TAL TECH
DEPARTMENT OF GEOLOGY

CARBON NEUTRAL BALTIC STATES: DO WE HAVE CCUS AMONG ACCEPTED OPTIONS?

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BASRECCS

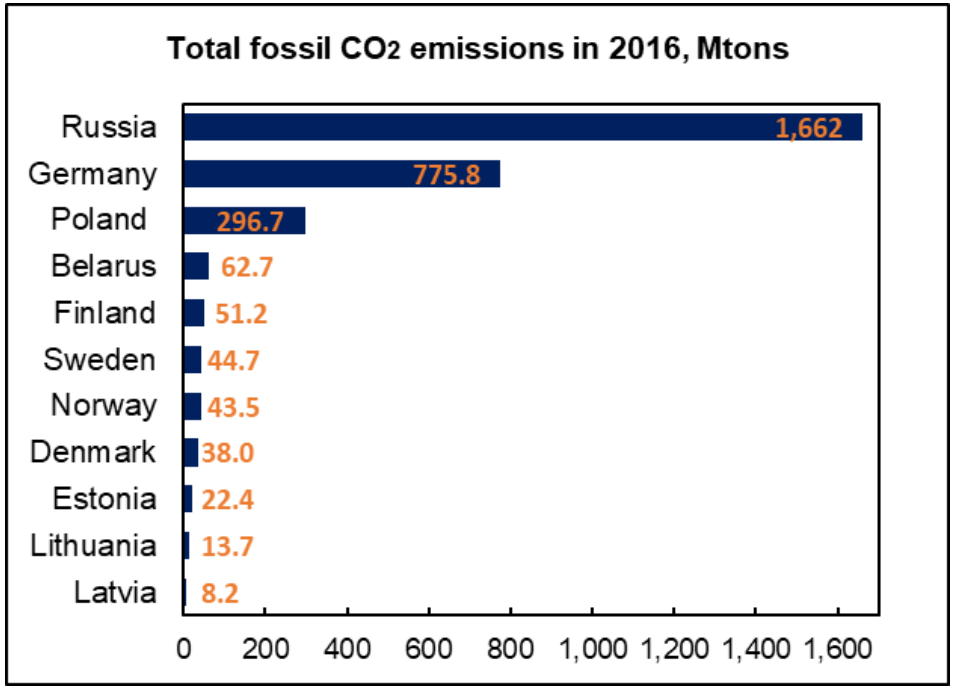
Introduction

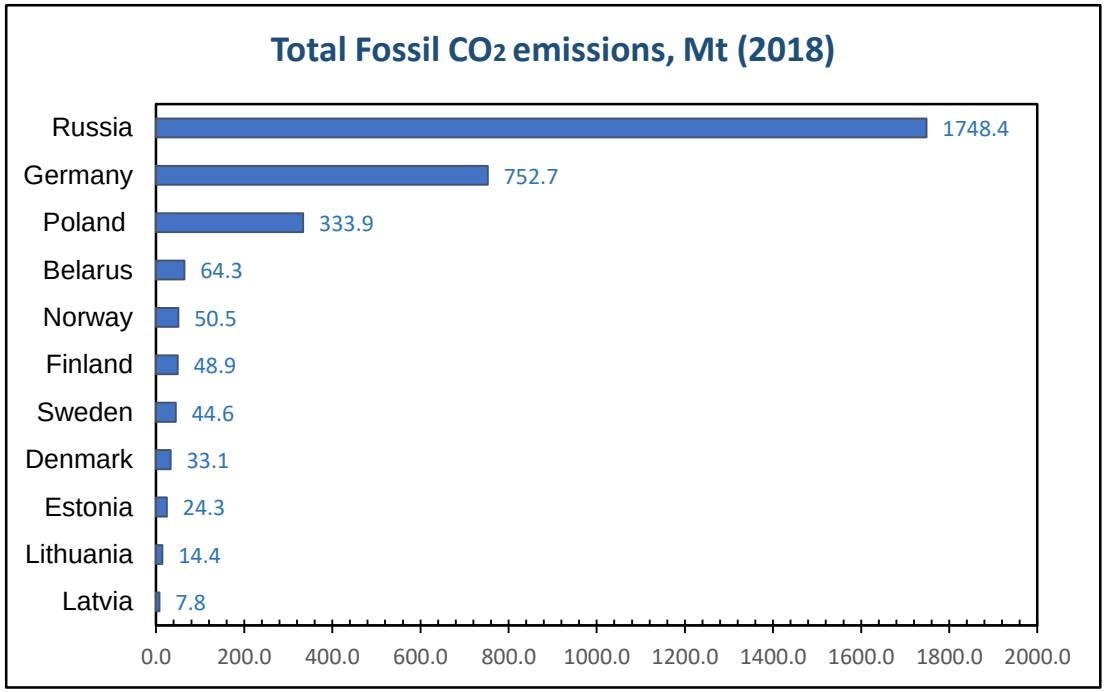
- Baltic Sea Region (BSR) covers fully or partly 11 countries, including Russia, one of the largest CO_2 emitters in the world, and Germany and Poland, the largest CO_2 emitters in Europe.
- Estonia, the smallest BSR country, produced the highest CO_2 emissions per capita and per GDP in the BSR until 2019, explained by use of its local oil shale for energy production.
- All the BSR countries have ratified the Paris Climate Agreement (PCA), and many of them have already defined their ambitious strategic climate targets.

New EU climate ambitions

- **The European Parliament voted on 6 October 2020 to update the EU's climate target for 2030, backing a 60% reduction in greenhouse gas emissions by the end of the decade, up from 40% currently.**
- Lawmakers in the EU assembly voted for the proposed amendment on the 2030 target.
- The text will be forwarded to the EU Council of Ministers representing the EU's 27 member states for final approval.
- The Parliament's decision on the 2030 climate target took place as part of a wider vote on a proposed European Climate Law, which seeks to enshrine into hard legislation the EU's goal of reaching **climate neutrality by 2050.**
- The Parliament also rejected the Commission's proposal to rely on carbon sinks like forests and grasslands to meet the 2030 climate target.

