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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

ESTONIA

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Used acronyms and definitions

CCS	Carbon capture and storage
CCU	Carbon capture and usage
CHP	Combined head and power/cogeneration
ETS	European Union emissions trading system
IVIA	Ida-Viru Industrial Areas Foundation – public development organisation in Ida-Viru region
KNC	Kunda Nordic Cement – Cement producer in Estonia
OIL SHALE	Sedimentary rock used for energy and oil production
PCC	Precipitated calcium carbonate – speciality mineral used as a functional filler in many industries

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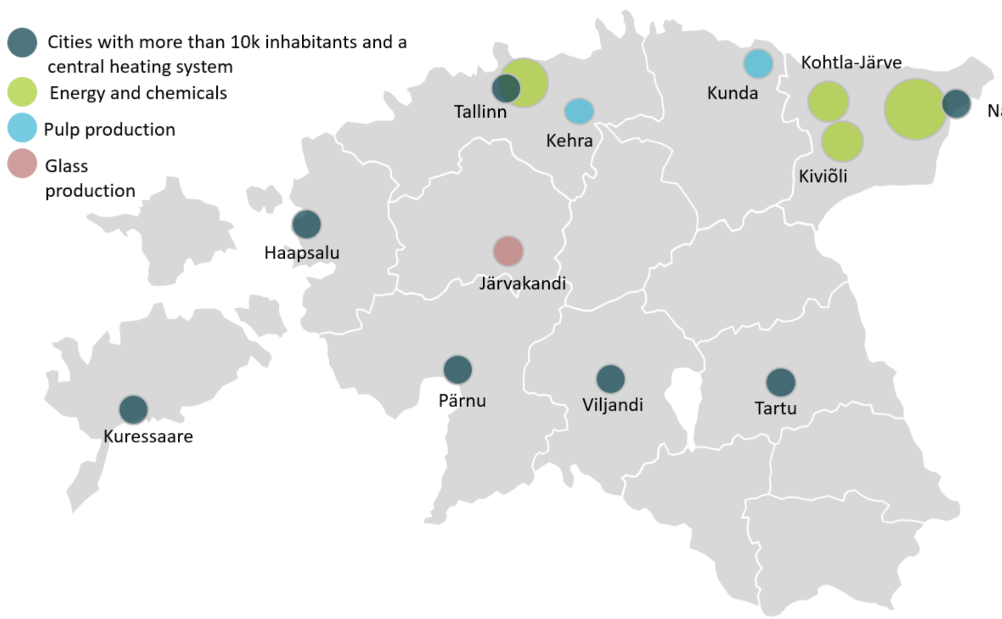
Chapter 1. CCS and CCU: current state and past experiences in Estonia

1. Description of relevant domestic economic sectors

Out of the industries that have potential for CCS and CCU, most are situated in the north-eastern region of Estonia, in Ida-Virumaa County. Most of Estonia's emissions come from the oil shale industry, which is the main source of electricity throughout the country and also provides the raw material for a few companies in the chemical production sector. The use of fossil-based fuels in energy production is the main cause of CO_2 emissions in Estonia. Oil shale energy production dates back to the 20th century and is the main energy source of Estonia to this day. Despite a significant decrease in carbon emissions in Estonia, 96% of all emissions still come from the carbon heavy oil shale mining and processing industries.

As the oil shale mines in Estonia are located in the eastern part of the country, the majority of the ETS regulated emitters are located in the same area. The map of the biggest CO_2 emitters is presented in Figure 1 below.

Figure 1. Location of biggest emitters and cities with central heat production in Estonia



Source: Civitta

The map presents the locations in Estonia that have industries with heavy emitters. Green areas represent energy and heat producers using both oil shale and shale oil; the red area represents a single round glass producer, and light blue, paper and pulp production. Dark blue areas represent major municipalities and/or cities with central heating or CHP plants. A more detailed description of each economic sector is provided in the next chapter.

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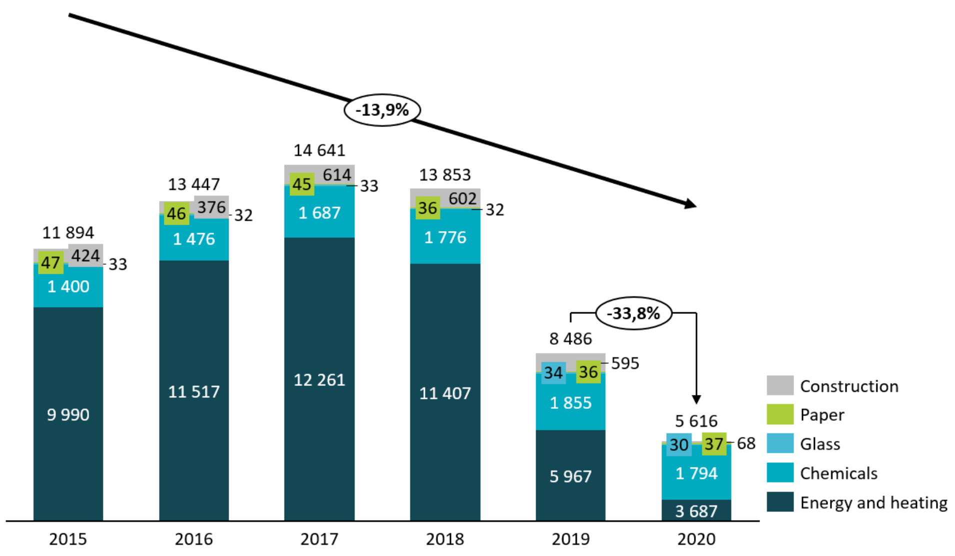
During the past six years, Estonia has significantly cut its emissions levels. With the adoption of newer, more ambitious climate goals in 2019, Estonia adopted a detailed plan - "General Principles of Climate Policy until 2050" (GPCP2050)[1] - to follow in order to reach climate neutrality by 2050 and decrease the emissions by 40% by 2030. The emissions have decreased on average by almost 14% between 2015 and 2020, while the decrease between 2019 and 2020 was 34%[2]. These trends in 2019 and 2020 were caused by emission decline in the energy sector, due to limited electricity production from oil shale, mainly due to high EU ETS prices. The country's leading energy producer Eesti Energia increased its renewable energy production significantly in 2019 and 2020. The majority was provided by its subsidiary Enefit Green, which is the largest wind energy producer in the Baltic states. Renewable energy production also increased in Ida-Virumaa thermal power plants, where the company produces electricity from wood waste. Figure 2 presents the total emissions between the years 2015 and 2020.

