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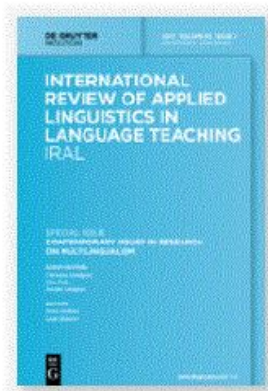
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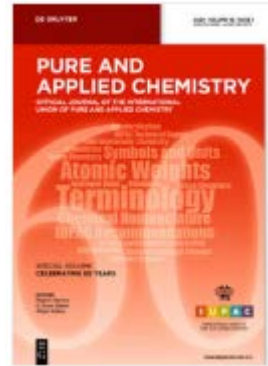
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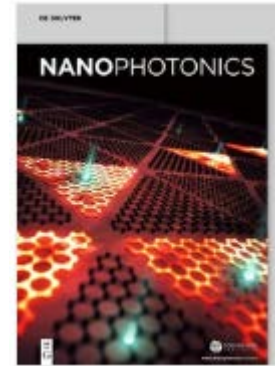
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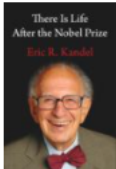
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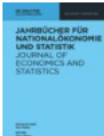
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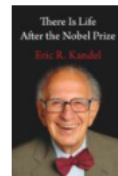
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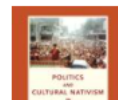
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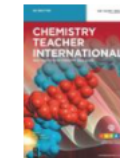
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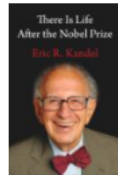
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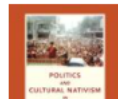
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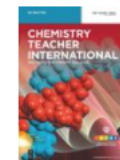
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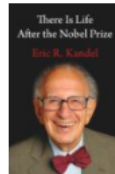
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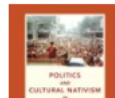
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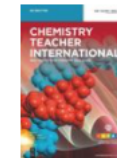


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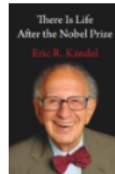
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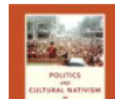
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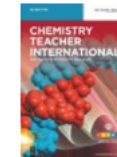


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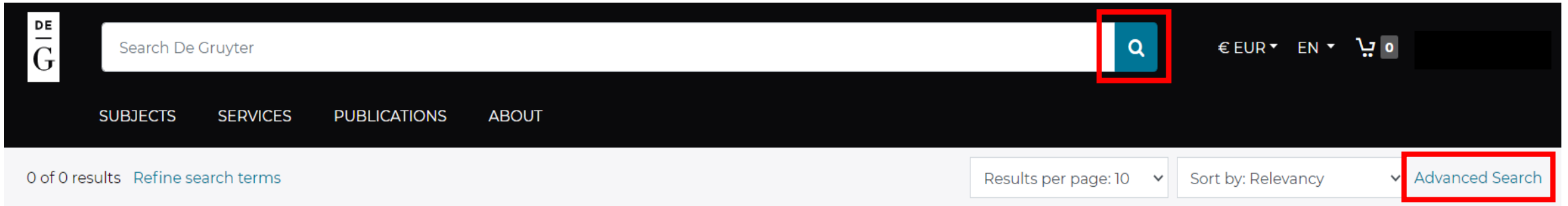
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Compressed air energy storage in aquifers (CAESA) can be considered a novel and potential large-scale energy storage technology in the future. However, currently, the research on CAESA is relatively scarce and no actual engineering practices have yet been performed due to a lack of detailed theoretical and technical support. This article provides a summary and analysis of the current research about the key problems in CAESA. The theoretical foundation and evaluation methods are first addressed, and then the aquifer selection criteria are proposed by analyzing the impact of the main geological factors on the performance. Subsequently, the optimal design of wellbore and the operation parameters are discussed, and different possible enhanced methods are proposed for extending the application of CAESA. Finally, conclusions are made and application outlook is addressed.

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Abstract

Compressed air energy storage in aquifers (CAESA) can be considered a novel and potential large-scale energy storage technology. Currently, the research on CAESA is relatively scarce and no actual engineering practices have yet been performed due to a lack of detailed theoretical and technical support. This article provides a summary and analysis of the current research about the key problems in CAESA. The theoretical foundation and evaluation methods are first addressed, and then the aquifer selection criteria are proposed by analyzing the impact of the main geological factors on the performance. Subsequently, the optimal design of wellbore and the operation parameters are discussed, and different possible enhanced methods are proposed for extending the application of CAESA. Finally, conclusions are made and application outlook is addressed.

Keywords: aquifers; compressed air energy storage; energy efficiency; wellbore

1 Introduction

Compressed air energy storage (CAES) is one of two worldwide commercial large-scale energy storage technologies (the other being pumped hydroelectric storage). It can effectively solve the unbalanced power supply caused by the utilization of intermittent clean energy (e.g. wind power, solar energy, and wave energy) and has more economic potential (Ribeiro et al. 2001, Svander 2007, Ibrahim et al. 2008, Chen et al. 2009). The existing large-scale CAES plants (Huntorf in Germany and McIntosh in America) have been successfully operating for decades with a total of maximum 431 MW energy storage scale, and other CAES plants are to be built in many countries (Kushnir 2012, Budt et al. 2016). In order to extend the application and improve the economic