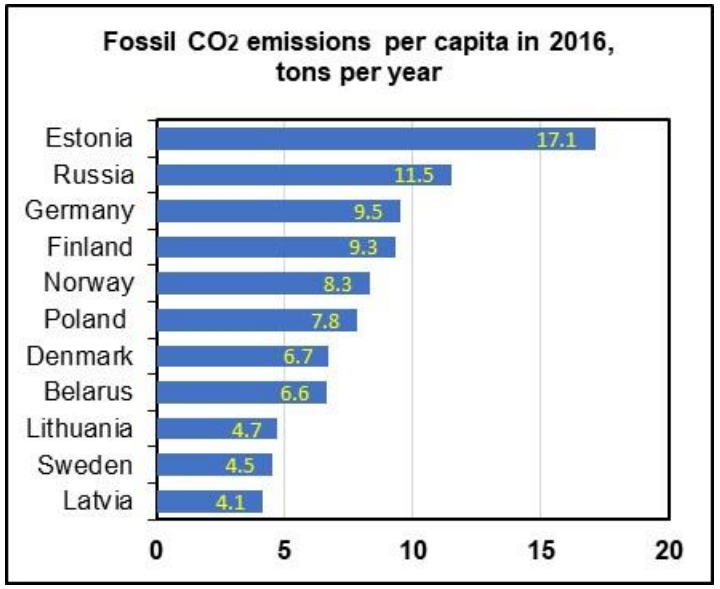
CO_2 emissions in the BSR

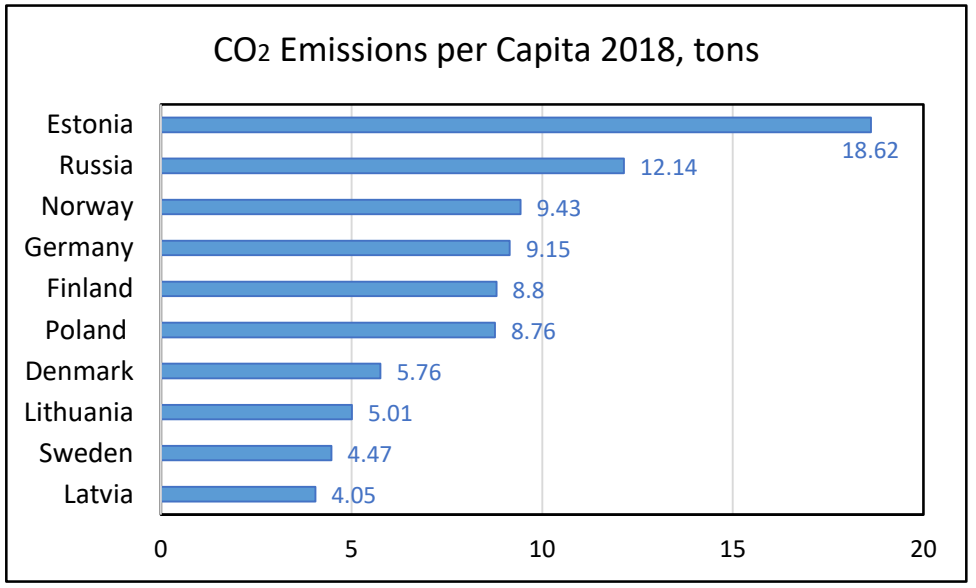




Data from:
EC JRC EDGAR - Emissions Database for Global Atmospheric Research; 2020.

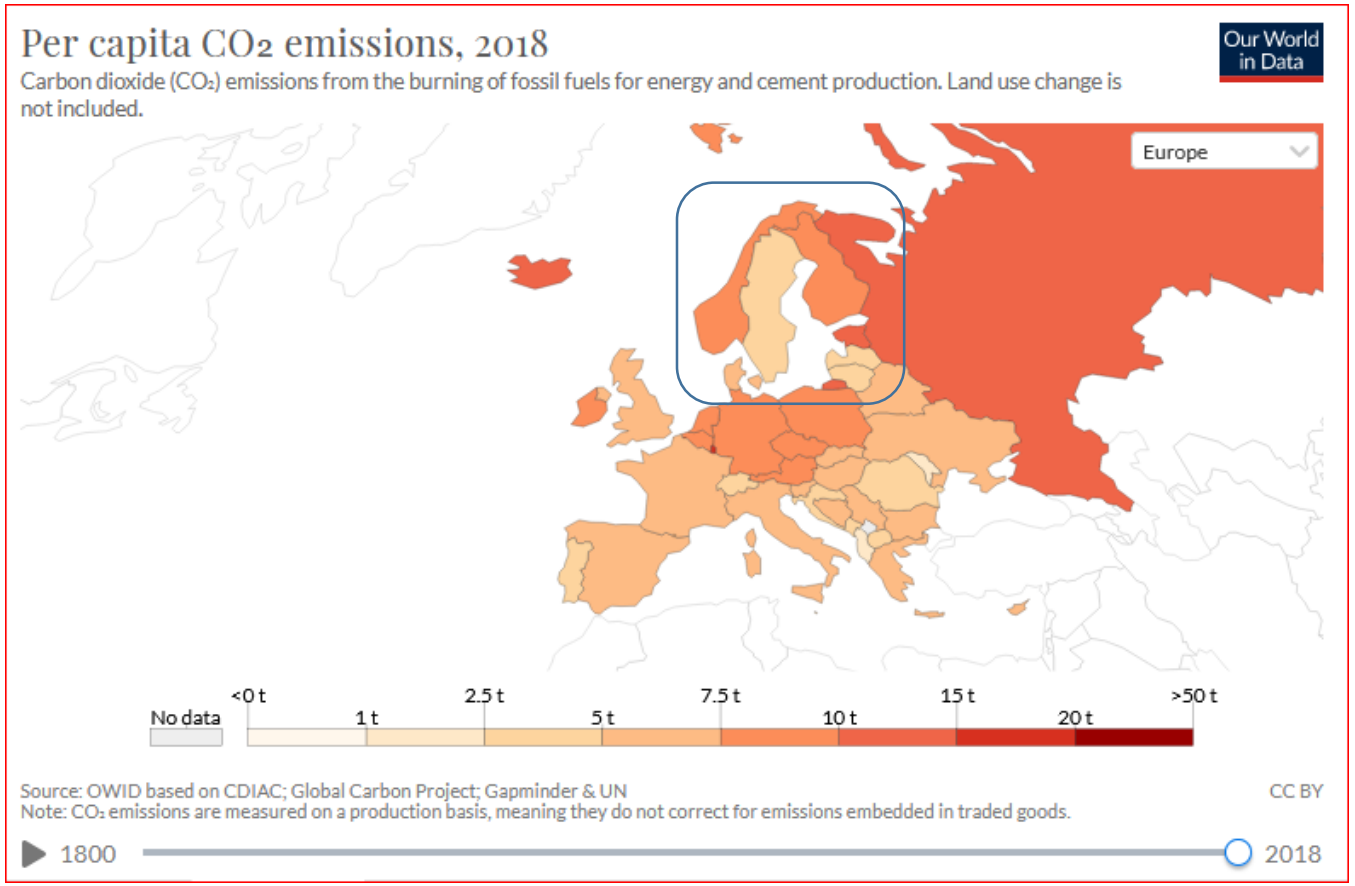
CO_2 emissions per capita





Data from:
EC JRC EDGAR - Emissions Database for Global Atmospheric Research; 2020.

CO2 emissions per capita in 2018



Source: https://ourworldindata.org/co2-emissions#per-capita-co2-emissions

TOTAL PRIMARY ENERGY SUPPLY, 2018

(SOURCE: WWW.IEA.ORG/REGIONS/EUROPE)

BSR Country	Coal (ktoe)	Natural Gas (ktoe)	Nuclear (ktoe)	Hydro (ktoe)	Solar, wind, etc (ktoe)	Biofuel and waste (ktoe)	Oil (ktoe)	Total (ktoe)
Denmark	1720	**2673**		1	1346	**4712**	**6113**	17024
Estonia	**4746**	**414**		1	57	**1147**	66	6268
Finland	4188	2172	**5939**	1144	512	**10133**	**8010**	33985
Germany	**68768**	**73552**	19804	545	14435	30122	**98044**	302079
Latvia	48	**1169**		209	11	**1687**	**1430**	4632
Lithuania	210	**1776**		37	106	**1419**	**2960**	7605
Poland	**49409**	**16124**		169	1207	8659	**29734**	105803
Sweden	2201	1001	1 861	**5349**	1475	**12771**	**10367**	49766
Norway	823	**5151**		**11934**	333	1859	**8978**	28326
Russia	**119587**	**413707**	53637	16435	185	8579	**148281**	759327
Belarus	846	**17083**		28	24	**1544**	**7524**	26963

1st place in country **Red**

2nd place in country **Green**

3rd place in country **Violet**

In the BSR: 1st place – oil, 2nd – biofuel and waste, 3rd – natural gas

The main drivers for implementation of CCUS technology in the BSR

- (1) a need to decrease the relatively high CO_2 emissions of the region;
- (2) obligations taken by countries under the Paris Climate Agreement and national climate strategies up to 2050;
- (3) European requirements for low-carbon and circulating economy;
- (4) provisional estimates are positive to storage in the BSR indicating a large potential storage capacity;
- (5) offshore CO_2 storage is demonstrated in the North Sea;
- (6) a well developed natural gas pipeline system that can be combined with the CO_2 transportation network;
- (7) good research capacity demonstrated by institutions within the BSR within international and national projects;
- (8) CO_2 injection has been already evaluated experimentally for EOR by an oil companies in Lithuania and Russia, with positive results.