Figure 2. Total emissions in Estonia 2015-2020 (thousand tonnes)



Source: Estonian Environmental Board

When looking at the annual emissions data for the ETS regulated companies in Estonia, more than 90% of all the emissions are created by three energy/oil groups that use oil shale to produce power. As a direct consequence of using oil shale for energy production, the emitted CO_2 is different in its formula and needs additional investments in purification stations before it can potentially be stored or used in other industries.

1.1. Carbon-intensive sectors of the Estonian economy

The following presents an overview of carbon intensive industries in Estonia: power, cement, pulp and glass. In addition, an overview of previous activities of a company from the chemical sector is included as carbon capture and utilisation was implemented within their activities. All other industries have emissions below 10 000 tonnes of CO_2 per annum, and are therefore outside of consideration for capture potential.

[1]"General Principles of Climate Policy until 2050" (GPCP2050) <link>

[2] Environmental Board of the Estonian Republic. <link>

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POWER PRODUCTION

Power production is the biggest industry with the highest emissions in Estonia. According to the Environmental Board of the Estonian Republic, the heating and power sector make up around 70% of all the CO_2 emissions in Estonia. This is a direct consequence of most of the production coming from fossil-based fuels, primarily oil shale. This is constantly changing however, and energy producers, mainly the government-owned Eesti Energia (internationally Enefit), are looking for ways to substitute oil shale with other fuels in order to discontinue the usage of oil shale for electricity production completely.

In total, Estonia produces around 8000 GWh of electricity, out of which approximately 70% is produced from oil shale or oil shale gas. Out of the total electricity production, approximately 85% of the total is produced by three powerplants: Auvere, Eesti and Balti electric power plants. Around 15-20% of the total electricity output is produced in cogeneration (CHP) power plants in the bigger cities such as Tallinn and Tartu, which frequently use other types of fuels in the process such as natural gas, pulp, waste etc. Regarding heat production, the total amount reaches approximately 5000 GWh, out of which 25% is produced from oil shale products. However, the majority of heating is produced by CHP plants using biomass for fuel and other renewable sources such as wind and sun energy, significantly decreasing the carbon footprint of the heating and electricity industry. An overview of the main energy production units is presented in table 1 below.

Overall, energy producers are gradually shifting to renewable energy sources by decreasing the amount of fossil fuels, but at the same time trying to find ways to extract more energy out of oil shale. Around 80% of the oil shale's energy potential can be used; this includes the usage of shale gas for production in the second round. The CO_2 emitted through the process of burning oil shale in Estonia is chemically different to most other cases. In order to somehow redirect the carbon to either storage or usage, it needs to be cleaned of all other chemical compounds. This creates, next to capturing technologies, the need for cleaning technologies in order for the captured carbon dioxide to be eligible for usage. Some of the biggest energy blocks are able to use multiple types of fuels depending on demand. For example, Auvere (the biggest energy production unit in Estonia) can substitute 50% of oil shale with biomass, 20% with peat and 10% with shale gas. Recent developments in decreasing total emissions have led to the biggest energy producer (Enefit Power) discontinuing the direct use of oil shale for electricity production by 2025. Energy production in Enefit is shifting to using shale gas as a by-product from chemical production by 2030, after which any use of oil shale is discontinued.

Table 1. Main Estonian energy production units

PRODUCTION UNIT	LOCATION	CO_2 EMISSIONS	FUEL	FUTURE PROSPECTS
Eesti Power Station (1615 MW)	North-East Estonia, Narva	1,650 kilotonnes	Oil shale, 50% can be substituted with biomass	By 2025, Enefit will stop energy production from oil shale and will continue with shale gas, a by-product from oil production.
Auvere Power Station (300 MW)	North-East Estonia, Auvere	799 kilotonnes	Oil shale, 50% can be substituted with biomass	By 2025, Enefit will stop energy production from oil shale and will continue with shale gas, a by-product from oil production.
Põhja Power Station (95 MW)	North-East Estonia, Kohtla-Järve	629 kilotonnes	Oil shale, natural gas	Future prospects unknown, however, a decrease in the use of oil shale is set by the Estonian energy management plan.

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PRODUCTION UNIT	LOCATION	CO_2 EMISSIONS	FUEL	FUTURE PROSPECTS
Utilitas Tallinn (46 MW elec., 143 MW heat)	Four CHP stations in Tallinn, Estonia	96 kilotonnes	Wood chips Peat	Tallinn power stations will continue operating on fuels with smaller emissions and are upgrading technologies to make the process more efficient.
Iru Power Station (190 MW)	Tallinn Estonia	7 kilotonnes	Natural gas Household rubbish	Iru power plant has been using household waste since 2013 and is continuing to generate power and heat for Tallinn.

CEMENT PRODUCTION

In addition to heat and power generation, one of the major polluting industries until 2020 was cement production, as one producer – Kunda Nordic Cement (KNC) – used clinker in their cement production plant located in the north-eastern part of Estonia. The production of clinker from raw material needs high temperatures and fuel for burning, and is therefore highly polluting. The company discontinued its clinker production in 2020. The major change in the product portfolio was caused by outdated and polluting technology and high production prices. Currently, the usage of clinker as a raw material is at the minimum and it is being imported from neighbouring countries. As a direct result of discontinuing a polluting product line, the total emissions were cut by 600 000 tonnes or a 7% decrease in Estonia's total emissions in 2020.[3] The fact that the cement industry no longer produces raw materials in-house due to higher prices of old technology, does not imply that there is no potential for a new company starting the production of cement using the clinker method. The competitive environment allows for new entrants into the market, therefore the potential for CCU potential in the cement industry has not vanished.

GLASS PRODUCTION

Regarding the glass industry, there is a glass producer in Estonia participating in the ETS trading system. O-I Estonia is the major producer of glass packaging (primarily bottles). In the Estonian plant around 65 tonnes of glass products are produced annually and the main target markets are Estonia, Latvia and Finland. The glass producer does not disclose any information publicly and did not express interest in participating in a discussion concerning CCS/CCU potential. The company itself contributes around 34 000 tonnes of CO_2, which is 0.4% of Estonia's total annual emissions.

