An overview of Baltic Carbon Forum conference 2022

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Abstract. Baltic Carbon Forum (BCF) is an annual event sponsored by Nordic Council of Ministers through Nordic Energy Research through their network BASRECCS. BCF 2022 was held on 13th and 14th Oct. in Kaunas, Lithuania. The aim of the BCF 2022 was to enable interested and engaged stakeholders to meet, discuss, share knowledge and experiences, and develop projects. BCF also aims to increase awareness about Carbon Capture Utilization and Storage (CCUS) among younger generations with aim of securing a sustainable future for all. The BCF2022 invited a number of academic and industry experts from the Baltic Sea region countries, which included policymakers, financial institutes, industry representatives and academics for sharing their experiences, conduct discussions and brainstorming sessions to identify gaps with aim of expediting the deployment of a large-scale CC(U)S project in the Baltic Sea Region (BSR). BCF 2022 was attended by 74 participants. There were 38 participants who attended the conference onsite and 36 participants attended the conference online. Participants came form 15 countries, which included Finland, Lithuania, Hungary, Sweden, Poland, Norway, Estonia, Denmark, Latvia, Belgium, Germany, USA, UK, India and South Africa. This paper presents a short summary of all the talks presented at the BCF 2022 conference [1, 2].

Keywords: Baltic Carbon Forum, CCUS, Baltic Sea region, CCS, carbon capture, storage, utilization, transport and use.

1. Introduction

The Paris Agreement's goal is to keep the increase in global average temperature to well below 2 °C above pre-industrial levels and, in doing so, to pursue efforts to limit the increase to 1.5 °C. This has been incorporated into the critical energy-related UN Sustainable Development Goals, which seek in addition to widen access to clean, affordable energy. In order to achieve the goals of the Paris Agreement, a transition to a low carbon economy is essential to combat climate change. Technological innovation is one of the ways to achieve this, therefore, CCUS technology can be used as one pioneering technology to bridge the gap until the next generation low-, zero-, or negative-carbon technologies are available. However, CCUS technology and its implementation faces geographical, environmental, social, and political challenges. A sustainable approach is needed to look beyond the future, identify key risks and mitigations to the challenges identified for a feasible use of CCUS technology [3].

Baltic Carbon Forum 2022 (BCF 2022) is an annual conference, which was held this year on 13th -14th Oct in Kaunas, Lithuania. The aim of the BCF 2022 is to enable interested and engaged stakeholders to meet, discuss, share knowledge and experiences, and develop projects. Increase awareness about Carbon Capture Utilization and Storage (CCUS) among younger generations with aim of securing a sustainable future for all. The BCF is a part of BASRECCS long–term strategy to foster full-scale development of the climate change mitigation technologies carbon capture, utilization and storage (CCUS) in the Baltic Sea Region, as a critical carbon dioxide reduction technology for climate change mitigation. The BCF 2022 invited relevant experts from the BSR and neighboring countries, including policymakers, financial institutes, industry representatives and academics for sharing experiences, discussion and brainstorming to identify gaps for expediting the deployment of a large-scale CC(U)S project in the Baltic Sea Region

(BSR). The speakers in BCF 2022 shared their knowledge and experience in these aspects: informed about the current situation regarding the development of CC(U)S and related technologies in the BSR; presented and discussed the regionalization of ongoing and finalized projects; presented the ongoing and potential future cooperation and networking on CC(U)S and related technologies.

Next, key learning and summary of the 18 talks and 1 poster presented at the conference is reported in next sections.

2. Key learnings (Presentations of BCF 2022)

2.1. Comprehensive sensitivity analysis on static and dynamic reservoir parameters impacting near wellbore injectivity during CO_2 sequestration

In this presentation given at BCF 2022 authors [2] have discussed modelling strategies for CCS using commercial simulation packages. It has been demonstrated that carbon capture and storage (CCS) is a successful strategy for lowering CO_2 emissions. The simulation methods presented in this talk highlighted the need for improved modelling strategies, which are necessary for assessment of different CCUS methods with aim of reaching the carbon neutral world with keeping global temperature below 1.5 °C goal.