CO_2 Storage capacity in the BSR

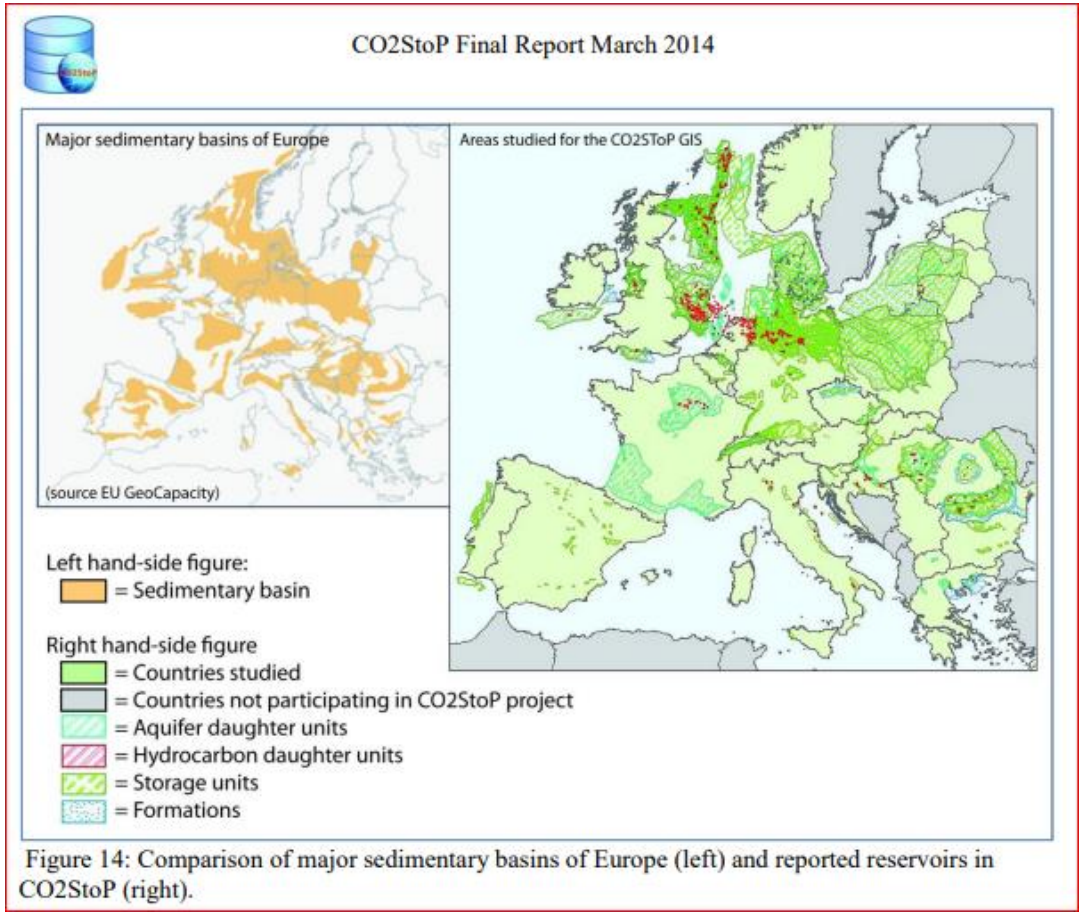
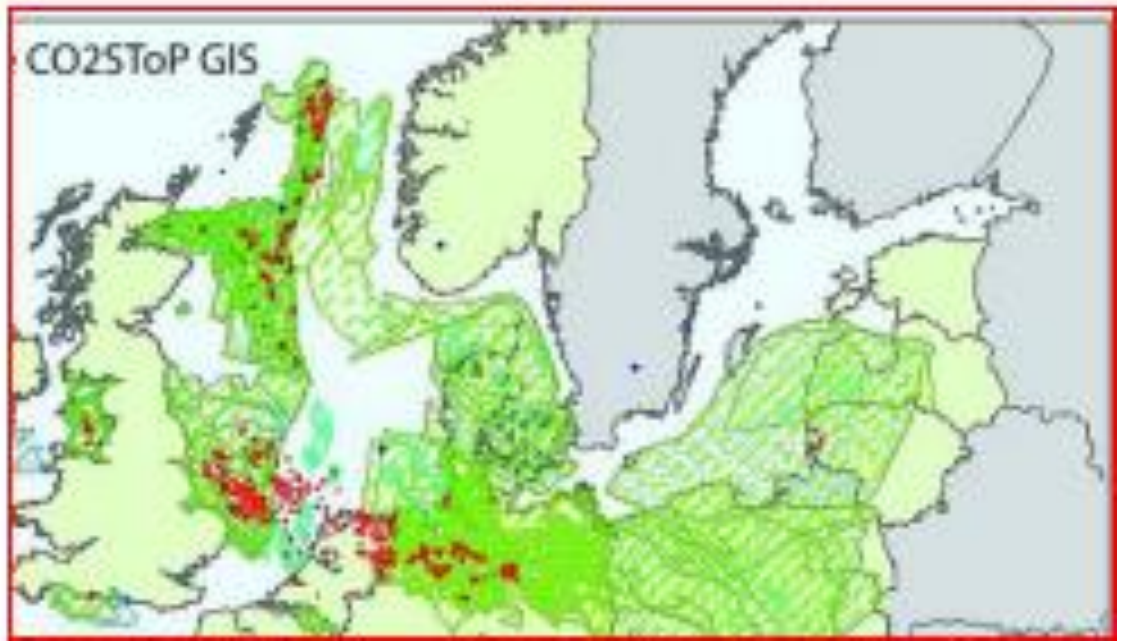


Figure 14: Comparison of major sedimentary basins of Europe (left) and reported reservoirs in CO2StoP (right).



CO2StoP database mapped large CO2 storage potential both onshore and offshore.
Sweden, Finland and Russia did not participate in the project.
CO2 storage atlas is still absent for the BSR!

There were some positive and negative political and regulatory changes in the BSR, in fall 2019:

The most significant positive changes are:

- Russia has officially ratified Paris Climate Agreement in October 2019 (entered into force in November 2019) and started to discuss possibilities to introduce carbon tax and an emissions trading scheme in 2025**.**
- Most of the EU BSR countries are among the 24 EU member states, which are in favour of an EU plan to slash greenhouse gas emissions drastically by 2050. Only Poland has insisted that going carbon-neutral by 2050 is not affordable.
- London Protocol Parties in October 2019 adopted a resolution to allow provisional application of an amendment to article 6 of the Protocol to allow sub-seabed geological formations for sequestration projects to be shared across national boundaries. This Provisional Application allows countries to agree to export and receive CO_2 for offshore geological storage. This now removes the last significant international legal barrier to CCS, and means that CO_2 can be transported across international borders to offshore storage.
- In terms of ratification progress, it was too slow, and only **Norway, UK, Netherlands, Iran**, **Finland and Estonia** have ratified over the ten years among 53 Parties to the London Protocol.

