Perspectives of the offshore CCS development in the polish EEZ on a Baltic Sea: insights from ongoing preliminary research for pilot CO_2 injection

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Abstract. The key to effectively combatting progressive climate change lies in promptly reducing greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2), whose concentration continues to rise due to human activities. The European Union (EU) has established legally binding targets, including achieving climate neutrality by 2050, with an intermediate goal of reducing GHG emissions by 55 % by 2030 compared to 1990 levels. Poland, one of the major CO_2 emitters in Europe, also possesses significant storage potential in terms of projected CO_2 capacity within its sedimentary basins. Considering this, the implementation of Carbon Capture and Storage (CCS) technology could play a crucial role in Poland's efforts to decarbonize its economy. For several years, the Oil and Gas Institute – National Research Institute (INiG – PIB) has been at the forefront of domestic research activities concerning underground CO_2 injection. The involvement dates back to 1996 by pioneering the development of a concept, design, and implementation of one of Europe's earliest industrial installations for reinjecting acid gas, consisting of approximately 80 % CO_2 and 20 % H_2S, into the reservoir water underlying a productive natural gas field. This facility in Borzęcin operated by PGNiG (now part of ORLEN GROUP), is a unique testing ground where the injection process has been running continuously for 27 years. The research conducted at INiG – PIB has played an important role in identifying appropriate geological structures in Poland with a total storage capacity of 10-15 Gt CO_2. Around 90-93 % of the CO_2 storage capacity is found in saline aquifers, with a significant portion of approximately 7-10 % identified within mature hydrocarbon fields.

Despite recent progress in managing industrial CO_2 emissions, the peace of CCS development falls short of meeting the objectives set by the Paris Agreement. The main hindrance lies in the absence of a suitable regulatory framework for CO_2 transport and storage infrastructure. Recognizing this challenge, the national offshore operator, Lotos Petrobaltic (LPB), presented in 2021 a Green Paper on CCS development in Poland. This document outlines a set of recommendations for legislative alternations to facilitate the initiation of large-scale, commercial CCS projects within the country. Given the current national regulations and assumptions regarding low social barriers, the most expeditious approach to implementing a First-of-a-Kind (FOAK) large-scale CCS project in Poland seems to involve deploying depleted hydrocarbon reservoirs located at the Polish Exclusive Economic Zone (EEZ) within the Baltic Sea. The LPB, with research and scientific support from INiG – PIB, has launched a program aimed at conducting a preliminary assessment of CO_2 injection in Middle Cambrian sandstones. The project is scheduled to begin with a pilot injection into the well-identified, depleted structure of the B3 oil reservoir. Subsequently, it may be expanded to include adjacent hydrocarbon reservoirs and could ultimately

encompass the entire Cambrian aquifer.

The Cambrian aquifer is characterized by complex tectonics, comprising several blocks separated by fault zones. These fault zones may act as barriers to the propagation of reservoir fluids, as demonstrated by the presence of hydrocarbon traps in the vicinity of some fault zones.

The B3 oil field, covering an area of 36,2 km^2, is an elongated SW-NE, asymmetric anticline, cut on the west side by an inverted fault zone. The reservoir interval, with an average depth of 1450 meters below sea level comprises of sandstones of the Paradoxides Paradoxissimus (Middle Cambrian Zone) horizon showing a monoclinal dip towards the south-east. The reservoir formation exhibits heterogeneity in both within the vertical profile and the horizontal direction, characterized by a wide range of petrophysical parameters values. According to preliminary assessments, the CO_2 storage capacity of the B3 site is estimated to be around 7 Mt CO_2. The expansion of CO_2 storage to the remaining hydrocarbon fields and the overarching Cambrian aquifer megastructure could potentially increase the total storage capacity to more than 150 Mt.

The envisioned CO_2 sources include emitters from the chemical industry, where CO_2 is a by-product of the fertilizer production process. During the project's pilot phase, the predicted CO_2 injection rate is expected to be between 25-50 kt CO_2 per year. As the project transitions to the upscaled phase, the injection rate is projected to increase significantly, reaching approximately 2 Mt CO_2 per year. The transportation of CO_2 for full-scale injection is planned through multimodal means, considering potential synergies with the multimodal CO_2 Terminal in Gdansk, which is being planned under the ECO2CEE project (formerly EU CCS Interconnector). A pipeline connection between the offshore storage area and the CO_2 Terminal is under consideration.

The main research problems addressed within the INiG – PIB and LPB joint initiative include determining the sequestration potential of the Cm2pp aquifer, assessing the feasibility of the CO_2-EOR process, recognizing the effects of injected CO_2/reservoir rock/caprock interactions on injectivity, geomechanical parameters, and sealing integrity, as well as investigating CO_2-induced corrosion of steel components in the transport and injection plant.

Keywords: CCS, CO_2, sequestration, depleted oil field, Cambrian sandstones, Cm2pp, CO_2-EOR.