Hybrid Subsea CCS System

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Abstract: Currently there is a demand for CCS of large quantities of CO₂ associated with CH₄ in the pre-salt offshore oil fields in Brazil. The pre-salt reservoirs have as caprock 2000 meters of continuous rock salt. Rock salt is a special geomaterial. It has negligible permeability and porosity, is able to support very high stresses, develops the self-healing effect, fractures will heal only with time and a good geomechanical project can design very large openings in the salt body. In Brazil the rock mechanics and computing modeling related to underground excavations in salt rock started in the years 1970’s with very complex challenges, starting with the project of an underground mining of sylvinitic (potash ore) overlying tachyhydrite, a very weak salt rock, solving the challenges of the solution mining of salt caverns, for brine production, in bedded stratified halite with intercalations of shales, development of special geomechanical projects of oil wells for drilling through very thick stratified salt rock barrier and finally the application of salt caverns opened by solution mining for natural gas storage and CCS of CO₂. Salt caverns onshore, opened by solution mining have been used since the years 1950’s to store hydrocarbons and contaminants. A good example of a very large underground storage is the Strategic Petroleum Reserve in the United States, storing since 1974 around 800 million barrels of crude oil. Today there are more than 4000 caverns opened by solution mining for the storage of oil and gas. This article introduces a new concept called the Hybrid Subsea CCS System, which performs all the offshore CO₂ separation process with subsequent storage in underground salt caverns offshore. Today much is said on the concept of "Subsea Factory" in the global oil industry, which is every day closer to become a reality. Many operators have been applying high R&D investments in bringing down to the sea floor equipment from the deck of the production platforms like: multiphase pumps, oil separators, electrical transformers, gas compressors, among other pieces of equipment, reducing the size of the floating platforms and in some sites, becomes the only solution available due to the water depth, which cause a great limitation in the elevation of the hydrocarbon through conventional and even with non-conventional riser systems. The main challenge of doing a complete Subsea "factory" or develop the "Subsea CCS System" is the storage. Shell, USP (University of São Paulo) and FAPESP (Sao Paulo Research Foundation) are developing a R&D project of a hybrid system using partially the subsea factory technology with the high structural performance of salt rock caverns, opened by solution mining, in ultra-deep water. This hybrid system is expected to do at the same time the separation between the natural gas and CO₂, Carbon Capture and Storage of CO₂ and allowing the monetization of the separated natural gas. This paper describes the conceptual design of this hybrid system showing the steps from the drilling phase of the wells, the process of opening the salt caverns by solution mining, the subsea equipment required, the basic logistic system to servo control this equipment and the geomechanical project of salt caverns to store Natural Gas and CO₂ in salt domes in ultra-deep water.