Extrica Journals

OCTOBER 2022
ISSN ONLINE 2783-6959
ISSN PRINT 2783-7211
VOLUME 1
PAGES 1-19

Baltic Carbon Forum

OPEN ACCESS JOURNALS

BCF Baltic Carbon Forum

Aims and Scope

Baltic Carbon Forum 2022 proceeding is a collection of abstracts presented at the annual Baltic Carbon Forum conference, held in Kaunas, Lithuania on October 13-14, 2022. 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.

All published papers are peer reviewed and crosschecked by plagiarism detection tools.

More information is available online https://www.extrica.com/journal/bcf

The proceedings material is referred:

Scilit: https://www.scilit.net
Google Scholar: https://scholar.google.com
Crossref: https://search.crossref.org

Internet: https://www.extrica.com
E-mail: publish@extrica.com
Publisher: JVE International Ltd., Geliu ratas 15A, LT-50282, Kaunas, Lithuania

ISSN PRINT 2783-7211, ISSN ONLINE 2783-6959

BCF Baltic Carbon Forum

OCTOBER 2022. VOLUME 1, PAGES (1-19), ISSN PRINT 2783-7211, ISSN ONLINE 2783-6959

Contents

ISSN PRINT 2783-7211, ISSN ONLINE 2783-6959

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

Parvin Ahmadi[1], Sina Rezaei Gomari[2], Faizan Ahmad[3], Mohammad Aziz Rahman[4]
[1, 2, 3]School of Computing, Engineering and Digital Technologies, Teesside University, Middlesbrough, TS1 3BA, United Kingdom
[4]Texas A&M Engineering Building Education City Qatar Foundation, Doha, Qatar
[1]Corresponding author
E-mail: [1]*p.ahmadi@tees.ac.uk*, [2]*s.rezaei-gomari@tees.ac.uk*, [3]*f.ahmad@tees.ac.uk*, [4]*mohammad.rahman@qatar.tamu.edu*

Accepted 3 August 2022
DOI https://doi.org/10.21595/bcf.2022.22784

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Carbon capture and storage (CCS) is proved to be effective measure for reducing CO_2 emissions. whilst the world still highly depends on the use of fossil fuel energy, this method is necessary for reaching the world's 1.5 °C goal.

In CCS, CO_2 is hindered from entering the atmosphere by capturing it from sources of emission and storing it in geological formation. Saline aquifers among all possible underground formations are most common targeted ones for CO_2 storage due to their frequent presence, and large storage capacity. However, this storage option suffers from sufficient well injectivity to inject large volumes of CO_2 at acceptable rates through a minimum number of wells.

The injectivity impairment / reinforcement happens through mineral dissolution, fine particle movement, salt precipitation and hydrate formation (known so far). Each of these mechanisms will be more dominant in injectivity alteration at different distance from the injection point depending on reservoir pressure and temperature, formation water salinity, rock mineralogy, and flow rate of CO_2 injection as well as its dryness.

Incorporating all the finding into radial flow near wellbore will help gaining insight into the resultant of injectivity changes over time and distant from injection point. In this study we have chosen Eclipse 300 together with an open-source code to investigate the impact of formation characteristics, CO_2 -Brine-Rock interaction, pressure, temperature as well as injection rate on injectivity alteration. The goal for this work is to provide a workflow which can help predicting injectivity alteration using the existing tools.

Simulation results show that the high homogenous horizontal permeability in combination with vertical flow baffles in the formation (among all other parameters) has positive impact on storage capacity by increasing residual trapping. However, permeability is affected severely by salt precipitation during CO_2 injection. Combined static and dynamic parameter study demonstrate that the injection rate plays a crucial role in size and expansion of CO_2 plume as well as growth rate of dry out zone length, amount of salt precipitation and length of equilibrium region. The higher the injection rate, the quicker activation of the capillary and gravity force which leads to drag more brine to near well-bore resulting in higher volume fraction of salt precipitation. However, low injection rate could result in smaller CO_2 plume, shorter dry out zone and longer equilibrium region in term of distance from injection point.

Keywords: CO_2 storage, simulation, injectivity.