By removing CO_2 from emission sources and storing it in geological formations, CO_2 is prevented from entering the atmosphere. Due to their widespread presence and substantial storage capacity, saline aquifers are the most frequently used subsurface formations for CO_2 storage. The drawback of this storage solution is that it requires a minimum of wells to inject substantial volumes of CO_2 at acceptable rates. Mineral dissolution, fine particle mobility, salt precipitation, and hydrate formation cause the injectivity impairment/enhancement (known so far). Depending on the reservoir pressure and temperature, the salinity of the formation water, the mineralogy of the rocks, the flow rate of CO_2 injection, and how dry the area is, each of these mechanisms will be more dominant in the alteration of injectivity at different distances from the injection point.

In this study authors [2] chose to investigate the effects of formation features, CO_2-Brine-Rock interaction, pressure, temperature, and injection rate on injectivity change using Eclipse 300 and an open-source code. To develop a methodology that can aid in anticipating injectivity modification, utilizing the available technologies was the aim of this effort. According to the results of the simulation, among all other parameters, the formation's vertical flow baffles and high homogeneous horizontal permeability have a beneficial effect on storage capacity by enhancing residual trapping. However, salt precipitation during CO_2 injection has a significant impact on permeability. The size and extension of the CO_2 plume, the growth rate of the length of the dry out zone, the amount of salt precipitation, and the length of the equilibrium region are all significantly influenced by the injection rate, according to a combined static and dynamic parameter research.

2.2. New CO_2 and Hydrogen storage site marketing: How to make your storage site unique and attractive?

The goal of this study [2] was to recruit participants by putting out a novel techno-ecological synergy concept for the cost-effective, self-sustaining geological storage of CO2 (CGS) and hydrogen (UHS).

The CO_2 storage capacity was calculated with varying degrees of accuracy using detailed petrophysical, mineralogical, and geochemical analyses of the Cambrian Series 3 Deimena Formation reservoir sandstones. With a total average CO_2 storage capacity of roughly 500 Mt, the E6 structure was determined to be the most potential and largest for CO_2 geological storage in the Baltic Region. To examine the viability of monitoring CO_2 storage in the E6, time-lapse numerical seismic modeling was used. The uniqueness of this method was the connection of the time-lapse numerical seismic modeling with the chemically induced petrophysical alteration effect of CO_2-hosting rocks, which was observed in the lab during the CO_2 injection-like experiment. Even with low CO_2 saturation rates, reflection seismic could detect CO_2 injected into the deep aquifer formations based on changes in the amplitude and two-way trip times in the presence of CO_2. Our findings demonstrated the efficiency of the time-lapse rock physics and seismic monitoring techniques used to track the CO_2 plume's evolution and movement in the E6.

Six innovative aspects of techno-ecological synergy make up the CCUS project concept: (1) CGS, (2) Geothermal energy recovery during CO2 geological storage (CPG), (3) CO_2-EOR, (4) underground hydrogen storage (UHS), (5) solar energy, and (6) wind energy recovery. This idea should increase productivity, reduce the carbon footprint of the entire CCUS process, and illustrate the "winx" situation (where "x" represents a number of extra project benefits). The produced hydrogen might be kept underground and sent to the port by ship when needed. For the first time, we calculated the 30 Kt hydrogen storage capacity in the E6-B, the structure's smallest compartment. The new idea of CO_2 and hydrogen storage site marketing is based on this scenario: how to retarget the fossil fuel industry (the depleted oil and gas fields) into the storage-targeted and renewable energy industry, allowing for the achievement of the transition to a carbon-free energy source using the principles of circular economy and sustainable resource use.