PRODUCTION OF PULP

The biggest producers of paper and pulp in Estonia are Estonian Cell and Horizon Pulp and Paper. Combined, the two companies account for 0.5% of total Estonian CO_2 emissions. As pulp and paper production is considered to be harmful to the environment, companies in Estonia are making large investments towards sustainability and environmental goals. For example, both have invested in their on-site CHP stations.

PRODUCTION OF AMMONIA

The only ammonia producer In Estonia – Nitrofert, discontinued their activities in 2015 due to the challenging economic situation. At the time the company was first of its kind to implement CCU solutions. They were producing urea from the leftover CO_2, and additionally CO_2 on a small scale for usage in the food and beverage industry. Since 2015, ammonia is imported from Russia. The

[3] Press release from company website <link>

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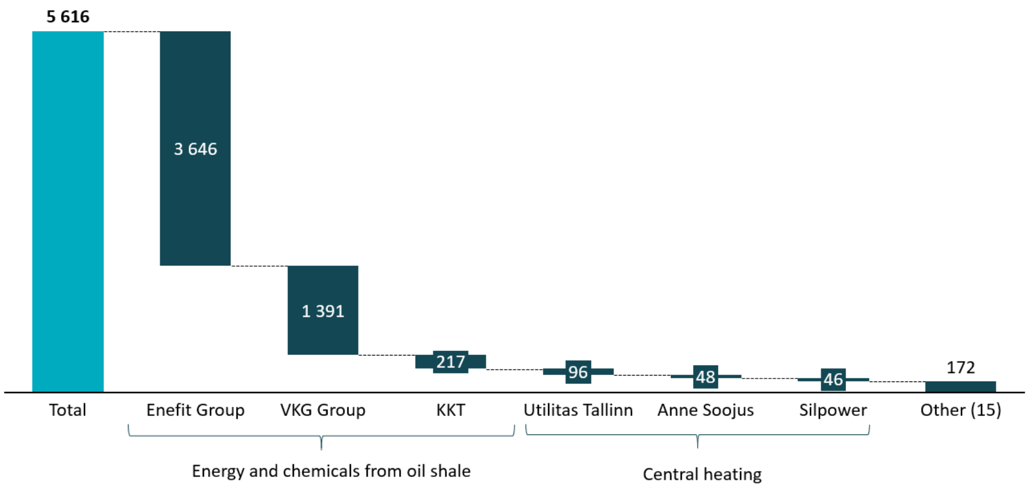
main reason for halting production in Estonia was the high cost of production compared to neighbouring countries. It is expected that production will not return to Estonia as the usage is relatively low and the production costs are too high.

1.2. Major CO_2 emitters in Estonia

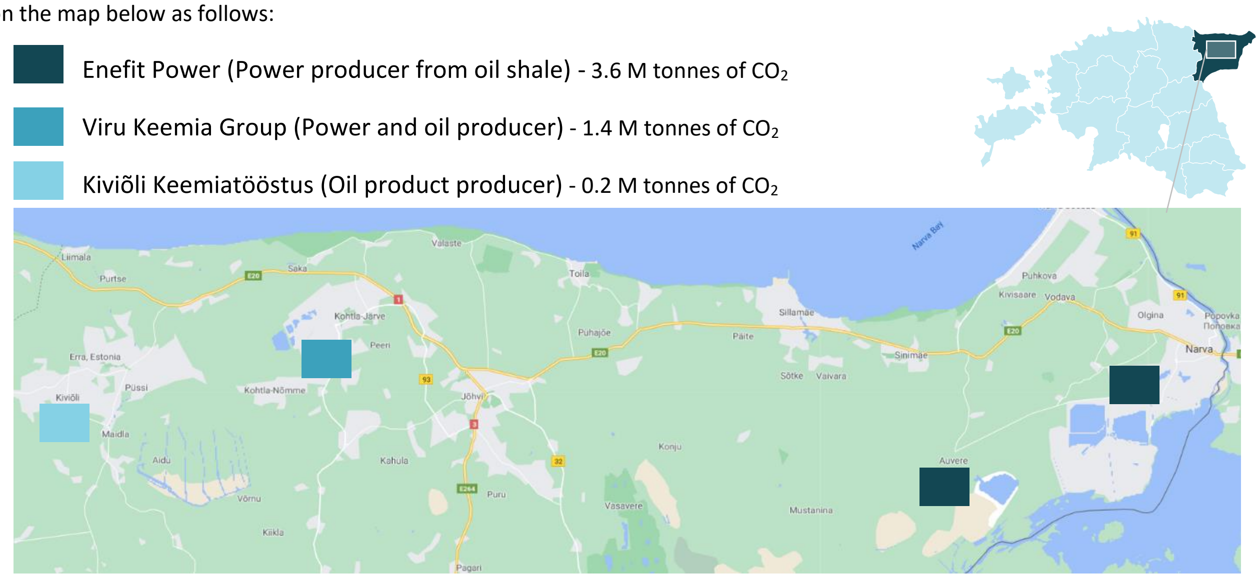
After a company-specific evaluation of emissions, it can be concluded that three companies operating in the oil shale sector are responsible for around 93% of all the emissions in the country and can therefore be declared as the main stakeholders for any CCS and CCU potential in Estonia. A more detailed split of companies contributing to emissions is presented in Figure 3 below.

Figure 3. Total emissions by ETS regulated company in thousand tonnes, 2020



Source: Civitta (data from the Estonian Environmental Board)

All of the three companies with the biggest emissions are energy and chemical producers who use oil shale. These companies are considered an extremely significant part of the economy in the north-eastern parts of Estonia. Each of the three companies have more than 600 employees and their combined tax footprint is more than EUR 116 million. The three companies are depicted on the map below as follows:



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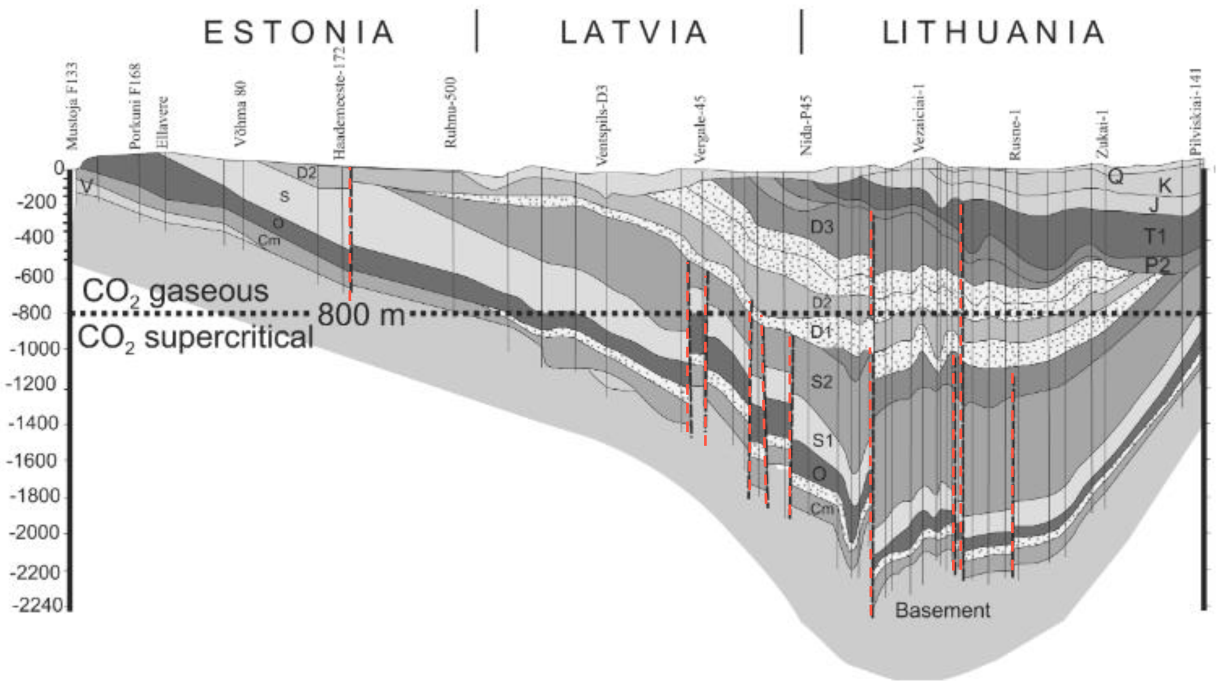
2. Assessment of geological potential for CCS

Estonia is located on the eastern edge of the Baltic sedimentation basin. The Baltic basin extends over the three Baltic countries and varies in thickness. In Estonia, the depth varies between outcrops and reaches 800 metres in certain areas. Suitable aquifers require a depth of more than 800 metres and due to this, the geological potential for carbon storage is limited in Estonia. The closest more suitable places for carbon capture and storage are in Latvia and Lithuania, as seen from the geological cross section in Figure 5. In addition to unsuitable sedimentary rock thickness in Estonia, any potential aquifers in the region contain potable water, which for purity purposes, could not be contaminated with any amount of CO_2.

Figure 4. Potential geological sinks in the Baltic Region



Source: Shogenova et al. 2008[4]. Major aquifers are indicated by red dotted lines. ***Np3, Ediacaran (Vendian); Ca, Cambrian; O, Ordovician; S1, Lower Silurian (Landovery and Wenlock series); S2, Upper Silurian (Ludlow and Pridoli series); D1, D2, and D3, Lower, Middle, and Upper Devonian; P2, Middle Permian; T1, Lower Triassic; J, Jurassic; K, Cretaceous; Q, Quaternary.***

As Estonia produces the largest amounts of CO_2 in the region due to oil shale, some producers have considered opportunities for CCS and CCU potential to aspire to the climate neutrality target. According to several studies (Šliaupa et al. 2008, Shogenova et al. 2009 and 2011), the nearest location for the storage of Estonian emissions is in Latvia, more specifically in the Cambrian aquifers in western Latvia. A highly theoretical opportunity mentioned by some stakeholders to store Estonian CO_2 in Latvia would require a pipeline that would extend over 800 km between the biggest cities of the two countries. Currently, the development of such a solution would be

[4] Shogenova et al. 2008. Industrial Carbon Dioxide emissions and potential geological sinks in the Baltic States <link>

an extremely expensive investment for any company, and when considering the country's sentiment on any bigger investment, such initiative would most probably not get the support of the wider public.

3. Description of implemented and planned projects

As CO_2 storage within the depths of the earth is forbidden in Estonia, except for the purpose of scientific research and development (see chapter 4: Legislation and regulation relevant for CCS deployment), no projects that would involve carbon capture have been implemented. Furthermore, due to the lack of geological potential for CCS, there are no ongoing projects by any stakeholders to deploy CCS technologies in Estonia. There are discussions regarding possible projects related to carbon heavy industries and CCU potential – mainly related to oil shale as this is the cause of most CO_2 emissions in Estonia. This topic has also been investigated through state-level research and development projects, which are described below.

PRODUCING PRECIPITATED CALCIUM CARBONATE FROM OIL SHALE ASH

Regarding CCU projects, a Scandinavian circular economy company is going to develop an alternative technology for the production of precipitated calcium carbonate (PCC). R-S OSA Service OÜ, a subsidiary of Ragn-Sells, is engaged in research projects on the value of oil shale ash. This project is based on ash valorisation technologies developed in Sweden, and in cooperation with Estonian researchers, they have developed a way to re-use the majority of Estonian leftover oil shale ash. The technology uses both leftover oil shale ash from the oil shale industry and captures the CO_2 from the burning process. Together with the capturing and cleaning of CO_2, the project can produce a high-quality end-product from waste materials that are otherwise either landfilled or emitted to the atmosphere. The produced calcium carbonate could be used in industries such as paper, plastics or construction, or even in the food or pharmaceutical industry as a functional filler to enhance product quality. The technology allows CO_2 to be captured during the process and directed into the formation of precipitated calcium carbonate. As a big difference compared to the traditional production method of PCC, the raw material limestone does not need to be mined. The technology uses already landfilled oil shale ash as the raw material for PCC production. It is estimated that approximately 600 M tonnes of oil shale ash has been landfilled in Estonia, indicating that in the long run, the technology does not need to depend on the energy sector. Avoiding the limestone mining process, the PCC made from oil shale ash creates a saving of approximately 300 000 tonnes of captured CO_2[5]. It is however important to note that the PCC production uses CO_2 from the energy sector that originates from the combustion of fossil fuels. Therefore, the exact climate benefit cannot be estimated as the CO_2 in all cases might not be permanently stored in the final product and at the end of the life cycle and still be emitted.