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

K. Shogenov[1], **A. Shogenova**[2]
[1]Department of Geology, Tallinn University of Technology (TalTech), Tallinn, Estonia
[2]SHOGenergy Consulting Company, Tallinn, Estonia
[1]Corresponding author
E-mail: [1]*kazbulat.shogenov@taltech.ee*, [2]*alla.shogenova@taltech.ee*

Accepted 8 August 2022
DOI https://doi.org/10.21595/bcf.2022.22840

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Today we met the situation, when our knowledge and expertise are far away from marketing – an ability to sell our knowledge to the end-user (public, policymakers, governments, and small and big enterprises). This study aimed to attract stakeholders by proposing new techno-ecological synergy concept of geological storage of CO_2 (CGS) and hydrogen (UHS) in a cost-competitive, self-supporting storage site.

The "story of success" of the offshore geological structure E6 in Latvia has started from an invisible point on the European map, oil-bearing but not very promising geological structure to the unique and one of the best cost-competitive, self-supporting, conceptual techno-ecological examples of a possible synergy of storage concepts with renewables energies.

Using detailed petrophysical, mineralogical and geochemical analyses of the Cambrian Series 3 Deimena Formation reservoir sandstones in this structure, the CO_2 storage capacity was estimated with different levels of reliability from a conservative 158 Mt (106-252 Mt) up to an average optimistic average of 396 Mt (264-631 Mt). The theoretical CO_2 storage capacity in the oil-bearing limestones of the Upper Ordovician Saldus Formation was estimated at the end of the Enhanced Oil Recovery cycle using the CO_2 (CO_2-EOR) as an average of 110 Mt (65-144 Mt). The E6 structure was estimated as the most prospective and the largest for CO_2 geological storage in the Baltic Region with a total average CO_2 storage capacity of about 500 Mt.

Time-lapse numerical seismic modelling was applied to analyze the feasibility of CO_2 storage monitoring in the E6. The novelty of this approach was the coupling of the chemically induced petrophysical alteration effect of CO_2-hosting rocks, measured in the laboratory during the CO_2 injection-like experiment, with time-lapse numerical seismic modelling. According to changes in the amplitude and two-way travel times in the presence of CO_2, reflection seismic could detect CO_2 injected into the deep aquifer formations even with low CO_2 saturation values. Our results showed the effectiveness of the implemented time-lapse rock physics and seismic methods in the monitoring of the CO_2 plume evolution and migration in the E6.

The new concept of techno-ecological synergy of the CCUS project with different eco-friendly renewable energy recovery technologies, which support circular economy targets, is presented. The concept of the CCUS project includes six innovative elements of techno-ecological synergy: (1) CGS, (2) Geothermal energy recovery during CO_2 geological storage (CPG), (3) CO_2-EOR, (4) underground hydrogen storage (UHS), (5) solar energy and (6) wind energy recovery. This concept should maximise efficiency, minimize the carbon footprint of the full-chain CCUS process and demonstrate the "win^x" situation (where "x" is a number of additional benefits of the project).

We demonstrated an example of the project supporting also a win^5 global situation (that is, a win-win scenario with a minimum of five potential global outcomes): greenhouse gas emissions (GHGE) reduction, (2) economic profitability, (3) increased CO_2 storage capacity, (4) public acceptance and (5) retargeting of oil and gas businesses.

Small wind offshore floating plant installed around the rig and solar panels covering free surfaces of the rig and a compact geothermal plant using CO_2 (20 times smaller than a conventional plant) will produce renewable energy added to the project electricity net to cover the energy needs of the project. The excess energy will be used by compact hydrogen production plant established directly on the rig. The produced hydrogen could be stored underground and when needed, transported by ship to the port. For the first time, we estimated hydrogen storage capacity in the E6-B, the smaller compartment of the E6 offshore structure as 30 Kt.

This scenario is a basis for the new concept of CO_2 and hydrogen storage site marketing: how to retarget fossil fuel business (the depleted oil and gas fields) into the storage-targeted and renewable energy business, permitted to achieve the carbon-free energy transition using principles of circular economy and sustainable use of resources and environment.