2.3. Techno-economic modelling of the Baltic CCUS onshore scenario

In this presentation [2] authors spoke about techno-economic modelling of the Baltic onshore CO_2 transport, storage, and utilization scenario included HeidelberCement-owned Kunda Nordic Cement (KNC) plant, the main Estonian cement producer, four Estonian and one Latvian power plant and CO_2 mineral carbonation of the oil shale ash, as possible CO_2 use option.

Oil shale ash (OSA), a byproduct of energy production, was produced in Estonia in 2019 in amounts close to 6.5 Mt. Estonian OSA has the potential to be a useful sorbent in the proposed CO_2 -mineralization process, which uses flue gas CO_2 and yields high-quality precipitated CaCO3 (PCC). In the CCUS scenario, the mineral carbonation of 0.42 Mt CO2 utilizing 3.8 Mt of fresh OSA and approximately 6.33 Mt CO_2 produced annually by five plants in Estonia and one plant in Latvia are mixed and delivered by pipeline for storage inside the North-Blidene structure in western Latvia. The chosen saline aquifer has Cambrian Deimena Formation reservoir sandstone at a depth of 1035-1150 meters. The CCUS project may be planned for 30 years, thanks to an optimistic storage capacity of roughly 270 Mt on average. 86.5 % of the Estonian emissions averted and stored in Latvia, including 8.2 % by KNC, will be made up of stored emissions from Latvia, which will make up 13.5 %. 6.8 Mt of CO_2 could be stored, transported, and injected per year; 0.42 Mt of CO_2 could be saved by using MC of Estonian OSA and 6 Mt could be saved by using storage and transportation. Nearly 204 Mt of CO_2 will be gathered, utilised, and stored over the course of 30 years, while 193 Mt of CO_2 might be avoided. The scenario's average total transport and storage (T&S) cost is 18.4 euros per ton of CO_2 injected. According to the technique used, this cost is determined by the transport distance and is the highest for the Eesti Energia PPs. The Latvenergo TEC-2 PP will be closer to the storage site, resulting in a lower T&S cost of 5.54 €/t CO2 injected. Three Eesti Energia and Latvenergo TEC-2 power stations may benefit from the CCUS scenario at the price of EEAP (CO_2 Emission Allowance Price in EU ETS) of 40 €/t CO_2 and 50 €/t PCC. The higher EEAP of around 48-50 €/t CO_2 is required for the KNC and VKG Energia facilities without CO_2 use options to cover all CCUS costs, including capture, compression, transport, storage, and monitoring. Since pipes are the most expensive component of the transport, storage, and monitoring costs, the costs of transit and storage depend on the distance traveled. The suggested scenario will be advantageous for all participating facilities at the current EEAP of roughly 90 €/t CO_2. The CLEANKER project, funded by the European Union's Horizon 2020 research and innovation program under Grant Agreement n. 764816, provided support for this study.

2.4. Höegh LNG and Altera Infrastructure is scaling up large scale CCS infrastructure

In this presentation given at BCF 2022 authors [2] discussed about companies Höegh LNG and Altera infrastructure that is scaling up large scale of CCS infrastructure. In a joint initiative, called "Stella Maris CCS" Altera Infrastructure and Höegh LNG are working together to provide cost efficient floating Carbon Capture and Storage infrastructure solutions for a global market, not limited to size or geographical location. The aim of this project is to continue to build on the joint heritage and experience, using combined skills of the two companies to contribute to carbon emission reduction around globe. With the "Stella Maris CCS" project, the companies will essentially continue to do what they are doing today, only in reverse. The solution, which was initiated in 2019 as the first of its kind, will offer a large-scale floating infrastructure for collection, transport, and injection of CO_2 into subsea reservoirs/aquifers. The projects infrastructure concept consists of 2-3 Carbon Collection Storage Units (CCSU) to aggregate volumes at different key locations, 3-4 CO_2 Shuttle Carriers and one Floating Storage and Injection Unit, the total amount of CO_2 injected with these assets can reach up to 10 million tons per year.