Negative changes and national CCS regulations

- The most negative latest change in the BSR is banning of CO_2 injection in Lithuania, which came into force in July 2020.
- Before this ban, Lithuania was only one BSR country, where CO_2 storage was permitted both onshore and offshore.
- In Denmark regulations have prohibited storage until 2020, except for offshore CO_2 -EOR.
- CO_2 storage is prohibited in Poland until 2024 except for demonstration offshore projects. CO_2 use for EOR and EGR and associated CO_2 storage onshore and offshore are allowed.
- The mass of CO_2 which can be stored was limited in Germany until 2018 (up to 4 Mt CO_2 can be stored annually and a maximum of 1.3 Mt for any individual project) and CO_2 storage is banned in 5 German Federal States.
- CO_2 storage is prohibited except for research and development in Estonia, Finland and Latvia.
- Offshore CO_2 storage is permitted in Sweden and in Norway.
- **Russia:** specific CCS regulations are not available yet. New proposed climate strategy is discussing to reach Paris climate agreement targets only by the end of the century

International Regulations
London Protocol (1996)

- In 1996, the "London Protocol" was agreed to further modernize the London Convention 1972 and, eventually, replace it.
- Under the Protocol all dumping is prohibited, except for possibly acceptable wastes on the so-called "reverse list".
- The Protocol entered into force on 24 March 2006 and there are currently 53 Parties to the Protocol.

"CO2 streams from CO2 capture processes for sequestration" have been added to this list.

- **The 2006 amendments** (which entered into force on 10 February 2007), state that:
- carbon dioxide streams may only be considered for dumping, if:

➢ **disposal is into a sub-seabed geological formation**;

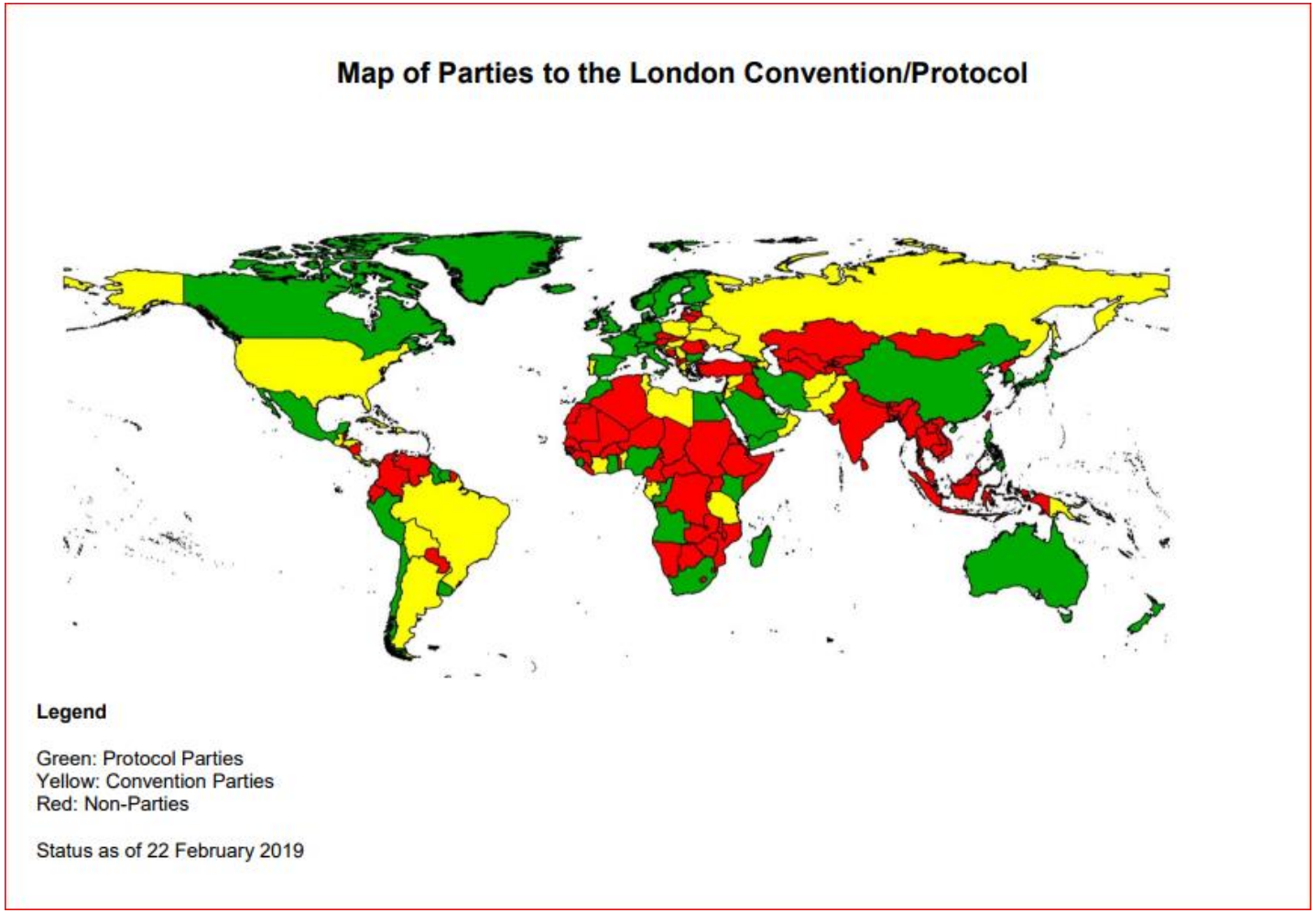
➢ they consist overwhelmingly of **carbon dioxide** (they may contain incidental associated substances derived from the source material and the capture and sequestration processes used);

➢ and **no wastes or other matter are added** for the purpose of disposing of them.

Amendment to article 6 of the London Protocol, 2009

- Steps towards the full ratification of an **amendment to Article 6 of the London Protocol** (**2009**), which would allow for the **export of CO_2 streams** in certain circumstances, remain more tentative.
- Two third of the current 53 contracting parties to the Protocol are required to ratify the amendment for it to enter into force.
- **To date (May 2020), only 6 countries (Estonia, Finland, Norway, The Netherlands, UK and Iran) has completed the ratification process.**
- The failure to ratify these amendments means that transboundary transportation of CO_2 for the purpose of geological storage still remains proscribed under the Protocol.
- **However, in October 2019 Parties to the London Protocol adopted a resolution to allow provisional application of an amendment to article 6 of the Protocol**

Parties to the London Convention (1972) and Protocol (1996)



Legend
Green: Protocol Parties
Yellow: Convention Parties
Red: Non-Party States
Status as of 22 February 2019 (last available versioon)
53 Parties to the London Protocol
87 Parties to the London Convention

Source: IMO, 2020, http://www.imo.org

MEMBERS OF LONDON PROTOCOL AND RATIFICATION OF ARTICLE 6 (2009 AMENDMENT)

BSR Country	London Convention 1972	London Protocol 1996	Amendment to LP 2006	Amendment to LP, 2009 Article 6
Denmark	X	X	X	–
Estonia	–	X	X	X
Finland	X	X	X	X
Germany	X	X	X	–
Latvia	–	–	–	–
Lithuania	–	–	–	–
Poland	X	–	–	–
Sweden	X	X	X	–
Norway	X	X	X	X
Russia	X	–	–	–