Keywords: CCUS, Hydrogen storage, Baltic sedimentary basin, CO_2 storage, Geothermal energy recovery, techno-ecological synergy.

Techno-economic modelling of the Baltic CCUS onshore scenario

Alla Shogenova[1], Kazbulat Shogenov[2], Mai Uibu[3], Rein Kuusik[4], Karl Simmer[5]
[1, 2, 5]Tallinn University of Technology, Department of Geology, Ehitajate tee 5, Tallinn, 19086, Estonia
[3, 4]Tallinn University of Technology, Department of Materials and Environmental Technology, Ehitajate tee 5 Tallinn, 19086, Estonia
[1]Corresponding author
E-mail: [1]*alla.shogenova@taltech.ee*, [2]*kazbulat.shogenov@taltech.ee*, [3]*mai.uibu@taltech.ee*, [4]*rein.kuusik@taltech.ee*, [5]*karl.simmer@taltech.ee*

Accepted 9 August 2022
DOI https://doi.org/10.21595/bcf.2022.22841

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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.

In 2019 nearly 6.5 Mt of oil shale ash (OSA) was produced in Estonia from energy production. Estonian OSA could be used as an effective sorbent in the proposed CO_2-mineralization process, using CO_2 from flue gas and producing precipitated $CaCO_3$ (PCC) of high quality.
Mineral carbonation of 0.42 Mt CO_2 using 3.8 Mt of fresh OSA and about 6.33 Mt CO_2 produced annually by five Estonian and one Latvian plant transported by pipeline for storage into the North-Blidene structure in western Latvia are combined in the CCUS scenario. Cambrian Deimena Formation reservoir sandstone is located at the depth of 1035-1150 m in the selected saline aquifer. The average optimistic storage capacity of about 270 Mt allows planning CCUS project for 30 years. The share of the Estonian emissions avoided and stored in Latvia is 86.5 %, including 8.2 % by KNC, while Latvian stored emissions will compose 13.5 %.

Annually 6.8 Mt CO_2 could be captured, transported and injected, including 6 Mt CO_2 avoided using transport and storage and 0.42 Mt CO_2 avoided using MC of Estonian OSA. During 30 years nearly 204 Mt CO_2 will be captured, used and stored, while 193 Mt CO_2 could be avoided.

The total average transport and storage (T&S) cost of the scenario is 18.4 €/t CO_2 injected. This cost depends on the transport distance, according to the applied methodology, and it is the most expensive for the Eesti Energia PPs. The lowest T&S cost of 5.54 €/t CO_2 injected will have Latvenergo TEC-2 PP located at a smaller distance from the storage site. At the price of EEAP (CO_2 Emission Allowance Price in EU ETS) of 40 €/t CO_2 and 50 €/t PCC, the CCUS scenario could be beneficial for three Eesti Energia and Latvenergo TEC-2 power plants. For the KNC and VKG Energia plants without CO_2 use options, the higher EEAP of about 48-50 €/t CO_2 is needed to cover all CCUS costs including capture, compression, transport, storage and monitoring. The transport and storage costs are distance-dependent, as pipelines are the most expensive part of the transport, storage and monitoring costs.

At the present EEAP of about 90 €/t CO2, all the participating plants will get benefits from the proposed scenario.

This study is supported by CLEANKER project, which has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement n. 764816.

Keywords: CCUS, economic modeling, CO_2 emissions, storage, pipelines, mineral carbonation, carbon tax, oil shale ash, cement plant.

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

Tore Lunde
Höegh LNG, Norway
E-mail: *tore.lunde@hoeghlng.com*

Accepted 8 August 2022
DOI https://doi.org/10.21595/bcf.2022.22844

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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.

Valuable infrastructure experience is brought together; with FPSO (Floating Production, Storage and Offloading) and Dynamically Positioned Shuttle Tankers from Altera and FSRU's (Floating Storage Regasification Unit) from Höegh. We intend to continue to build on our heritage and experience, using our combined skills to contribute to carbon emission reduction around globe. With the "Stella Maris CCS" project, we will essentially be doing what we are doing today, only in reverse. Our solution, 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.