In order to realize large scale CCS, the unit costs must come down, and the barriers for emitting industries to invest in capture plants must be lowered. With Stella Maris we are addressing these hurdles. The larger ship design enables carrying volumes of CO_2 at low pressure and will allow for greater economies of scale in the absence of a pipeline which places less limitations on distance to reservoir and ultimate flow capacity. Having a centralized conditioning of CO_2 in a CCSO hub allows more flexibility for on-site capture design from multiple onshore industrial emission sources with shared port access.

2.5. The importance of a realistic leakage evaluation to support public awareness and acceptance for carbon capture and storage

In this presentation [2] authors spoke about the importance of leakage evaluation and to increase public awareness and acceptance for carbon capture and storage. Carbon Capture and Storage is not only highly recommended by the IPCC [3] as a mechanism to significantly lower carbon emissions to the atmosphere, it is now also gaining traction in terms of large-scale implementation. Its importance is increasing in many parts of the world to directly decrease emissions from industrial sources, but also to lower the carbon footprint of blue hydrogen production.

With most CCS projects being planned for offshore locations, public acceptance is less of a determining factor than it used to be 10-20 years ago, where discussions were rather for onshore locations. CO_2 leakage has always been a risk highlighted in the public debate, while no or minimal leakage has been reported for current CCS projects worldwide. However, as scientific community, it is important to realistically highlight the risk of leakage across sealing units for CO_2 stored to inform various stakeholders like regulators, the public and of course also operating companies. Caprock leakage needs to be studied across various length and time scales, considering the undisturbed matrix as well as fracture networks and faults; we need to consider advective and diffusive flow and transport and incorporate mineral alterations, potentially leading to changes in hydraulic or mechanical properties.

This work highlighted the current state of research, advancements and future research required for a realistic evaluation of caprock leakage. It's based on past research related to matrix transport as well as current research focusing on single and multiphase flow along faults and fractures.

2.6. Potential of CCS at SC Achema

In this presentation [2] authors presented potential of CCS at Achema, a leading producer of nitrogen fertilizers and chemical products in Lithuania and the Baltic states. First construction works of the factory date back to 1962, however officially the company was founded on

February 9, 1965 after the first tons of synthetic ammonia were produced in a newly launched ammonia unit.

Carbon capture and sequestration has been considered as suitable measure of decarbonization during middle term – till year 2030. There is developed technology and logistic chains for on shore and offshore projects. The geographical location of companies plays crucial role because of logistics. SC "Achema" yearly emits more than 2 million tons of CO_2. Their advantage is in having 200-300 kilo T of pure CO_2 suitable to liquify and transport. Disadvantage of this topic in Lithuania is political attitude and big distances till real wells at North Sea. The deep check of all aspects necessary to estimate real potential of CCS in Lithuania. The company aspires for significant reduction in greenhouse gas emissions and is the winner of 'Most Environment Friendly Process' nomination for greenhouse gas emission (NO) mitigation in the nitric acid manufacturing process. Company aspires for sustainable and safe production of fertilizers and has also has also developed capabilities to liquify and transport CO_2 over long distances. In this conference Achema' s capabilities to liquify 200-300 kilo T of pure CO_2 was highlighted. Potential challenges related to long distance transfer and political challenges were also highlighted.

2.7. Greensand project – transport and offshore storage of CO_2 in Denmark – status, outlook and challenges

In this presentation authors [2] have discussed transport and offshore storage of CO_2 in Denmark, it's challenges and status. The Greensand project includes, beside from safe and efficient geological offshore CO_2 storage, offshore transport by ship and/or pipeline of CO_2 from key side onshore facilities established to capture, liquefy, onshore transport and temporarily store the CO_2 before offloading to storage site. The Greensand project builds on the usage of the offshore Siri complex sandstone reservoirs no longer in use for oil and gas production. The storage sites, offloading and injection systems and transportation means are currently being technically matured. The target is to be able to offer customers safe and reliable transport and storage services from the start of 2026. Currently meanwhile maturing a technical concept, commercial and regulatory activities are ongoing in parallel. The Greensand partners INEOS Energy and Wintershall Dea have also decided to perform an offshore pilot test of injecting liquified CO_2 into a particular reservoir serving as candidate for future long terms storage of CO_2. Along the pilot testing offshore project, material testing and deployment of monitoring techniques are being matured. The Pilot testing offshore planned to take place late 2022 with a 3-months duration.