International Regulations for offshore CO_2 storage

- All the BSR countries are contracting parties of the **Helsinki Convention 1992 (HELCOM)**, which aims to protect the Baltic marine environment and includes regulation of dumping, pollution as well as exploration and exploitation activities of the seabed and its subsoil in the Baltic Sea

National CCS Regulations

- **Lithuania:** CO_2 geological storage was permitted both onshore and offshore before July 2020. **Now any CO2 injections are prohibited, according to decision taken in October 2019!**
- **Denmark:** regulations have prohibited CO2 storage until 2020, except for offshore CO_2-EOR
- **Poland:** CO_2 storage is prohibited until 2024 except for demonstration offshore projects in Cambrian reservoir.
- CO_2 use for enhanced hydrocarbon (oil and gas) recovery and associated CO_2 storage onshore and offshore are allowed.
- **Germany:** the mass of CO_2 which can be stored was limited in Germany until 2018 and later until 2016 (up to 4 Mt CO_2 can be stored annually and a maximum of 1.3 Mt for any individual project).
- CO2 storage is at present prohibited or permits will not be filed in Mecklenburg-Vorpommern, Niedersachsen, Schleswig-Holstein, Bremen and Brandenburg Federal States. In their evaluation report (according to § 44 KSpG), that was presented and discussed in the parliament in December 2018, the German federal government stated that they see currently no need for modifying the KSpG. In consequence**, CO2 storage is currently not permissible in Germany on scales >100 kt** CO2 due to the given application deadline (2016).
- **Estonia, Finland and Latvia:** CO_2 storage is prohibited except for research and development
- **Sweden and Norway**: offshore CO_2 storage is permitted
- The EU CCS Directive is applied only to CO_2 storage amounts of more than 100000 tons. Therefore:
- **CO_2 injection is permitted for research and pilot projects in all BSR countries, which are members of the EU (except for Lithuania now). Anyway permit for injection is needed from Local authorities. For offshore transboundary storage Amendment to article 6 of London Protocol should be ratified.**
- **Russia:** specific CCS regulations are not available yet

National Carbon Tax (NCT)

- The first carbon tax ever introduced was in **Finland**, in **1990**.
- Norway, Sweden (both in **1991**) and Denmark (**1994**) followed.
- These four countries also introduced the first taxes and fees on other air pollutants, particularly on emissions of sulphur dioxide and nitrogen oxides.
- **A carbon tax introduced in Norway in 1991** has been successful in **incentivising** the development of the Sleipner and SnØhvit CCS projects.
- At US$17/tCO2, the cost of injecting and storing CO2 for the Sleipner project was much less than the US$50/tCO2 tax penalty at the time for CO2 vented to the atmosphere
- This was complemented by a commercial need to separate the CO2 from natural gas to meet market requirements and provided a clear business case to invest in CCS.
- The current level of the tax is higher than the level when it was introduced, making the business case for CCS at Sleipner even stronger
- In 2018 NCT:
- in Finland – 77 US$=65 Euro/Tonne CO2
- Norway – 56 US$=50 Euro/Tonne CO2
- Sweden – 139 US$=120 Euro/Tonne CO2
- Denmark - 29 US$=25 Euro/Tonne CO2

Source: IMF POLICY PAPER, 2019 FISCAL POLICIES FOR PARIS CLIMATE STRATEGIES—FROM PRINCIPLE TO PRACTICE

EUROPEAN UNION EMISSION TRADING SYSTEM (EU ETS)

- EU ETS was previously known as the EU Emissions Trading Scheme.
- The scheme currently has three operating phases (EU ETS, 2018):
- *Phase I* : 1 January 2005 - 31 December 2007 and was a 'learning by doing phase';
- *Phase II* : 1 January 2008 - 31 December 2012 and includes revised monitoring and reporting rules, more stringent emissions caps and additional combustion sources;
- *Phase III*, 1 January 2013 - 31 December 2020, brings major changes including, harmonised allocation methodologies and additional greenhouse gases and emission sources.
- The EU ETS now operates in 31 countries (the 28 EU Member States plus Iceland, Liechtenstein and Norway).
- As of 2013 it covers CO_2 emissions from 11,000 power plants and manufacturing installations and slightly over 500 aircraft operators flying between EEA's airports.
- It covers around 45% of the EU's GHG emissions. EU ETS works on the "cap and trade" principle.
- This means there is a "cap", or limit, on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system.
- Within this cap, companies receive emission allowances which they can sell to or buy from one another as needed.
- The limit on the total number of allowances available ensures that they have a value.

CO2 emission price is very close to 30 Euro since July 2020: https://ember-climate.org/data/carbon-price-viewer/

Prospects for BioCCS and Negative emissions

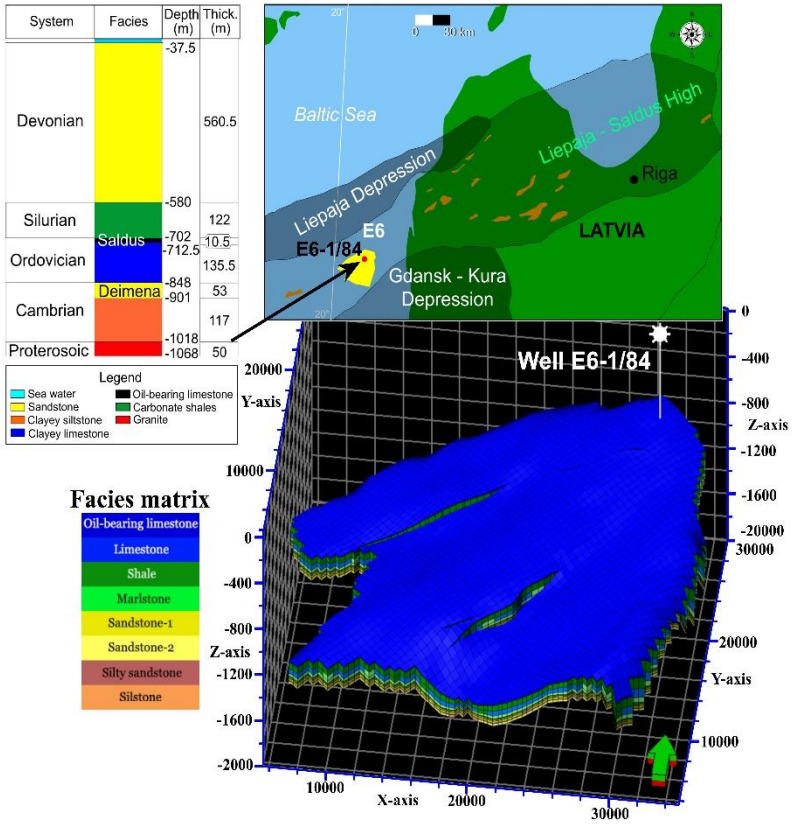
- BSR countries use a lot of biomass and waste (2nd place), it means they have good prospects for BioCCS and Negative emissions
- However, during combustion of biomass not only CO_2 should be considered
- Key messages from European Environmental Agency Report 2019:
- Since 2005, the increasing substitution of polluting fossil fuels for renewable energy across the EU led to a 7 % drop in total sulphur dioxide (SO_2) and a 1 % drop in nitrogen oxide (NO) emissions in 2017.
- By contrast, particulate matter (PM) directly released into the air and emissions of volatile organic compounds (VOCs) increased because of the growth in biomass burning since 2005. PM increased by 11 %, PM by 7 % and VOCs by 4 %.
- To maximise the climate and health co-benefits of the energy transition, policymakers need to be aware of the interplay between renewable and non-renewable energy sources and pay attention to potential impacts from biomass burning.