RITA RESEARCH PROJECT CLIMATE CHANGE MITIGATION WITH CCS AND CCU TECHNOLOGIES

A research and development project funded by the RITA programme and implemented by Tallinn University of Technology was completed in early 2021[6]. The main goal of the project was to evaluate the applicability of various CO_2 capture technologies for use in the oil shale industry and to develop scenarios for their implementation in the Estonian oil shale industry based on the best information available. Additionally, the aim was to analyse the environmental impact of the most suitable solutions and the technological and economic ability of the Estonian industrial sector to utilise captured CO_2. The research project provides the following conclusions:

As a result of the study, it was found that, based on the technological aspects of the oil shale industry, the most suitable CO_2 capture technologies in the near future are absorption and oxyfuel combustion. Depending on the CO_2 capture technology selected, the CO_2 footprint of electricity production would fall from 1026 kg CO_2 eq/MWh to 169 kg CO_2 eq/MWh (absorption) or 146 kg CO_2 eq/MWh

[5] Ida-Viru county CO_2 use Development Strategy 2021-2030 + <link>
[6] Climate change mitigation with CCS and CCU technologies <link>
* Represents the views of the RITA report not the views of the CCS4CEE project

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(oxyfuel combustion), using the Auvere plant as a reference. CO_2 capture would not be financially feasible under the current market conditions – CO_2 capture, cleaning, transportation, and storage (total at least 76-88 EUR/t CO_2 assuming full capacity operation) would significantly exceed the current alternative of CO_2 emission quota cost (approx. 40 EUR/t as of March 2021) and environmental charges. Feasibility of state aid for investments into CO_2 capture technologies or for operating these would be questionable as it would mean higher taxes or transferring the cost to the private sector, thereby reducing the overall competitiveness of the Estonian economy. Also, an increase in the CO_2 emission quota tariff or in the cost of CO_2 capture and storage would mean an additional cost component in electricity generation, and thus be a competitive disadvantage for CO_2 emitting producers of energy from fossil fuels, including oil shale.*

Briefly, the research concluded that CO_2 capture is not financially feasible in Estonia due to the CO_2 emission quota tariffs being less costly in comparison to developing any CCS/CCU technologies.

AUVERE AGROPARK

Auvere Agropark is a planned project of the Ida-Viru County Industrial Areas Development Foundation (IVIA). The main goal of IVIA is to create new jobs in Ida-Viru County. The Auvere Agropark project involves the construction of a carbon dioxide (CO_2) capture plant, which would allow the captured gas from the Auvere power plant to be sold or reused in the greenhouses used for crop husbandry of the planned agropark. The parties involved in the project believe that the cost of technology itself is going down, and operating costs are declining in the same way. The cost of the carbon capture plant is estimated to be EUR 200 million. According to preliminary estimates, phase I of the agropark could be used to achieve a capacity of up to 294 tonnes of CO_2 per day, making a maximum annual consumption of almost 110,000 tonnes of carbon dioxide. After all stages are carried out, the annual consumption potential could reach almost 0.5 million tonnes of CO_2. Currently Auvere Agropark is in the planning phase, the with first expected companies starting operations between 2027-2031.

4. Legislation and regulation relevant for CCS deployment

The legal landscape of CCS deployment in Estonia currently has some inconsistencies that leave room for misinterpretation. Regulations relevant for CCS deployment can be found in three legal acts: the Atmospheric Air Protection Act[7], the Earth's Crust Act[8] and the Water Act[9]. All of the mentioned legislative documents provide information related to carbon dioxide storage but there is no coherency in the information provided across the documents. The main incoherence lies in the information provided in the Atmospheric Air Protection Act, which seemingly allows the storage of carbon dioxide, while the other two documents prohibit these actions. Each of the acts are described as follows.

The Atmospheric Air Protection Act establishes the rights, duties and responsibilities of either private or legal persons in the exploration, transporting and storing of any potential carbon dioxide. Division 7 of the Act additionally sets the requirements for reporting standards, disclosure of information and the assessment of geological locations for storage. The Atmospheric Air Protection Act defines and regulates the overall carbon dioxide storage topic and by reading this, one could get the impression that the storage of carbon dioxide is allowed.

The Earth's Crust Act of 2016, section 105 states that "Geological storage of carbon dioxide in accordance with the Atmosphere Air Protection Act in the territory of the Republic of Estonia and under the continental shelf of Estonia is prohibited." This ban does not

[7] The Atmospheric Air Protection Act <link>
[8] The Water Act <link>
[9] The Earth's Crust Act <link>

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apply if the total volume of geologically stored carbon dioxide is less than 100,000 tonnes and the storage is undertaken for research, development or testing of new products and processes.

In addition to the Earth's Crust Act, the Water Act, Chapter 5 "Use and Protection of Marine Environment", section 34, prohibits any storage of carbon dioxide in marine areas. In the act, the storage of carbon dioxide in marine areas means placing carbon dioxide into a water column in a marine area or onto the seabed for the storage of CO_2 in geological formations under the seabed.

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Chapter 2. Estonia's outlook for CCS and CCU

This chapter reflects the CCU and CCS landscape in Estonia according to the data gathered through background research and expert insights from stakeholders involved.

1. Summary of stakeholder engagement

15 stakeholder representatives, including all major emitters, were mainly approached and engaged through interviews and also seminars and workshops. Three academic (a), two public (b), eight industry (c) and two civil society and NGO representatives were contacted. These stakeholders were chosen based on: their impact on (a) research performed 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. Chapter 2: Stakeholder positions on CCS and CCU provides a detailed overview of the opinions presented by the stakeholders who agreed to be interviewed.