2.8. Socio-political development of CC(U)S in the Baltic Sea region

In this presentation authors [2] presented a socio-political development of CCUS in the Baltic Sea Region. According to EU goals and the Paris Agreement, an urgent need exists to reduce CO2 emissions while still securing energy supply. Thus, the timely deployment of carbon capture and storage (CCS) is seemingly unavoidable, especially for the cement and steel industries. However, diverse perceptions of CCS among stakeholders such as experts, politicians, and laypeople exist that could hinder the deployment of the technology, not least in the Baltic Sea Region (BSR). Hence, this research discusses these diverse perceptions and their roots.

Furthermore, when it comes to political developments of CCS, after the unprovoked Russian invasion of Ukraine, the whole process of the energy transition in the region is under shadow for the seemingly mid-term while the approach to the energy security and security of supply needs to be revisited. In other words, the countries of the BSR need to manage the energy crisis in the region while following their plans for decarbonization. In this light, CCS is, therefore, an option to secure energy supply from undesired alternatives like fossil fuels for the short-term and also biomass while curbing CO_2 emissions. In sum, this research also discusses the role of CCS in energy security and security of supply concerning the Russian invasion of Ukraine.

2.9. Bio-CCS as a policy measure to achieve climate goals – the pioneering support scheme in Sweden

In this presentation [2] authors spoke about the Bio-CCS as a measure of policy to meet climate targets. Sweden must have no net emissions of greenhouse gases into the atmosphere by the year 2045. Sweden should reach negative emissions by 2045. Utilizing bioenergy with carbon capture and storage (bio-CCS) will be crucial for achieving this. By 2030, Sweden should seek to absorb and store two million tonnes of biogenic CO_2. The practical potential for bio-CCS in Sweden, however, is estimated to be at least 10 million tonnes of biogenic carbon dioxide annually in 2045. The Swedish Energy Agency has been given two official tasks to aid in the development and implementation of CCS.

1. The creation of a national center for CCS was the first task, which was issued in December 2020. Planning, coordinating, and promoting CCS across the nation are part of this effort. The Swedish Energy Agency will carry out its work in consultation with both domestic and foreign parties, including businesses, academic institutions, governing bodies, and Swedish government offices. The center's current responsibilities include putting in place a support structure for bio-CCS and making sure it complies with international agreements including the London Convention and the London Protocol as well as the UN Convention on Biological Diversity and its ban on geoengineering. The center is also addressing issues with accounting for and disclosing negative carbon dioxide emissions in relation to national and international climate goals and monitoring the formation of a carbon market for negative emissions that is either voluntary or regulated.

2. The agency’s earlier support system was to be implemented as the second task. The Swedish Energy Agency has determined that reversing course is the most economical support strategy and is also compliant with EU state aid regulations. The budgetary framework for the bio-CCS support system is €3.6 billion. A pulp and paper company or a combined heat and power plant, for instance, could place a bid on how much carbon dioxide they could capture and store and how much it would cost in a reverse auction. The auction is won by the bidder who can deliver bio-CCS in accordance with the required specifications for the least amount of money. The Swedish Energy Agency expects to hold the first auction in 2023 and to begin storing the carbon dioxide it has captured there in 2026.

It's crucial to collaborate with other nations in order to install bio-CCS widely across the Nordic-Baltic region and reach net-zero emissions by 2045.

2.10. Carbon capture utilization and storage (CCUS) – it’s happening now! However, are there still any challenges?

In this presentation authors [2] presented importance of carbon capture utilization and storage and answered to a question: do we face any challenges in CCUS field?

