Geophysical Research Abstracts
Vol. 21, EGU2019-10840, 2019
EGU General Assembly 2019

Solution underneath our feet - Germany's geological subsurface provides heat and storage

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The energy supply in Germany is subject to a profound change. The objectives for the transition to a new energy era (referred to as "Energiewende" in German) are very ambitious as the Federal Government decided to step back from nuclear power and to expand renewable energy resources to become the central pillar of the future energy mix. Different studies show that a greenhouse gas neutral Germany is technically and economically feasible by 2050. The present paper addresses the question which contribution can be expected from the geological subsurface to the implementation of Germany's new energy policy. Hereby we focus on resources and potentials of geothermal energy, subsurface geological storage of renewable excess energy and possibly long-term storage of CO_2 to reduce the release of greenhouse gases into the atmosphere.
Heat supply by shallow and deep geothermal energy is considered state of the art in Germany, whereas large-scale production of electricity from geothermal energy is not yet possible. The existing capacity could cover 30-100% of the heat pump demand by shallow geothermal energy in a sustainable and economical way [1].
With more than 50 years of experience, subsurface storage of CH4 to balance seasonal demand and supply is a well-developed technology in Germany. This is the basis to store excess energy produced from renewables via the power-to-gas-to-power technology. We suggest to integrate subsurface storage of CH4 and CO_2 to close the carbon cycle. Our assessment shows that selected gas storage sites already have the potential to take up 20-60% of the 90-270 TWh excess energy estimated for Germany in 2050 [2].
Geological CO_2 storage can be applied to reduce CO_2 emissions in general. However, major concerns are potential fluid leakage and saltwater displacement into shallow aquifers associated with the pressure increase in the mainly targeted deep reservoirs due to injection of supercritical CO_2. The suggested solution is storage of CO_2 exclusively in the dissolved state. In our exemplary regional case study of the North East German Basin we have quantified that 4.7 Gt of CO_2 can be stored in solution compared to 1.5 Gt in the supercritical state [3].

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