The engaged stakeholders were as follows:

- Enefit Power (Eesti Energia AS)
- Estonian Cell (AS Estonian Cell)
- Estonian Green Movement
- Ida-Viru Industrial Areas (IVIA (SA Ida-Virumaa Tööstusalade Arendus))
- RS-OSA Service (RS-OSA Service OÜ)
- Tallinn University of Technology (TalTech)
- The Geological Survey of Estonia
- Ministry of the Environment
- University of Tartu
- Viru Keemia Grupp (Viru Keemia Grupp AS)
- Keemiatööstuse Liit (Chemical Union) – *not interviewed*
- Kunda Nordic Cement (AS Kunda Nordic Tsement) – *not interviewed*
- Kiviõli Keemiatööstus (Kiviõli Keemiatööstuse OÜ) – *not interviewed*
- Estonian Environmental Research Centre – *not interviewed*

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2. Stakeholder positions on CCS and CCU

The overall position regarding CCU/CCS in Estonia is relatively modest. The major stakeholders in the field are represented by the academic institutions who have performed research on the matter in Estonia but nevertheless conclude that the potential is minimal. The representation from the industry is twofold; there are companies who actively try to develop new solutions for tackling high emissions, however at the current state these stakeholders conclude that there is just no financial or economical reasoning to develop the technologies due to high prices and the cold acceptance of the topic. Public institutions and civil society also take a similar position: from a political point of view it is a necessary topic, however due to a lack of inter-sectoral framework and cooperation, geological potential for storage and the high price of technologies and relatively low current prices of emissions and environmental taxes, the stakeholders have no clear incentives to follow through with the solutions.

STAKEHOLDER	POSITION	ROLE
ACADEMIC INSTITUTIONS		
Tallinn University of Technology	Experts from the research centre engaged in geological research see their role as an advisory and informational partner to other institutions as at the current moment there is not much room for research due to non-existent CCS potential. The research centre has had experience in the past of collaborating with scientists from other companies and various institutions in Europe.	Pacesetter
University of Tartu	As claimed by other academic institutions, the main researcher in the field from the University of Tartu also deems the potential for any CCS and CCU technologies as limited. Can be considered as a pacesetter because of the emphasis on the subject. After continued research and projects, CCU would have more potential, but only approximately 1% of all emissions could be reused because of the technology and the specificity of Estonian CO_2.	Pacesetter
INDUSTRY REPRESENTATION		
Enefit Power	The biggest energy producer and emitter (3.6 Mt of CO_2) that considers it important to find alternative technologies, even though the outlook is currently not very positive. Currently trying to select 1-2 technologies to develop further. This would allow one to change the current production to some extent without having to implement completely new technology.	Pacesetter
Viru Keemia Grupp	Major oil shale producer and the third largest emitter (200 kt of CO_2) that is familiar with the technology and is informed of the academic research. Have performed their own small-scale in-house analysis on how production could be improved. The stakeholder is not optimistic because the CO_2 from their production is very specific and is not emitted from a single place. The current ETS price also makes them less optimistic, because capturing is so expensive, making it more cost-effective to continue paying for the quotas.	Foot-dragger
Estonian Cell	Pulp producer, the annual emissions of which are relatively low (26 kt of CO_2), but are still regulated. No development towards carbon capture or utilisation technologies. They are tackling the issue from the other side and are aiming to change their natural gas fuel for biogas, which would be more environmentally friendly.	Fence-sitter
RS-OSA Service	Leading Estonian circular economy company that is constantly researching and developing new technologies that reuse and recycle existing materials creating a positive environmental effect. RS-OSA is developing a technology that uses the oil shale industry's leftover ash and CO_2 as raw materials to create high-quality	Pace-setter

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STAKEHOLDER	POSITION	ROLE
	precipitated calcium carbonate, which is used as a filler substance in many different industries and products. Even though the production of PCC mainly solves the problem of oil shale ash, they also bind around 300 kg of potential CO_2 per 1 tonne of produced material. In the stakeholder's view this is one of the few developments in Estonia that has higher potential.	
Ida-Viru Industrial Areas	The entity represents an industrial area developer that focuses on bringing relevant players and technologies to the area to create new, innovative and sustainable solutions. IVIA promotes movement in the region towards carbon neutrality and is supporting the ideas of oil shale ash PCC production and the Agropark solution. Even though both methods can use relatively small amounts of CO_2 from the total Estonian emissions, the two projects would still carve a new path and mentality for the industry that would create new opportunities to develop capture and usage technologies further.	Pace-setter
PUBLIC INSTITUTIONS AND CIVIL SOCIETY		
Estonian Ministry of the Environment	Represents the overall idea, that the potential in Estonia is limited and the industries are not very active. Emphasises the issue and the importance, but due to a lack of funds, there are more important areas in Estonia that need to be developed as a priority. Can still be considered as the lead role from the public sector side and they are planning different communication strategies to inform the wider public about climate issues in general.	Pacesetter
Geological Survey of Estonia	The problem is acknowledged by the organisation similarly to other stakeholders, but the entity is not actively engaged in activities relevant to the topic. One of the main identified issues according to the Geological Survey is related to a lack of motivation from the industry players' side, because currently it is more economically feasible to pay for the emissions tax.	Fence-sitter
Estonian Green Movement	The organisation acknowledges the issue but raises concerns over how the problem is tackled or approached. They stress the point that CCS/CCU technologies are meant for industries where heavy pollution is unavoidable. In their view, the Estonian energy sector usage of oil shale is unavoidable, therefore the overall approach should be to find alternatives. However, the issue lies deeper, as publicly most stakeholders support CCS/CCU development, however from a closer view, no-one really finds the solutions feasible, mainly due to the costs and the complexity of the chemical formation of the CO_2 that is emitted.	Foot-dragger

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

3.1.1. Overall prospects for CCS/CCU in target country

The overall prospects for CCS/CCU are relatively low in Estonia. The low potential is twofold: the country lacks the geological potential for any storage of carbon dioxide, and the readiness for high-potential carbon capture and usage technologies are too expensive for any industry participant to develop them. Another issue regarding CCU potential is the specificity of the gases emerging from the oil shale industry. The gas needs to be purified from any additional elements to use it in other potential industries.

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3.1.2. The role of CCS/CCU in sector integration

The major emissions come from the energy sector, which is already fairly integrated in Estonia. Three major companies have good ties, but developing CCS/CCU solutions together could benefit the whole industry. All three major companies need to tackle a similar issue in close geographical proximity in the north-east of Estonia, however the level of cooperation is low. Currently, out of the three, one is a pace-setter aiming to adopt any carbon capture technologies, one is pessimistic about the technologies but is taking some form of statement in favour of future development towards alternatives, and the third major player did not wish to provide further comments regarding CCS/CCU potential within their activities.