Many European nations now have more detailed project plans and increased interest in CCS, however most of these projects are still far from being completed with a road to “Net Zero”! This suggests that CCS will be promoted more vigorously across Europe. Although CO_2 has been permanently stored offshore of Norway for the past 26 years in deep geological formations that have undergone extensive study and monitoring, there are still numerous uncertainties regarding whether CCS is a safe and practical technology. This technique is viable and secure, according to this experience and many years of study and development.

There is a need to collect the significant CO_2 emissions because studies have indicated that Europe has a substantial storage potential for CO_2 both on land and offshore. Cooperation is required for CCS to attain the economies of scale required to lower prices and advance technology. CO_2 capture needs to be more effective and, thus, less expensive. We also need to make an effort to hasten the mapping and characterization of safe CO_2 storage capacity. CCUS is necessary to achieve large-scale and long-term CO_2 removal since it is the most affordable or only alternative for many industries to decarbonize, and these industries will be completely exposed to the carbon price by 2023. The Norwegian government agreed in 2020 to create a large-scale carbon capture and storage project, known as Longship, with the goal of aiding in the development of technologies for the capture, transport, and storage of CO_2. We can already see that this choice has already ushered in the next stage of CCS, with an increase in industrial demonstration projects for emission reductions and a growing demand in new locations for CO_2 storage. Future success of Longship depends on other nations utilizing the technology and benefiting from the project's lessons. Three offshore CO_2 storage licenses, involving a total of five companies, have just been granted on the Norwegian continental shelf, and more license applications and new businesses are on the way. These businesses have presented well-defined initiatives that span the whole value chain.

2.11. Building CCS momentum in the Baltic states

In this presentation given at BCF 2022 authors [2] have discussed climate change challenges and what kind of actions that may be beneficial in developing CCS should be taken.

Climate change is a challenge which is currently being faced by everyone. In this regard CCS could play a major role in mitigating the impact of climate change. To promote CCS requires collaborative efforts and momentum is currently being built in Baltic States to promote CCS. In this talk authors provided details of the findings from the Baltic states on the project CCS4CCE: Building momentum for the long-term CCS deployment in the CEE region. Also, a review of actions that may be beneficial in developing the CCS value chain in the broader decarbonization context was presented. The project, #CCS4CEE, focuses on the renewal of the discussion on the long-term deployment of CCS in the CEE region, leading to new policies and joint projects. Project also examines the socio-economic and socio-political aspects of CCS deployment in several European countries, including the Baltic States.

2.12. New attempt of the implementation of CCS technology in Poland

In this presentation authors [2] presented new attempt of the implementation of CCUS technology in Poland.

No notable changes in that area have occurred until 2021, following the cancellation of the PGE Bechatów demo CCS project in 2013 and the adoption of the EU CCS directive into Polish law (which in some ways generally impeded the growth of CCS projects in Poland). The Polish CCS law, a draft of which was prepared in 2021, is currently being worked on. It is anticipated that the Council of Ministers will approve it soon, after which it will be sent to the Parliament. The law's overall goal is to make it easier for Poland to develop CCUS technologies (commercial projects, onshore and offshore storage in saline aquifers and depleted/depleting hydrocarbon fields, including EHR, no exploration permits/concessions, just storage permits as required by the directive, transport modes). In parallel, the Team on Development of CCUS Technologies was established by the Polish Minister of Climate and Environment in August/September 2021, with participation from members of the Polish government, business, and academic institutions. As a result of one of the Team's duties, a partnership lead by AGH developed a number of prefeasibility studies on the whole CCS value chain of recently built power and CHP blocks (mostly gas fueled). With regard to other industrial sectors, particularly cement and chemical facilities, similar studies are being created or taken into consideration. The national project "Assessment of formations and structures for CO_2 geological storage including monitoring plans" (finished in 2012/2013 by a consortium led by PGI-NRI) and its update (completed in 2021 at the Ministry's request) have both been used in the storage portion of these studies. Results of pre-feasibility studies conducted in 2009-2013, along with hypotheses and findings from the new, significant AGH project CCUS.pl launched in May 2021, have been used in the case of the entire CCS value chain. Other international CCS/CCS projects (funded by Norway Funds) have begun in Poland, including Agastor and the SltPreCO2 project. Within a decade, these improvements may help create a Polish

CCS cluster (or clusters), which will integrate different emission sources with transportation and storage infrastructure.