State of the art in the BSR

Prospects for CO_2 storage: Latvia

- Latvia has very good geological options for CO_2 storage of emissions captured in the Baltic Sea Region (BSR) by countries without CO_2 storage potential. The largest Latvian emissions could be also stored together.
- Regulations for CO_2 storage are not yet enough developed in Latvia and it should be done as soon as possible in order to reach 2030 and 2050 targets in the BSR.
- Latvia should join the London Protocol and ratify its 2009 amendment to article 6, enabling the export of carbon dioxide streams for the purpose of sequestration in trans-boundary sub-seabed geological formations should be ratified.
- Latvia should consider the possible synergy of CO_2 storage and use for Geothermal energy recovery and EOR (Shogenov et al, 2019).

CO_2 storage capacity in the Baltic Basin – offshore E6 structure



- For the first time, we estimated theoretical storage capacity of the **Upper Ordovician Saldus Formation** with different levels of reliability at the end of CO_2-EOR cycle:
- 65–144 Mt, average: 110 Mt
- Total capacity of the E6 structure in two different formations
- **(Saldus and Deimena**) at the end of CO_2-EOR cycle;
- by optimistic: **320–745 Mt,** average: **490 Mt**
- and conservative approaches: **170–385 Mt,** average: **265 Mt**
- (Shogenov & Shogenova, 2017)

Country	CO_2 storage capacity reported (Mt)			Reference
	Onshore	Offshore	EOR (onshore + offshore)	
Latvia	400	300	-	Šliaupa, et al., 2013
Latvia, E6 structure		370	110 offshore	Shogenov & Shogenova, 2017
Lithuania	29	0	5.7/ >200 onshore	Šliaupa, et al., 2013/ Haselton, 2019
Sweden	0	145	-	Sopher, et al., 2014
The Russian Federation (Kaliningrad)	-	-	33	Šliaupa, et al., 2013

Prospects for CO_2 storage: Lithuania

- Among the Baltic States Lithuania was only one country allowed CO2 geological storage both onshore and offshore before October 2019.
- In October 2019 new government of Lithuania with large lobby from agricultural party adopted new Subsurface Law in Lithuania, The injection and/or storage of carbon dioxide in natural and/or artificial underground cavities and/or aquifers is prohibited.
- This ban came into force on 1st July 2020 (http://www.infolex.lt/ta/556859:str1).
- Fortum plans for capture pilots: Klaipeda Lithuania (50% biogenic CO2), CO2 transport to Northern Lights, Norway
- Minijos Nafta company made successful experiments with CO2 use for EOR and is ready to inject at least 1 Mt CO2 annually for EOR and CO2 storage.
- Total estimated capacity for CO2 storage in the ROZ is more than 200 Mt CO2

Fortum CO_2 capture pilot in Klaipeda, Lithuania

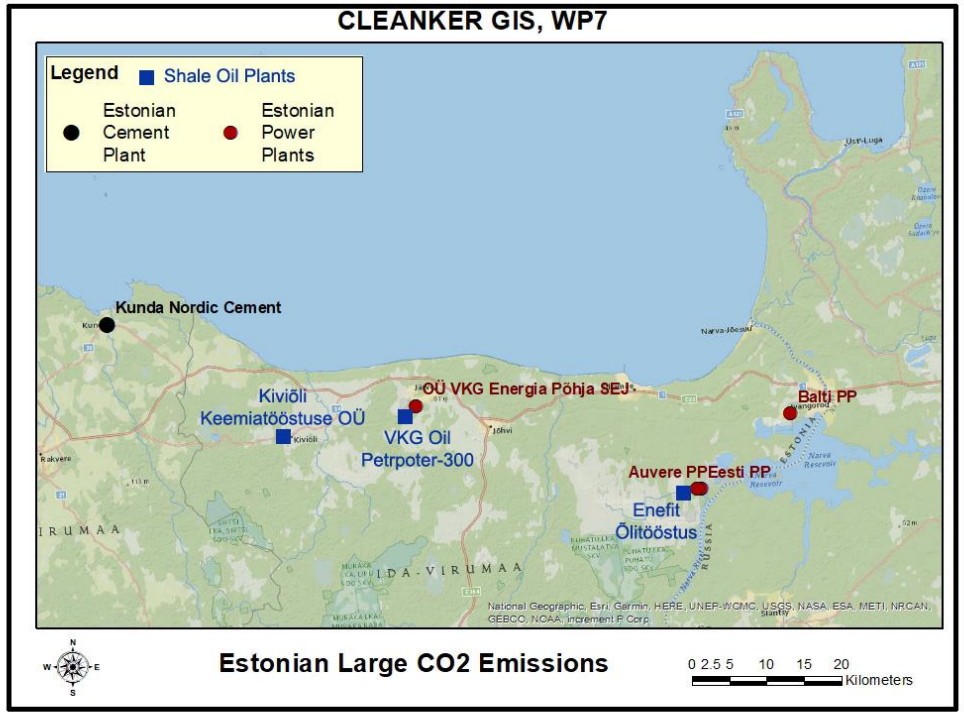
- Potential CCUS plant location in Klaipeda CHP (combined heat and power) premises
- Annual volume of CO2 produced:~275000 t/year
- With capture rate 95%: 260000 t of CO2to capture annually (870t daily)
- ~50% Biogenic CO2
- Two capture technologies evaluated based on Stockholm Exergi and Fortum Oslo Varme experience – Amine and hot potassium carbonate
- Pilot plant testing planned in 2020
- Talks initiated with Northern Lights regarding CO2 transport and storage

Source: Jørgen Thomassen, 2019, Fortum presentation at the BCF2019

Prospects for CO_2 storage: Estonia

- Estonia has ratified the London Protocol, and in 2019 has ratified 2009 amendment to article 6, enabling the export of carbon dioxide streams for the purpose of sequestration in trans-boundary sub-seabed geological formations. Now Estonia is among 6 countries which ratified this amendment.
- In 2019 increase of CO2 emission allowance price up to 25-30 Euro per tonne in EU ETS led to increase of the oil-shale based energy price and made it not competitive to the cheaper Russian energy (as Russia is not paying any carbon taxes).
- As a result, the largest Estonian national energy company Eesti Energia decreased production of energy for about 2 times and decreased production of CO2 for 5 mln tons in 2019, compared to 2018.
- As reported by Eesti Energia, Estonia's total CO_2 emissions decreased by about a quarter over the year. The European Union is setting a target of reducing carbon emissions by 50-55% by 2030 compared to 1990, but Estonia is ahead of that ambition and has already reduced its emissions by nearly 65% (https://www.energia.ee/en/uudised/avaleht/-/newsv2/2020/01/14/eesti-energia-vahendas-aastaga-co2-jalajalge-kaks-korda).
- However, Estonia has future plans to produce hydrogen. Producing Hydrogen with CCS could be one of the future options to implement CCS technology and may be Bio-CCS will also help to reach carbon neutrality by 2050. National financial support for research is targeted now for CO2 capture and use.

