needs. The cost of transporting carbon is also a major issue, since carrying carbon over long distances requires significant infrastructure investment and storing it onshore before shipment requires terminal utilities.

4.3. Infrastructure

Currently, no widely used infrastructure for CCS/CCU or even CO_2 transportation is implemented in Lithuania. Achema has stated that they have the capabilities to capture CO_2, but only 3% of it is utilised by the beverage industry. The most pertinent infrastructure questions surround CO_2 transportation, since the most likely outcome is that the major emitters in Lithuania will export their captured CO_2. State involvement in establishing CO_2 transportation Infrastructure would provide incentives for private companies to go forward with CCS/CCU projects.

4.4. Market

The most pertinent question for the CCS/CCU market is the ETS allowance price per tonne of CO_2. Currently (at the time of writing) the price of one tonne is EUR 53[6]. Several industry stakeholders have stated that this price is not yet enough to start moving towards CCS/CCU, but a price closer to EUR 100 per tonne would mandate them to take action. It is important to note that CCS chain development takes at least 5 years, so to avoid substantive financial costs due to CO_2 emissions, governments and key companies that would benefit from CCS should think ahead and prepare for the price of carbon to reach the critical mark of EUR 100 per tonne.

4.5. Financial frameworks

Financial frameworks and grants for pilot projects would incentivise companies to prioritise carbon capture on their agenda. The EU's Taxonomy initiative might be one of these options: The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities[7]. This system is an important enabler to scale up sustainable investment and to implement the European Green Deal. Notably, by providing appropriate definitions to companies, investors and policymakers on which economic activities can be considered environmentally sustainable, it is expected to create security for investors, and protect private investors from greenwashing, help companies to plan the transition, mitigate market fragmentation and eventually help shift investments where they are most needed. CCS/CCU could be one of the activities that are classified as a part of the EU taxonomy.

4.6. Inter-sectoral and regional collaboration

[6] https://ember-climate.org/data/carbon-price-viewer/

[7] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

Different types of collaboration would have an impact on CCS/CCU: regional collaboration can help with the dissemination of scientific research and possible benefits of CCS/CCU, while Inter-sectoral collaboration can help reduce the risks and costs of implementing projects related to CCS/CCU.

4.7. Social aspects

CCU/CCS deployment requires the active public participation of scientists and experts. Communication of factual data and results of research could help disseminate realistic information, not personal opinion. This could help in showing the benefit of CCS/CCU to business, climate and local communities.

Conclusions

Currently, CCS/CCU in Lithuania has few prospects due to the legal changes in recent years. This is countered by timid hope from various stakeholders that this might change. In any case, stakeholders from the side of industry have taken into account the fact that carbon capture is unavoidable in the future and some of them have preliminarily evaluated the possible costs of transporting CO_2 offshore (i.e. the North Sea). CCU is another option that keeps stakeholder's hopeful of reaching a financially viable way of capturing carbon, even though the actual effectiveness in emission reduction is not yet fully known and the detriments of different CCU processes might even be worse for the climate but in separate ways.

Chapter 3. CCS and CCU: Public acceptance in Lithuania

Public acceptance of CCS and CCU in Lithuania was mostly formed by statements of public officials, especially ones that overstated the negative aspects, thus causing the public to get agitated without even analysing any factual Information. Thus, the overall awareness of the public on the topics of CCS and CCU is limited at best and negatively skewed at worst.

One of the three most CO_2-emitting companies have made public statements about the future and possible use of CCS/CCU. “Compared to 1990, we have achieved 25% lower CO_2 emissions, they have decreased from 3 million to 0.8 million tonnes. All of our previous investments in new technologies have focused on this. We are now preparing for the second step. We will abandon the use of fossil fuels - coal - as much as possible, we will replace it with an alternative, so that by 2030 we will reduce emissions by 55%. This is not easy and will require large investments - we hope that we may have the opportunity to use the DNA (Deoxyribonucleic acid) Plan of the Future Economy or the Fair Transformation Fund.” says Artūras Zaremba, CEO of the cement production company Akmenės cementas[8].

In the next three years, Akmenės Cementas will be able to abandon fossil fuels and replace them with alternative ones at a cost of about EUR 15-20 million. However, these investments will not determine everything. Fuels account for about 40% of total CO_2 emissions, with the remaining 60% being from raw materials. Limestone emits carbon dioxide when exposed to high temperatures. And there is nothing to change in the production of limestone cement yet.

"By 2050, we will have to achieve zero CO_2 emissions. The technology (*CCS*) is there, but it is not very widespread - in Europe, the new technology is currently being installed in one factory, apparently with the support of the Norwegian government. Then we will see how this technology works,” says the head of the company[9].