2.13. Screening of future carbon storage sites – selecting the best spots

In this presentation [2] authors spoke about the future of carbon storage sites and selecting the best spots. Subsurface carbon storage can occur in depleted oil and gas fields, in water-wet structures, or in open aquifers. All three types of storage sites present advantages and inconveniences, which will be reviewed in this talk. The selection of future sites for carbon storage balances storage capacity (how much CO_2 can be stored), injectivity (how efficiently or fast CO_2 can be stored), and containment risk (how safely CO_2 can be stored). Authors presented a rigorous uncertainty-based approach involving estimates of pore volume, pressure and temperature conditions and resulting fluid properties, and sealing and containment behavior, to highlight areas with best potential for safe and effective carbon storage.

2.14. Decarbonization options of existing thermal power plant burning natural gas

In this presentation given at BCF 2022 authors [2] have discussed the decarbonization options of existing thermal power plant while burning natural gas.

The power sector is currently experiencing its worst crisis ever as a result of both massive price shocks and climate issues. On the one hand, it has become clear that the power industry needs to reform its energy use in order to move toward a more sustainable future with technologies that are climate neutral. On the other hand, it became clear that this change could not occur instantly and that a period of transition is required, with certain fossil fuel technology continuing to play a significant role as a backup for renewable energy sources. The main concern is how to decarbonize the current thermal power generation in the most effective and economical manner. These concerns were clarified using the existing combined cycle gas turbine (CCGT) power plant as an example. It was evident that the following solutions were viable:

1. Replacement of natural gas with alternative gases, such as green hydrogen, bio or synthetic methane.
2. Carbon capture and underground storage (CCS) in geological formations.
3. Carbon capture, liquefaction and export, 4) carbon capture and utilization (CCU) or 5) replacement of power generation technology.

Despite not being directly comparable, different solutions were compared in this paper. The Latvian CCGT plant Riga TPP-2, which runs on natural gas and has an installed capacity of 881 MW (in condensing mode), served as an example for the analysis.

Option 1. Electroliers with a capacity of at least 2600 MW are required to replace natural gas with green hydrogen at a rate of 100 % in energy terms. Roughly speaking, this amounts to an investment in hydrogen supply, storage, and production of at least 2,6 billion euros. Additionally, extra wind or solar capacity must be built in addition to the CCGT plant's need for upgrading in order to support 100 % hydrogen firing. The efficiency of conversion from power to gas is over 60 %, whereas that from gas to power is between 55 and 57 %. 33-35 % of the conversions are successful.

2.15. Public acceptance of CCS/CCUS technology in onshore areas in NW Poland

In this presentation [2] authors spoke about the public acceptance of CCS/CCUS technology in Poland. The research is a part of the AGaStor project realized in AGH-UST and University of Stavanger. The aim of the paper is to present social aspects of the developing the CCS/US technology in Poland described as social awareness (SA) and public acceptance (PA). The main research questions of the CCS/US PA concentrates on knowledge, acceptance of the technology, risks and benefits, the existence of NIMBY movements.

The quantitative method of analysis of CCS PA is a survey method. The most of the former research was realized only in small communities. The AGaStor research describes the mezzo-social level of the CCS/US PA. The randomized sample ($N = 695$) was made in Zachodniopomorskie region (West-North Poland) in 2021. It allows to recognize differences of the level of CCS/US PA in different in that part of Poland. The main variables which influence CCS/US PA are: place of living, education, economic situations and general worldview of the respondents.