The largest Estonian CO_2 emitters



Name of the Plant	Company owner/owners	CO_2 total emissions (Mt/yr)			
		2016	2017	2018	2019
Eesti Power Plant	Eesti Energia/Enefit Energy Production	7.94	8.357	7.759	3.429
Auvere Power Plant	Eesti Energia/Enefit Energy Production	1.63	1.36	1.519	0.649
Balti Power Plant	Eesti Energia/Enefit Energy Production	1.05	1.603	1.125	0.915
Enefit Õlitööstus (shale oil production)	Eesti Energia/Enefit Energy Production	0.65	0.815	0.838	0.842
VKG Oil Petrpoter-300 (shale oil production)	VKG Oil, Viru Keemia Grupp	0.57	0.594	0.667	0.709
OÜ VKG Energia Põhja SEJ (Thermal Power Plant)	OÜ VKG Energia	0.45	0.6	0.589	0.676
Kunda Nordic Cement	Heidelberg Cement Group	0.33	0.56	0.548	0.547
Kiviõli Keemiatööstuse OÜ (shale oil production)	Alexela Group	0.15	0.146	0.147	0.172
	Total for Estonia	**12.76**	**14.033**	**13.191**	**7.939**

Prospects for CO_2 storage: Finland

- Finland **has ratified the London Protocol, and 2009 amendment to article 6**, enabling the export of carbon dioxide streams for the purpose of sequestration in trans-boundary sub-seabed geological formations. Now Finland is among 6 countries which ratified this amendment.
- Finland has to close its coal plants by 2028. Now it is possible to propose carbon-neutral energy decisionsm which will replace coal energy.
- Cross-border CO2 storage is possible now offshore Norway, for offshore storage in Sweden – article 6 of LP should be ratified by Sweden.
- Cross-border storage in Latvia and Lithuania will be possible only after changes in international and national CCS regulations in these countries.

Helsinki Energy Challenge

- Helsinki wants to find long-term sustainable solutions to heat the city in the future and to act as a platform for new and innovative solutions that also other cities around the world can benefit from.
- For this purpose, it opened the international Helsinki Energy Challenge competition with deadline on 30 September 2020.
- The competition seeks solutions through which the city can be heated sustainably in the coming decades – **without coal and with as little biomass as possible**. The competition's first prize **is one million euros**.
- The competition inspired **252 teams from 35 countries** from around the world to participate.
- The participating teams presented their proposals on how Helsinki can stop using coal for heat production as sustainably as possible by 2029 and speed up its journey to becoming carbon-neutral by 2035.
- The finalist teams will be selected early November.
- The evaluation criteria include the proposed solution's climate impact, impact on natural resources, cost impact, implementation schedule and feasibility, security of supply, and capacity.
- A maximum of 15 teams will be selected for the final phase of the Helsinki Energy Challenge.
- These teams will be invited to the co-creation phase during which they will receive support for further developing their solutions, as well as additional information for tailoring their idea even better for the context of Helsinki.
- The competition's website: www.energychallenge.hel.fi

www.energychallenge.hel.fi

Prospects for CO_2 storage: Sweden

- In Sweden offshore CO_2 storage is permitted.
- Sweden has to ratify amendment (2009) to the article 6 of the London Protocol to make possible CO2 storage from neigbouring countries (for example Finland will be interested).
- **Capture pilot activities and transport infrastruture project in Sweden have been started** (simulated by high National Carbon Tax and EEAP), but now there are planning to transport CO2 to Norway from Swedish plants, as CO2 storage site offshore Sweden is not ready.

Examples:

- **(1) Launch of Sweden's Largest Carbon Capture and Storage Plant:**

Sweden's largest test facility for carbon dioxide capture has begun operation at **Preem's refinery in Lysekil**. The project is a collaboration between Preem, Aker Solutions, Chalmers University of Technology, Equinor and the Norwegian research institute SINTEF. The Swedish Energy Agency and the Norwegian research and development program CLIMIT contribute with funding. Within the pilot project, the entire value chain will be evaluated - **from carbon capture at the refinery, local storage, transport to the planned storage location off the Norwegian west coast and for the storage itself**. For more information read at https://www.prnewswire.co.uk/news-releases/launch-of-sweden-s-largest-carbon-capture-and-storage-plant-801623131.html

- (2) GOTHENBURG, Sweden, June 29, 2020 /PRNewswire/:

Gothenburg and Sweden could be the first in the world to create a joint infrastructure for the transport of liquefied carbon dioxide extracted using CCS technology. The project -**CinfraCap** - is a unique collaborative venture between Preem, Göteborg Energi, Nordion Energi, St1, Renova, and Gothenburg Port Authority.

Stockholm Exergi, Sweden, Fortum

- Potential CCUS plant location in Stockholm •
- **100% Biomass**
- Annual volume of CO2 produced: ~1 000 000 t/year
- With capture rate 80%: 800 000 t of CO2 to capture annually (~3000 t daily)
- Waste heat from CCS-process can be re-used
- Close proximity to ocean
- Thorough screening study performed to evaluate technology and provider of process packages
- CO2 to be picked up by Northern Lights

Source: Jørgen Thomassen, 2019, Fortum presentation at the BCF2019

Prospects for CO_2 storage: Denmark

Offshore CO2 storage is permitted for EOR by 2020.

Denmark is providing national financial support of about 20 mln Euro for CCS demonstration.

- Danish offshore drilling company Maersk Drilling has joined a consortium formed by INEOS Oil & Gas Denmark and Wintershall Dea, whose aim is to develop an offshore storage solution for CO2 captured in Danish onshore facilities. The aim is to develop offshore storage with the capacity to store approximately 3.5 million tons CO_2 per year by 2030 https://www.oedigital.com/news/479407-maersk-drilling-joins-offshore-co2-storage-project).
- The first phase of the project will be a feasibility study to validate reservoir compatibility, followed by a pilot to test CO_2 injection. The Geological Survey of Denmark and Greenland (GEUS) will act as a research partner to the project, conducting specialized laboratory experiments and results in analysis.
- The project aims to store CO_2 captured onshore 1700 meters beneath the seabed. For the onshore capture, proven carbon capture technology can be used at carbon-intensive facilities.
- The captured CO_2 will be bunkered in ports and transported by ship to the offshore storage platform which will reuse existing infrastructure originally built for oil and gas production. The target is to have the first well ready for injection from the Nini platform offshore Denmark in 2025.
- Longer-term, the goal is to develop the capacity to store approximately **3.5 million** tons CO_2 per year by 2030, matching the Danish Climate Council's recommendations of actions needed to meet Denmark's 70% reduction target.