Our 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. To defray high logistics cost in e.g. the Baltic region, a hub and spoke transportation approach enables collection in smaller parcels, milk-run gathering and conditioning for large scale transfer for storage in an offshore subsea reservoir on the Norwegian Continental shelf.

Keywords: CCS infrastructure solution, large scale, one-shop-stop CCS.

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

Andreas Busch
Heriot-Watt University, Lyell Centre, Research Avenue S, Edinburgh, Scotland, United Kingdom
E-mail: *a.busch@hw.ac.uk*

Accepted 8 August 2022
DOI https://doi.org/10.21595/bcf.2022.22854

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Carbon Capture and Storage is not only highly recommended by the IPCC 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, we need 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 talk will highlight the current state of research, advancements and future research required for a realistic evaluation of caprock leakage. It will be based on past research related to matrix transport as well as current research focusing on single and multiphase flow along faults and fractures.

Keywords: caprocks, matric, faults, public acceptance, advective and diffusive transport.

Potential of CCS at SC Achema

Juozas Tunaitis
Achema UAB, Lithuania
E-mail: *J.Tunaitis@achema.com*

Accepted 22 August 2022
DOI https://doi.org/10.21595/bcf.2022.22864

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Achema is 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. Our 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 will be highlighted. Potential challenges related to long distance transfer and political challenges will be also be highlighted.

Keywords: carbon capture sequestration, Achema, CCS, pilot.

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

Søren Reinhold Poulsen
INEOS Energy Denmark, Teknikerbyen 5, 2830 Virum, Denmark
Department of Mathematical Modelling, Faculty of Mathematics and Natural Sciences, Kaunas University of Technology, Kaunas, Lithuania
E-mail: *soeren.reinhold.poulsen@ineos.com*

Accepted 17 August 2022
DOI https://doi.org/10.21595/bcf.2022.22866

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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 CO2 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.

Keywords: CO_2 storage, pilot testing, ship transport, capacity of up to 8 MTPA, aquifers, oil reservoirs, Denmark, Offshore.

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

Farid Karimi
Novia University of Applied Sciences, Raseborg, Finland
E-mail: *farid.karimi@novia.fi*

Accepted 17 August 2022
DOI https://doi.org/10.21595/bcf.2022.22872

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. According to EU goals and the Paris Agreement, an urgent need exists to reduce CO_2 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 decarbonisation. 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.

Keywords: CCS, social acceptance, Baltic Sea region, energy security.

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

Svante Söderholm[1], Nicki Carnbrand Håkansson[2]
Swedish Energy Agency, Sweden
[1]Corresponding author
E-mail: [1]*svante.soderholm@energimyndigheten.se*, [2]*nicki.carnbrandhakansson@energimyndigheten.se*

Accepted 22 August 2022
DOI https://doi.org/10.21595/bcf.2022.22885

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. By 2045, Sweden is to have zero net emissions of greenhouse gases into the atmosphere. After 2045, Sweden should achieve negative emissions. To accomplish this, the use of bioenergy with carbon capture and storage (bio-CCS) will be important.

Sweden should aim to capture and store two million tonnes of biogenic carbon dioxide per year by 2030. However, the feasible potential for bio-CCS in Sweden amounts to at least 10 million tonnes of biogenic carbon dioxide per year in a 2045 perspective. To support the development and deployment of CCS the Swedish energy Agency has been given two governmental assignments.

1. The first task/assignment, given in December 2020, was to establish a national centre for CCS. This task entails planning, coordination and promotion of CCS throughout the country. The Swedish Energy Agency will carry out its work in dialogue with both national and international stakeholders: industries, academia, governmental authorities and the Government Offices of Sweden. The present tasks for the centre are to implement a support system for bio-CCS and ensure that it is line with international conventions, such as the UN Convention on Biological Diversity and its moratorium on geo-engineering, and the London Convention and the London Protocol. The centre is also working with questions related to the accounting and reporting of negative carbon dioxide emissions in relation to national and international climate goals as well as following the emergence of a carbon market – voluntary and/or regulated – for negative emissions.