The results show the correlation between place of living and CCS PA (higher PA in big cities); education with CCS SA (higher declarations of knowledge and SA by well educated people); NIMBY potential in villages and small towns, and the pro-technological worldview with the CCS PA. The research points that the main social obstacle is the lack of knowledge about the CCS/US technology. Even respondents who declare the general acceptation of new technologies in energy production are ambivalent towards acceptance of CCS/US.

2.16. Analyzing technology landscape of carbon capture storage and utilization in Baltic Sea region through patents

In this presentation authors [2] presented carbon capture storage and utilization in Baltic Sea region through patents. It was first proposed in 1977 to capture CO_2 and prevent its escape into the environment by re-purposing already-existing technology. Since the 1920s, CO_2 capture technology has been utilized to separate the saleable methane gas from the CO_2 that can occasionally be present in natural gas sources. In recent years, the push for decarbonization has been led by the oil and gas industries, together with the cement, iron and steel, and chemical production industries. The carbon dioxide is compressed, transported, and injected underground for long-term storage once it has been isolated from other gases. This method may capture 90-100 % of the carbon dioxide that is produced. Since leveraging CCS is anticipated to produce 14-19 % of the reductions needed by 2050, many are placing their bets on it as a key to reducing greenhouse gas emissions [1, 2, 3]. We released 40 billion tons (t) of carbon dioxide into the atmosphere in 2020. According to the Intergovernmental Panel on Climate Change, we must reduce that number to zero by 2050 if we want to prevent the worst effects of climate change (IPCC). The goal of this paper is to outline the patent landscape of the Baltic Sea Region (BSR), which comprises Lithuania, Latvia, Estonia, Finland, Denmark, Sweden, Russia, Poland, and Norway. Searches have been made for patents relating to carbon capture and sequestration for the BSR in order to undertake the study. Searches for patent analytics are only permitted for the years 2000 through 2020. The technologies that are being examined mostly center on CO2 monitoring, transport, consumption, and storage.

To find patents relating to CCUS technology, patent analytics searches have been carried out. There were 3299 patent families found in the search. 497 patent families were identified using a relevance analysis of patents that are connected to CCUS. According to the findings of this patent analytics project, the most IP activity for CCUS occurred in 2009. Since 2005 to 2009, CCUS activities have increased exponentially, while between 2010 and 2015, CCUS activities have decreased exponentially. Russia and Poland are leading the research and patent applications in the CCUS field in northern and eastern Europe. General Electrics (GE), Mitsubishi, and Siemens are the companies with the most publications from an industry standpoint. 497 relevant Patent families, or 85 %, are still alive. Around 78 % of the families at GE are still living. The most researched technology/CCUS type, along with storage, is CO_2 capture. Sadly, since 2016, there has been a decline in the number of patent applications. The CCUS technologies are making an effort to acquire momentum in the range of options for addressing climate change, but growth is very slow as a result of public mistrust, rising costs, and developments in other options like renewable energy and shale gas.

3. Conclusions

Climate change is an increasing complex problem, which requires multi-fold initiatives from Academicians, Industry and Politicians. To meet the Paris Agreement's goals and to keep the increase in global average temperature to well below 2°C above pre-industrial levels initiatives like BCF are very important as they provide platform for interaction between different stake holders. From this point of view, it can be said that BCF 2022 was a success as it was attended by 74 participants from many countries, e.g. Finland, Lithuania, Hungary, Sweden, Poland, Norway, Estonia, Denmark, Latvia, Belgium, Germany, USA, UK, India and South Africa. Different stakeholders gathered for a 2-day event and discussed existing projects and new initiatives. Younger generation of students was also present, which was key to the event. Variety of topics covered showed that conference was a success and it enabled fostering a very health dialogue between different stakeholders. It also showed that a number of initiatives are already taking place in Baltic Sea region countries but more still needs to be done from policy framework point of view. As many industry players are looking at regulations and laws which limits the CCS activities in many countries. A renewed interest from policy maker front is needed to make CCS urgent and realizable to meet the commitments made to keep the global temperature below 2 degrees.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflict of interest.

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