Prospects for CO_2 storage: Poland

- Poland need changes in international and national CCS regulations.
- Poland is not member of London Protocol and CO2 storage is permitted only for demo projects offshore until 2024 .
- Poland has significant CO2 emissions from fossil fuels (the largest among eastern EU member states, but also significant CO2 storage capacity.
- Poland has been the only European Union state to refuse to pledge climate neutrality by 2050, with the ruling Law and Justice party saying that it needs more time and money to shift its economy from coal to cleaner energy sources.
- But rising carbon emission costs, the European Union's ambitious climate policies and the coronavirus outbreak are forcing Warsaw to speed up its energy transformation (first nuclear power plant with 6-9 GW of capacity, 8-11 gigawatts of offshore wind capacity by 2040).
- Many industrial, power and oil companies should be interested in CCS.
- Fortum is planning CO2 capture pilot in **Zabrze, Poland**

Fortum CO_2 capture pilot in Zabrze, Poland

- Potential CCUS plant location in Zabrze CHP (combined heat and power) place of old heavy oil installations.
- Annual volume of CO2 produced:~500 000 t/year
- With capture rate 95%: 475 000 t of CO2 to capture annually(~1600 t daily)
- River/railway transport analyzed
- Road transport included in the analysis for short way transport to the closest river port only.
- Due to distance to Polish sea ports and river ports pipeline transportation excluded from the analysis
- Talks initiated with Northern Lights regarding CO2 transport and storage from one of seaports

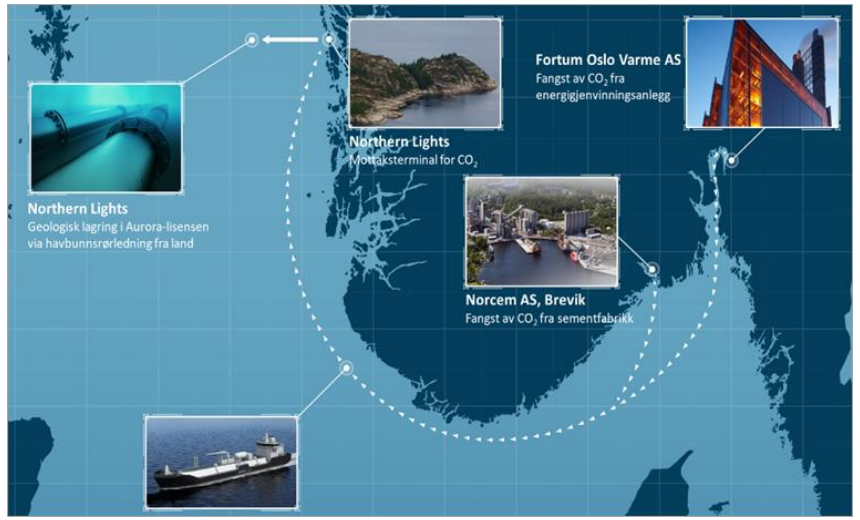
Source: Jørgen Thomassen, 2019, Fortum presentation at the BCF2019

Prospects for CO_2 storage: Germany

- Germany produced the highest CO2 emissions in Europe. However CO2 storage is banned now, amendment (2009) to the article 6 of the London Protocol is not ratified.
- **CO2 storage**: The pilot injection site at Ketzin has been the only research site in Germany for CO2 injection and storage. For studying CO2 migration through the subsurface and soil and assessing potential environmental impacts as well as for testing near-surface monitoring methods, various sites in Germany have been used where CO2 naturally emanates from the ground, e.g. at Laacher See.
- Research activities in CO2 capture, use and storage in Germany are high.
- German Chancellor Angela Merkel stated in May 2019 at the Petersberger Klimadialog that (geological) storage of CO2 is one option to be considered to compensate future CO2 emissions that can not be avoided easily otherwise (Merkel 2019).
- For industry, the increasing price of CO2 emission allowances is becoming a game changer turning CCS/CCU into a considered technological option for CO2 emission reduction.

Prospects for CO_2 storage in Norway

- Northern Lights project is ready and interested to take CO_2 captured in the BSR for CO_2 storage in Norway
- Why: it is too expensive to Norwegian tax-payers to pay for captured CO_2 (example of Waste to Energy Oslo plant) and future need of CO_2 for EOR
- **Regulatory challenges for transportation of CO_2 to Norway:**
  - Ship transport is not yet included in CCS regulations and EU ETS (only pipelines considered), but negotiations with EC have been started.
  - Many EU countries have not implemented amendment (2009) to the article 6 of the London Protocol, some of them are not members of LP yet.



Credit: Gassnova

Prospects for CO_2 use for EOR and storage in Russian part of the BSR (Cherepovitsyn et al, 2018)

- The Northwestern Federal District is characterized by significant distances between large power plants (North-Western part—Leningrad, Vologda, Kaliningrad provinces) and oil-fields (Northern part—Komi Republic and Nenets Autonomous Area).
- Deposits in the Timan-Pechora oil-bearing province have difficult geographic and economic conditions, a large share of hard-to-recover oil, and weak transport infrastructure.
- The most developed area is in the south (Komi Republic), while the Nenets oil-fields are only at the initial stages of development.
- The Kaliningrad province has numerous small oil-fields with a high level of depletion, but their cumulative storage potential is quite small
- Therefore the province can serve as a good option for small-scale pilot projects demonstrating the safety and technological maturity of CO2-EOR.

Prospects for CO_2 storage in Russia

- Russia has officially ratified Paris Climate Agreement in October 2019 (entered into force in November 2019) and started to discuss possibilities to introduce carbon tax and an emissions trading scheme in 2025**.**
- In October 2019 the Russian government has drastically watered-down its new package of climate change legislation after push-back from the country's leading businesses. Plans for quotas on carbon emissions at Russia's largest companies, a new national carbon trading system and penalties for the biggest polluters have now been scrapped.
- Instead, Russia will only go ahead with proposals to measure and collect data on emissions as part of a five-year green audit.
- In March 2020, Russia released its draft long-term strategy for diversifying economic development and reducing greenhouse gas emissions by 2050. Even under the most ambitious scenario in the strategy, Russia will only reach carbon neutrality "close to the completion" of the century.
- It has been estimated that 71 coal-fired power plants, and 185 of the gas-fired

power plants of Russia annually produce 297.1 and 309.6 Mt of CO2 that can cover 553.4 Mt of the demand of 322 Russian oil fields.

- At the same time, the total CO2 storage capacity of the Russian fields is estimated at

7382.6 Mt, however, due to geological and technical factors, only 22.6% can be used for CO2-EOR projects. The most promising of the estimated regions are located in the **North-Western**, Volga, and Ural Federal districts. (Cherepovitsyn et al, 2018)

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Conclusions: The main barriers for implementation of CCUS technology in the BSR are:

- (1) limitations and bans in the implemented national CCS regulations;
- (2) not all BSR countries are parties of the London Protocol;
- (3) amendment to Article 6 of the London Protocol, enabling export of carbon dioxide streams for the purpose of sequestration in transboundary sub-seabed geological formations are ratified only in three BSR countries;
- (4) absence of a CO_2 storage atlas for the BSR;
- (5) public communication and acceptance of CO2 storage options are low in most of the BSR countries;
- (6) high costs of CCS projects;
- (7) low awareness about possible revenues for CCS projects and low understanding how these revenues could be used and considered (National and European carbon taxes, possible CO2 use revenues)
- (8) low or absent national support of CCS research and pilot projects;
- (9) low public awareness and limited education options for CCUS;
- (10) onshore CO_2 storage in saline aquifers is not well established in Europe.
- (11) absent infrastructure for CCS projects – Baltic Project of Common Interests (PCI) is needed

Conclusions

- Application of CCUS technology in the BSR can effectively support all other possible measures and technologies and enable reaching CO_2 neutrality by 2050, if implemented in synergy and supported by policy makers.
- However, national governments and policy makers have to be more careful to the needs of industrial companies when taking new laws, or putting bans on CO_2 injection.
- Many industrial and power plants, oil companies would like to capture CO_2, but they need possibility to store and use CO_2 at the nearest available storage sites for the lowest possible costs.
- Cooperation through clustering of CO_2 emitters and CO_2 storage sites and using common infrastructure could decrease these costs and will make easier communication with governments and local population, creating new working places in the BSR.
- The most prospective for the BSR is could be CO2 use for EOR, then BioCCS and the third priority could be Natural gas with CCS (considering primary energy supply 2018).

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