2. The second assignment was to roll-out the support system earlier proposed by the agency. The Swedish Energy Agency has concluded that a reverse action as the most cost-effective support system as well as to be compatible with EU state aid rules. The support system for bio-CCS has a budget framework of 3.6 billion €. A reverse auction means that, for example, a pulp and paper industry or a combined heat and power plant can submit a bid on how much carbon dioxide they can capture and store, and at what cost. The one who can deliver bio-CCS according to the stipulated requirements at the lowest cost, wins the auction. The Swedish Energy Agency hope to launch the first round of auction in 2023 and have the first storage of Swedish captured carbon dioxide taking place in 2026.

Other countries can use Sweden’s knowledge and experiences when implementing bio-CCS. Exchanging knowledge, experiences and ideas with other countries are important to achieve large-scale deployment of bio-CCS in the Nordic-Baltic region and net-zero emissions in 2045.

Keywords: Bio-CCS, Sweden, negative emissions.

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

Eva Halland
CarbonGeo Consulting/CCUS, Norway
E-mail: *eva.halland@carbongeo.no*

Accepted 22 August 2022
DOI https://doi.org/10.21595/bcf.2022.22890

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. These days we see a growing interest and more concrete project plans for CCS in many European countries but with a pathway to "Net Zero", we are fare from on-track! This definitely implies a stronger push for CCS in Europe.

Although we can show 26 years of permanently stored CO_2 in deep geological formations offshore Norway, heavily studied and monitored, there are still many questions about whether CCS is a safe and viable technology. Based on this experience and many years of research and development, we can conclude that this is a viable and safe technology.

We know that we have a large storage capacity for CO_2 on land and offshore in Europe, and we have large CO_2 emissions that need to be captured. If CCS is to achieve the economies of scale necessary to reduce costs and develop technology, cooperation is needed. Like other technologies that are expensive at the start, CO_2 capture needs to be more efficient and by that less expensive and we need an effort to speed up the mapping and characterization of safe CO_2 storage capacity.

However, CCUS is the lowest cost, or only, option for many industries to decarbonize, and these industries will be fully exposed to the carbon price by 2023, so CCUS is essential to deliver large-scale and permanent removal of CO_2.

To contribute to the development of technology for capture, transport, and storage of CO_2, with the ambition of achieving a cost-effective solution, the Norwegian government decided in 2020 to develop a full-scale carbon capture and storage project, called Longship.

As a result of this decision, we now see that the next phase for CCS is already underway with a growing interest in new areas for CO_2 storage and more industrial demonstration projects for emission reductions. For Longship to be a success for the future, other countries must make use of the technology and learn from the project.

On the Norwegian continental shelf, three licenses for offshore storage of CO_2have been awarded in recent years, these involve 5 companies, and new license applications and new companies are on the way. These companies have presented clear projects involving the entire business chain.

We have the knowledge and the technology is ready, so why isn't the CCUS flying? Perhaps it is about setting clear political goals, transporting CO_2 across national borders, removing potential regulatory barriers and developing new business models. Easy? Let's talk about it and cooperate.

Keywords: CO_2 storage, CCUS, business models, cross-border cooperation.

Building CCS momentum in the Baltic states

Ervinas Škikūnas
CIVITTA UAB, Gediminas Ave. 27, LT-01104, Vilnius, Lithuania
E-mail: *ervinas@civitta.com*

Accepted 6 September 2022
DOI https://doi.org/10.21595/bcf.2022.22893

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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. We will provide details of the findings from the Baltic states on the project CCS4CCE: Building momentum for the long-term CCS deployment in the CEE region. We will review actions that may be beneficial in developing the CCS value chain in the broader decarbonization context. 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.

Keywords: CCUS, carbon capture, storage.