Doubts about CCS have been put forward both by institutional representatives and NGO's. The former minister of environment has stated[10] that: "Landfilling of carbon dioxide is a rather dubious project. (...) If scientists emphasise that CO_2 buried in the ground can cause additional problems due to carbonation, acidification, other chemical reactions, and knowing that Lithuania's groundwater resources are huge, the threat to groundwater resources and quality is really in first place.”

Several members of parliament expressed their concerns publicly, showing doubt about the benefit of CCS and deliberated about alternative costs[11]: “Today, the territories of western Lithuania are rich in geothermal water, which can be successfully applied in various areas in the future, but by turning these territories into landfill storage, we prevent any other innovations. With the installation of carbon storage in these areas, in order not to damage the tightness of the storage, we could hardly extract oil further in the deeper layers of the earth.” Fear about the safety of underground water reserves was a resounding argument amongst the proponents of forbidding CCU/CCS, with some suggesting that storing CO_2 would be carried out as deep as underground water reserves are found, and this could cause harm to these reserves[12].

[8] https://www.vz.lt/pramone/2020/12/08/akmenes-cementas-nulines-tarsos-kaina&template=api_article
[9] Ibid.
[10] https://www.vz.lt/pramone/energetika/2019/07/04/k-mazeika-co2-laidojimas-zemeje-keltu-gresme-vandens-istekliams
[11] https://www.delfi.lt/news/ringas/politics/kestutis-bacvinka-ar-lietuva-paversime-co2-saugykla.d?id=82257543
[12] https://www.lrt.lt/naujienos/verslas/4/1105669/draudimas-zemes-gelmese-laidoti-anglies-dioksida-vieni-mato-pavoju-kiti-pasiusta-neigiama-zinia-verslui

In the discussion surrounding CCS doubts were raised about the relevance of CO_2 in global warming. Concerns were raised due to the lack of scientific research[13]: "This is a matter for one firm or private individual. The plans that are being drawn up and made with the aim of reducing emissions are too optimistic. But no scientist has yet answered whether the increase in CO_2 is due to rising global temperatures or whether rising temperatures are due to rising CO_2. There is a fundamental question here, but there is no answer." These doubts are renounced by most major climate change institutions, academic circles, and various multilateral organisations.

Amidst the discussion about the safety and necessity of CCS, some politicians saw possible private interests being put ahead of public interests. This was over a feasibility study for a new gas-fired power plant in Lithuania. The use of so-called zero-emission technologies in a 300 MW gas-fired power plant were being considered, i.e. the CO_2 captured would be buried in the depths of the earth rather than released into the atmosphere, thus avoiding huge pollution charges. But after Seimas passed amendments to the law restricting the use of CCS technologies in Lithuania, American investors were forced to bury their plans and retreat from their planned projects.

Public organisations and non-profits related to circular (or green) economy idea propagation criticise industrial companies for not paying enough to offset the damage they enact on the environment[14]. This is further strengthened with comparisons of taxes paid per tonne of CO_2, showing that the largest polluters pay significantly less taxes than the effect their emitted CO_2 has on the environment. Provided demands or, rather, recommendations are to use fewer polluting fuels or exchange the produced products into more sustainable alternatives.

Conclusion

As of writing this report, public awareness and the public image of CCS/CCU technology in Lithuania is not favourable. This is in part due to statements of public figures that were widely deliberated, and the opinions of researchers and geologists were pushed to the sidelines. No research or surveys have been conducted on this specific topic and the interviewed stakeholders also expressed that public discourse regarding CCS/CCU is lacking. Looking at the context of legal changes in 2019, public acceptance of CCS/CCU was formed in a negative manner due to the communication of several actors that tried to accentuate risks and problems with related technology and projects. However, both the increasing activity of industry leaders and the EU's agenda on transitioning to a carbon-neutral economy will surely increase the flow of information from multilateral sources. As a result, both discussions and possible project implementations should have a more nuanced evaluation in terms of public acceptance. This can be best done together with academic and research personnel that have long-term experience in topics of CCS/CCU (Nature Research centre, Lithuanian Geology service) and industry leaders who plan to be pace-setters of CCS development in the region.

[13] Ibid.

[14] http://www.circulareconomy.lt/10-daugiausiai-prie-klimato-kaitos-prisidedanciu-imoniu-lietuvoje-2020/?fbclid=IwAR3PvBHXHEUqW7HKqGMXF5Hzzdd8sR0AH7aY0gwIhE_hOw8nz7g59xvAhxY

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