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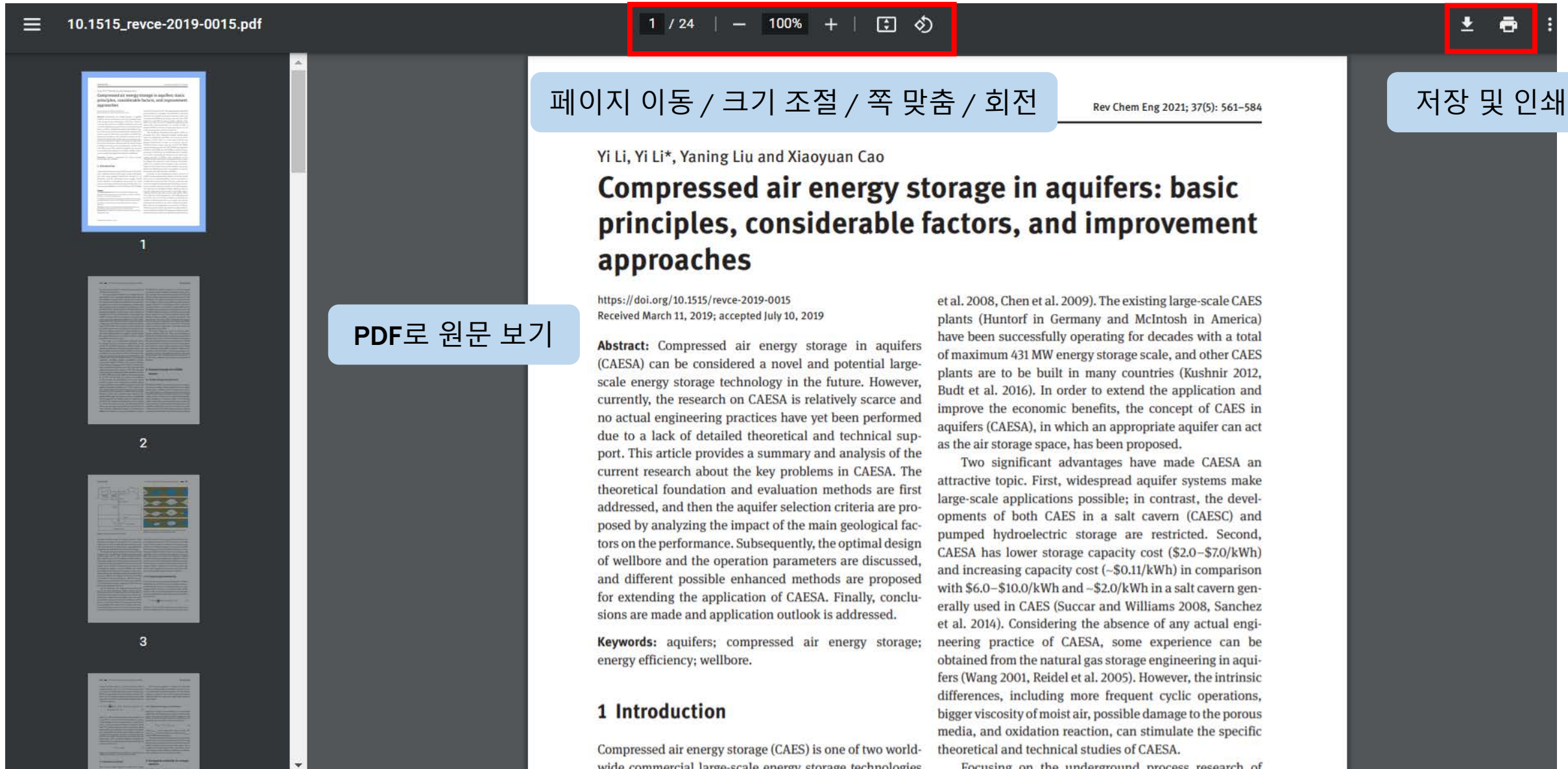
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Compressed air energy storage in aquifers: basic principles, considerable factors, and improvement approaches

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Abstract: Compressed air energy storage in aquifers (CAESA) can be considered a novel and potential large-scale energy storage technology in the future. However, currently, the research on CAESA is relatively scarce and no actual engineering practices have yet been performed due to a lack of detailed theoretical and technical support. This article provides a summary and analysis of the current research about the key problems in CAESA. The theoretical foundation and evaluation methods are first addressed, and then the aquifer selection criteria are proposed by analyzing the impact of the main geological factors on the performance. Subsequently, the optimal design of wellbore and the operation parameters are discussed, and different possible enhanced methods are proposed for extending the application of CAESA. Finally, conclusions are made and application outlook is addressed.

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Two significant advantages have made CAESA an attractive topic. First, widespread aquifer systems make large-scale applications possible; in contrast, the developments of both CAES in a salt cavern (CAESC) and pumped hydroelectric storage are restricted. Second, CAESA has lower storage capacity cost (\$2.0–\$7.0/kWh) and increasing capacity cost (~\$0.11/kWh) in comparison with \$6.0–\$10.0/kWh and ~\$2.0/kWh in a salt cavern generally used in CAES (Succar and Williams 2008, Sanchez et al. 2014). Considering the absence of any actual engineering practice of CAESA, some experience can be obtained from the natural gas storage engineering in aquifers (Wang 2001, Reidel et al. 2005). However, the intrinsic differences, including more frequent cyclic operations, bigger viscosity of moist air, possible damage to the porous media, and oxidation reaction, can stimulate the specific theoretical and technical studies of CAESA.

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