New attempt of the implementation of CCS technology in Poland

Stanisław Nagy[1], Adam Wójcicki[2]
[1]Faculty of Drilling, Oil and Gas, AGH University of Science and Technology in Kraków, Kraków, Poland
[2]Polish Geological Institute-National Research Institute, Warsaw, Poland
[2]Corresponding author
E-mail: [1]*nagy@agh.edu.pl*, [2]*awojci@pgi.gov.pl*

Accepted 13 September 2022
DOI https://doi.org/10.21595/bcf.2022.22926

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. After 2013 when the PGE Bełchatów demo CCS project was canceled and the EU CCS directive implemented into Polish law (in a way generally obstructing the development of CCS projects in Poland), no significant effects in that field have occurred till 2021. In 2021 the draft of a new law on change of Polish geological and mining law and some other laws (Polish CCS law) was prepared and is being proceeded – it is expected to be accepted soon by the Council of Ministers and then submitted to the Parliament. Generally, the law is to facilitate the development of CCUS technologies in Poland (commercial projects, both 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). Concurrently, in August/September 2021 Polish Minister of Climate and Environment appointed an advisory board – the Team on Development of CCUS technologies, where representatives of government, industry and research organizations were invited to facilitate CCUS technologies implementation in Poland. One of the Team's tasks resulted in the development of several prefeasibility studies on the full CCS value chain of newly constructed power and CHP blocks (mainly gas fired) carried out by a consortium led by AGH. Similar studies are being developed or considered in the case of other industry sectors, especially cement and chemical plants. In the storage part of these studies, the national project "Assessment of formations and structures for CO2 geological storage including monitoring plans" (completed in 2012/2013 by a consortium led by PGI-NRI) and its update completed upon request of the Ministry in 2021 have been utilized. In the case of the complete CCS value chain, results of pre-feasibility studies carried out in 2009-2013, together with assumptions and results of the new AGH-important project CCUS.pl initiated in May 2021, have been utilized. Several other international projects (financed by Norway Funds) oriented on CCS/CCS have been started (e.g., Agastor, SltPreCO_2 project) in Poland. These developments might contribute to creating Polish CCS cluster (or clusters) where various emission sources and transport and storage infrastructure will be integrated, possibly within a decade.

Keywords: CCUS (Carbon Capture, Use and Storage), Poland CCUS update, CCS value chain.

Acknowledgements

The presentation has been done with the support of Norwegian Funds as part of the Polish-Norwegian Research Cooperation program, POLNOR CCS 2019, implemented by the National Center for Research and Development (Contract NOR/POLNORCCS/AGaStor/0008/2019) and National Fund of Environmental Protection and Water Management (Contract 2532/2022/Wn-07/FG-go-dn/D).

Screening of future carbon storage sites – selecting the best spots

Martin Neumaier
ArianeLogiX, Sassenfelder Str. 56, 41334 Nettetal, Germany
E-mail: *m.neumaier@ariane-logix.com*

Accepted 16 September 2022
DOI https://doi.org/10.21595/bcf.2022.22931

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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). We present a rigorous uncertainty-based approach involving estimates of pore volume, pressure and temperature conditions and resulting fluid properties, and sealing and containment behaviour, to highlight areas with best potential for safe and effective carbon storage.

Keywords: carbon storage, screening, exploration, risk, storage capacity.

Decarbonisation options of existing thermal power plant burning natural gas

Olegs Linkevics[1]**, Polina Grebesa**[2]**, Janis Andersons**[3]
[1]Institute of Energetics, Faculty of Electrical and Environmental Engineering, Riga Technical University, Azenes iela 12/1, Latvia
[2, 3]Research and Development Department, AS Latvenergo, Pulkveza Breeze iela 12, Latvia
[1]Corresponding author
E-mail: [1]*olegs.linkevics@latvenergo.lv*, [1]*olegs.linkevics@rtu.lv*, [2]*polina.grebesa@latvenergo.lv*, [3]*janis.andersons@latvenergo.lv*

Accepted 19 September 2022
DOI https://doi.org/10.21595/bcf.2022.22934

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Nowadays power industry faces deepest crises ever with unprecedented prices shocks and climate challenges at the same time. From one hand we realise the need of energy transformation of power industry towards more sustainable future with climate neutral technologies. From the other hand it become obvious that this change could not happen immediately, and transition period is needed with some fossil fuel technology still playing an important role as a back-up for renewable energy sources. The biggest question what the best and cost-efficient way is to decarbonise existing thermal power generation. We try to address it on the example of existing combined cycle gas turbine (CCGT) power plant fuelled by natural gas. Clearly the following possible options were identified: 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.