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

The stakeholders have a clear understanding and awareness of EU policy and convergence towards climate neutrality by 2050. For Estonia, the mid-target of reducing emissions on a national level by 70% compared to 1990 levels has been brought to 2030 and the companies are aware of it. This leads to the companies' overall mentality that developing CC technologies in Estonia will take significantly longer than for other countries and will be solved much later. The stakeholders are aware of the financial instruments and support potential for the research and development of the technologies, however, the whole process of capturing, cleaning, and re-using CO_2 is not considered economically feasible. Even with a sudden increase in the ETS price, at current technological readiness it is more cost efficient for a company to pay for the quota.

3.1.4. Perceived deployment barriers and risks

The biggest barrier is the price of finding any alternative use to CO_2. In today's political climate, the storage of CO_2 both inshore and offshore is prohibited. Any potential of shipping it to other countries needs to be validated in high detail. Estonia is at the furthest end of the Baltic Sea; thus, transportation becomes increasingly more expensive. Another major barrier comes from the infeasibility of land transportation. To store Estonian emissions, a pipeline of over 800 km would need to be built and maintained on a yearly basis, including building liquefaction plants.

4. Stakeholder recommendations for CCU/CCS

4.1. Regulations

The stakeholders see no critically important changes in the regulation that would lead toward CCS/CCU technology development. Even if carbon storage were allowed within the depths of the earth or under the seafloor, there would not be much change in activity as all the stakeholders are aware of the non-existent potential of CCS in Estonia.

4.2. Technology

Two main technologies would need development or government support: specific CO_2 capture devices and CO_2 cleaning technology. Emission structures within different industries require in-depth knowledge concerning different methods of capturing carbon. As previously mentioned, CO_2 in Estonia is chemically different to most other cases. This is a direct consequence of burning from oil shale, and redirecting the carbon into storage or usage requires cleaning it from other chemical compounds. This creates, next to capturing technologies, the need for cleaning technologies. CO_2 could only be directed elsewhere after the cleaning process.

While some companies may just wait for developments from other players, the major industry companies will be more inclined to perform small-scale pilot projects and find the best technology for their own needs. At the current price levels, it is not economically viable to implement investments towards CCS/CCU technologies. Costs of capturing, cleaning and transporting carbon are also a

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major issue as the long-distance hauling of clean CO_2 and the liquefying process take the price per tonne to very high levels, making the companies not interested in pursuing this.

4.3. Infrastructure

Currently, no widely used infrastructure for CCS/CCU or even CO_2 transportation is implemented in Estonia. None of the industry participants have constructed any infrastructure that could catch and transport emissions coming from the production facilities. In any scenario, significant investments for capture, cleaning and transport need to be made. Pipelines would be the most difficult form of infrastructure, expanding through multiple territories and counties. If Estonia were to cooperate with Latvia and transport the CO_2 to their deposit sites, this would require the construction of the longest pipeline, exceeding 800 km together with a liquefaction terminal. As the potential for the storage of Estonian CO_2 in Latvia is low, another option in theory is to export the gas by sea transport. The closest port to the region with the most emitters is approximately 50 km away from the plants. This would once again require a proper pipeline and a liquefaction plant in the terminals. State involvement in establishing CO_2 transportation infrastructure would provide incentives for private companies to move forward with CCS/CCU projects.

4.4. Market

The most pertinent question for the CCS/CCU market is the quantity and the price per tonne of CO_2. Currently, the price of one tonne is EUR 53[10]. Several industry stakeholders stated that this price has significantly increased over the past year but is still below the point that would encourage some movement in the direction of CCU. At the current level, companies engaging in carbon capture activities would bear significant costs for capturing, cleaning and re-using. Therefore, at the current price, the majority of stakeholders would only continue current operations and seek new technologies after the ETS price reaches more than EUR 100-120 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[11]. Carbon capture and storage (CCS) qualifies as a taxonomy-eligible sector. The report states that "CCS can be eligible in any sector/activity if it enables that primary activity to operate in compliance with the threshold - for example, steel, cement or electricity production." 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, protect private investors from greenwashing, help companies to plan the transition, mitigate market fragmentation and eventually help shift investments to where they are most needed. In the view of the participated stakeholders, CCS and CCU solutions could be one of the activities that are classified as a part of the EU taxonomy incentive.

4.6. Inter-sectoral and regional collaboration

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. Estonian policy makers would like to see major emitters in the energy production industry working together in finding a suitable technology for their level of emissions. As oil shale remains one of the most important fuels in Estonia,

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10 Ember Daily EU ETS carbon market price <link>

11 EU taxonomy for sustainable activities <link>

some steps for negative climate effect mitigation need to be made. As the majority of the energy and chemical industry is located in North-East Estonia, there is great potential for regional collaboration between heavy polluting energy and chemical producers.

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 opinions of stakeholders. This could help with showcasing the benefit of CCS/CCU to business, climate and local communities.

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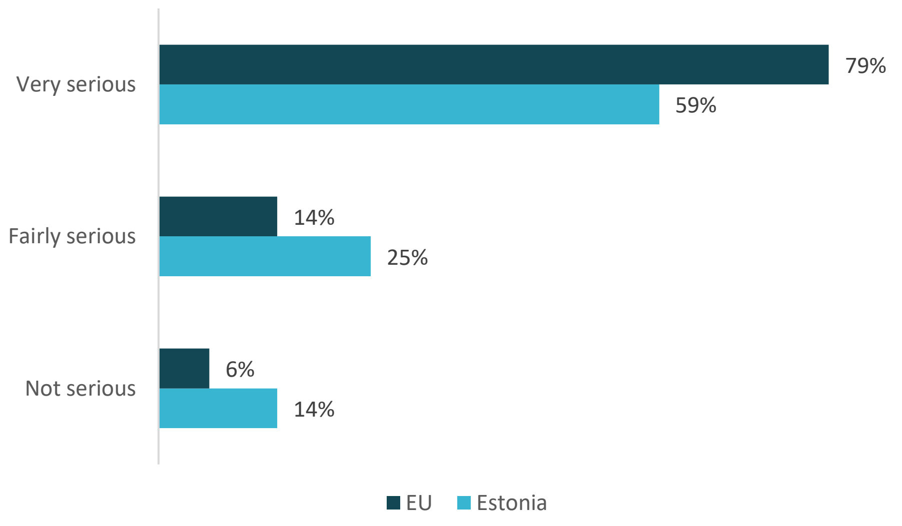
Chapter 3. CCS and CCU: Public acceptance in Estonia

Relying on currently available information, it can be concluded that no definite public image has been formed in connection with CCS/CCU technologies as these have not been heavily implemented In Estonia. No research or surveys have been conducted on this specific topic, and the interviewed stakeholders also expressed that public discourse regarding CCS/CCU in Estonia remains non-existent. When discussing the potential discourse in a scenario where CCS/CCU technologies would be implemented, the stakeholders believed that the general public would most likely not oppose it, as reducing CO_2 emissions would be seen as a positive matter. Nevertheless, some stakeholders were of the opinion that opposing views (so-called NIMBYism) would most likely be seen from the habitants of specific areas where new plants, CO_2 transport infrastructure etc. would be built. Such attitudes have been witnessed in relation to wind farms being built in Estonia as locals in the vicinity are concerned about the noise they produce.

Regarding Estonians' general perception of climate change and cutting carbon emissions, the proportion of those who see global warming as a problem is still one of the lowest in the European Union. According to the 2019 Eurobarometer study[12] on EU climate and energy policies, 59% of Estonian respondents consider climate change to be a "very serious" problem, while the European Union average is 79% (Figure 6).

Figure 5. How serious of a problem do you think climate change is at the moment?



Source: Eurobarometer 2019

[12] 2019 Eurobarometer study on EU climate and energy policies <link>

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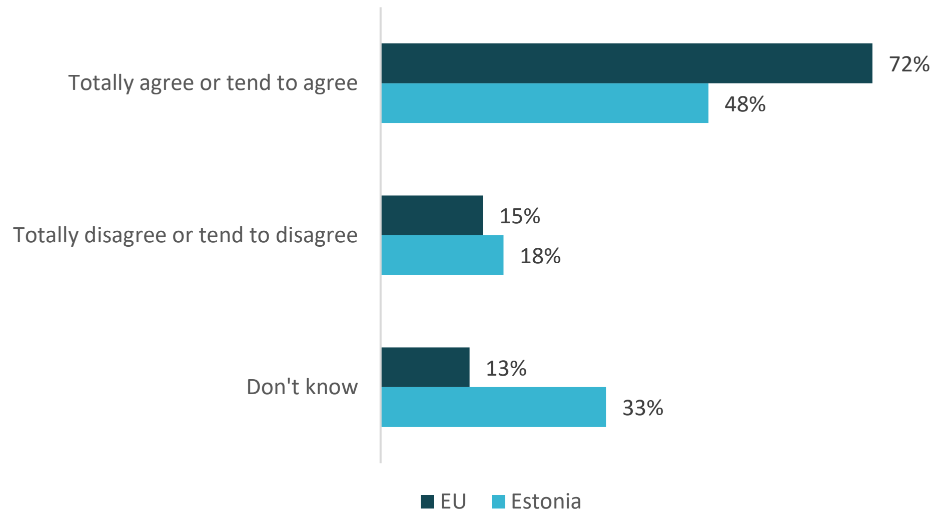
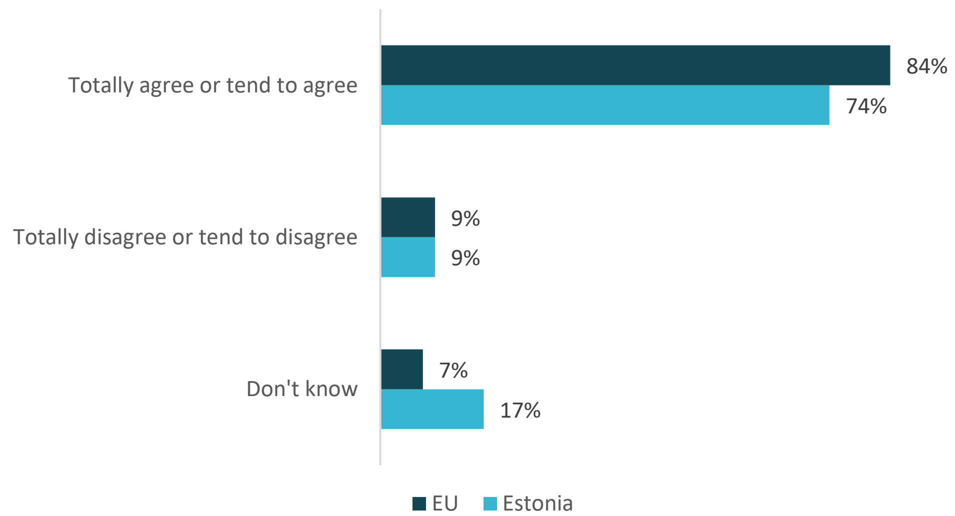
Estonia is also the only country in the European Union where less than half of the respondents - 48%, agreed with the statement that reducing the import of fossil fuels can increase energy security and be economically beneficial for the EU. The EU average was 72% (Figure 6).

Figure 6. Reducing fossil fuel imports from outside the EU can increase energy security and benefit the EU economically



Source: Eurobarometer 2019 When asked whether more public money should be allocated for the transition to clean energy, even if it meant reducing fossil fuel subsidies (Figure 7), Estonian respondents agree with this somewhat less (74%) than the EU average (84%). In addition, Estonia had the lowest share who totally agreed with it (27%), while the EU average was 44%.

Figure 7. More public financial support should be given to the transition to clean energies, even if it means that subsidies for fossil fuels should be reduced



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Source: Eurobarometer 2019

These notions indicate that while people in Estonia are becoming more concerned about the impact of climate change, it is not seen as an immediate threat and there is a significant number of people who do not see reducing the use of fossil fuels as a solution. According to the stakeholders involved, further societal education is needed as many people in Estonia do not have a good understanding regarding the country's approach to tackling climate change. Furthermore, the different actors involved pointed out that people feel quite disconnected from the topic as they do not see the impact on their personal lives or they have unreasonable fears associated with innovation in climate change mitigation.

Publications in media

The concepts of CCU and CCS are not widely published in the Estonian media. During recent years, news has been published on the research carried out as well as some interviews with experts in the field, but as the overall perception of CCS/CCU in Estonia is quite minimal, the media houses do not put significant emphasis on the matter. Opinion articles from politicians on the matter have been published, indicating that CCS/CCU in the oil shale industry could become the next big development area in Estonia, however without the proper support or understanding from the major stakeholders regarding the fact that CCS/CCU in Estonia is difficult to develop, especially at the current stage, these media publications have not been repeated.

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