In this publication we try to compare these different options, despite they are not clearly comparable. For the analysis we take natural gas fired CCGT plant Riga TPP-2 in Latvia with installed capacity of 881 MW (in condensing mode).

Option 1. In order to completely (100 % in energy values) replace natural gas by green hydrogen, we need electroliers with capacity of at least 2600 MW. Very roughly this is an investment of at least 2,6 billion EUR for hydrogen production, storage and supply. Additionally, we shall take into account necessary modernisation of CCGT plant to be capable for 100 % hydrogen firing as well as necessity to construct additional wind or solar capacity. Conversion efficiency from power to gas is approximately 60 %, while from gas to power – around 55-57 %. Overall conversion efficiency is 33-35 %. The main advantages of this option are a) possibility for wide use of renewable energy sources (wind and solar) in hydrogen production, b) avoidance of carbon dioxide emissions during the electricity production, c) possibility to supply a surplus of hydrogen to transport sector and industry, d) avoidance of all problems associated with CCS option, including the ban for geological storage of CO_2. The main disadvantages of this option: a) very high costs of hydrogen production, b) very low conversion efficiency, c) necessity to convert CCGT plant for hydrogen combustion and to install considerable wind and solar capacity.

Keywords: carbon capture utilisation and storage (CCUS), green hydrogen, synthetic fuels.

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

Dariusz Wojakowski[1], Oluf Langhelle[2], Mohsen Assadi[3], Stanislaw Nagy[4]
[1, 4]AGH University of Science and Technology, Krakow
[2, 3]University of Stavanger, Norway
[1]Corresponding author
E-mail: [1]*wojakowski@agh.edu.pl*, [2]*oluf.langhelle@uis.no*, [3]*mohsen.assadi@uis.no*, [4]*nagy@agh.edu.pl*

Accepted 19 September 2022
DOI https://doi.org/10.21595/bcf.2022.22935

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. 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 [1].

The quantitative method of analysis of CCS PA is a survey method. The most of the former research was realized only in small communities [2, 3]. 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.

Keywords: carbon capture and storage (CCS), social awareness of CCS/CCUS, public acceptance of CCS/CCUS, social research of the public acceptance of new technologies.

References

[1] P. Tcvetkov, A. Cherepovitsyn, and S. Fedoseev, "Public perception of carbon capture and storage: A state-of-the-art overview," *Heliyon*, Vol. 5, No. 12, p. e02845, Dec. 2019, https://doi.org/10.1016/j.heliyon.2019.e02845

[2] S. Brunsting et al., "Social Site Characterisation for CO2 Storage Operations to Inform Public Engagement in Poland and Scotland," *Energy Procedia*, Vol. 37, pp. 7327–7336, 2013, https://doi.org/10.1016/j.egypro.2013.06.671

[3] M. Kaiser, R. Zimmer, S. Brunsting, J. Mastop, and M. Pol, "Development of CCS Projects in Poland. How to Communicate with the Local Public?," *Energy Procedia*, Vol. 51, pp. 267–273, 2014, https://doi.org/10.1016/j.egypro.2014.07.031

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

Mayur Pal[1], Vilte Karaliute[2]
Department of Mathematics, Kaunas Technical University, Kaunas, Lithuania
[1]Corresponding author
E-mail: [1]*mayur.pal@ktu.lt*, [2]*vilte.karaliute@ktu.edu*

Accepted 19 September 2022
DOI https://doi.org/10.21595/bcf.2022.22939

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Capturing CO_2 and preventing it from being released into the atmosphere was first suggested in 1977; using existing technology in new ways. CO_2 capture technology has been used since the 1920s for separating CO_2 sometimes found in natural gas reservoirs from the saleable methane gas. More recently, investment in CCS is being driven by the oil and gas industries as well as cement, iron and steel, and chemical production industries in the push for decarbonization. Once it is separated from other gases, the carbon dioxide is then compressed, transported, and injected underground for permanent storage. About 90-100 % of produced carbon dioxide can be captured in this manner. Many are betting on CCS as a key to greenhouse gas emission reductions, since leveraging CCS is expected to achieve 14-19 % of the reductions needed by 2050 (1,2,3). In 2020, we sent 40 billion metric tons (t) of carbon dioxide into Earth's atmosphere. We need to cut that number to 0 by 2050 if we are to avoid the worst consequences of climate change, according to the Intergovernmental Panel on Climate Change (IPCC). The objectives of this paper is to present the patent landscape of Baltic sea region countries (BSR), which includes Lithuania, Latvia, Estonia, Finland, Denmark, Sweden, Russia, Poland and Norway. To perform the analysis searches have been conducted to identify patents related to Carbon capture and sequestration for the BSR. Patent analytics searches have been restricted to dates from 2000-2020. Technologies investigated mainly focuses on CO_2 storage, monitoring, utilization and transport.

The patent analytics searches have been conducted to identify patents related to CCUS technology. The search resulted in 3299 patent families. A relevancy analysis was done to identify patents which are related to CCUS & resulted in 497 patent families. Identified relevant patents have been categorized in a classification scheme. Results of this patent analytics work shows that in 2009 we have the greatest number of IP activity for CCUS. Exponential growth in patent filing since 2005-2009, showing an increasing trend for CCUS activities, 2010-2015 has an exponential decreasing trend for CCUS activities. In northern and eastern Europe, Russia & Poland are leading the research & patent filing in the CCUS domain. From industry point of view General Electrics (GE) has the highest number of publications followed by Mitsubishi and Siemens. 85 % of 497 relevant Patent families are Alive. GE has around 78 % of its families alive. The top patents are related to capture, storage, sequestration or disposal of greenhouse gases and followed by patents related to separation processes. CO_2 capture is the most explored technology/CCUS type along with storage. Unfortunately, there is a decreasing trend in patent filings since 2016. The CCUS technologies are striving to gain traction in the set of options for dealing with climate change, but growth is very slow due to absence or low intervention of government action on climate change, public scepticism, increasing costs, and advances in other options including renewables and shale gas.

Keywords: carbon capture, utilization, storage, CCUS, patents, Baltic Sea region countries, carbon reduction.

References

[1] A. Shogenova et al., “Carbon Neutral Baltic Sea Region by 2050: Myth or Reality?,” in *SSRN Electronic Journal*, 2021, https://doi.org/10.2139/ssrn.3817722

[2] J. M. English and K. L. English, “An Overview of Carbon Capture and Storage and its Potential Role in the Energy Transition,” *First Break*, Vol. 40, No. 4, pp. 35–40, Apr. 2022, https://doi.org/10.3997/1365-2397.fb2022028

[3] B. L. Salvi and S. Jindal, “Recent developments and challenges ahead in carbon capture and sequestration technologies,” *SN Applied Sciences*, Vol. 1, No. 8, pp. 1–20, Aug. 2019, https://doi.org/10.1007/s42452-019-0909-2

Carbon removal – pathways, technologies, and need

Shantanu Agarwal
Chemical Engineering, Indian Institute of Technology, Roorkee, India
Harvard Business School, Harvard University, Cambridge, USA
E-mail: *sa@susteon.com*

Accepted 24 September 2022
DOI https://doi.org/10.21595/bcf.2022.22946

Check for updates

Baltic Carbon Forum 2022 in Kaunas, Lithuania, October 13-14, 2022

Abstract. Far from being Plan B, carbon di oxide removal is a critical part of Plan A (as laid out by IPCC > 5GT will be needed by 2050). Without removing excess carbon from the air our toolbox is missing a major tool needed to curb climate change. Current global capacity of carbon removal is ~10,000 tons/annum.

This paper will present a summary of current state of technology of carbon removal alternatives, with a specific focus on engineered Direct Air Capture systems. The current energy intensity, capex intensity and cost challenges faced by many of the DAC players will be discussed.

The presentation will also cover nature-based capture methods and current challenges in the measurement, reporting and verification and eventual trading of these carbon credits.

The presentation will present a market view of the potential scale of carbon removal credits in the near future, its demand and potential supply constraints.

Keywords: carbon removal, direct air capture, CCUS, nature-based carbon capture.