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## Romania's Participation to the European Assessment Project Titled HyUnder, Multi-Criterial Analyses of Salt Cavern Locations

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**ROMANIA'S PARTICIPATION TO  
THE EUROPEAN ASSESSMENT PROJECT TITLED HYUNDER,  
MULTI-CRITERIAL ANALYSES OF SALT CAVERN LOCATIONS**

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**Abstract** - The scope of the work is to assess the potential, the actors and relevant business cases for large scale storage of renewable electricity by hydrogen underground storage in Romania. This presentation intends to provide a picture of the multi-criterial analyses of salt cavern locations in Romania.

The energy sector is facing with the necessity to store large energy quantities for short to long term in order to adapt to the increasingly intermittent renewable energy. The results of this presentation have originated from an ongoing European assessment project by the name of HyUnder (FCH JU, grant 303417) regarding utilization of salt caverns for hydrogen underground storage.

Currently, main uses of salt caverns include storage of hydrocarbons or wastes disposal. Salt caverns have stirred the interest of the scientific community regarding the potential applications in hydrogen economy. Romania has active mines or caverns and others closed, many of them have the potential to be used for hydrogen storage. These facts represent an interested situation in order to initiate studies or assessments of the potential hydrogen underground storage. The salt mines, hydrogen producers, renewable energy sources and research centers with high qualified scientists, represent essentially elements for new type of studies regarding hydrogen economy. In the context of scientific community's efforts from Romania to assert active in the area of hydrogen technologies, this approach can certainly constitutes an attractive example for pan-European cooperation.

The work disclaims the technic multi-criterial analyses of salt cavern locations regarding hydrogen underground storage. The introduction of hydrogen into economy offers the possibility to provide a number of advantages: sustainable development, valorization of local resources and improvement of competitiveness. The opportunities and viabilities of salt cavern locations are analyzed.

**Index Terms** hydrogen storage, HyUnder, multi-criterial analyses, salt caverns

## I. INTRODUCTION

The scientific literature describe the intelligent decision system as a window-based software package that has been developed on the basis of the evidential reasoning approach, that successfully is used for handling hybrid multiple criteria decision analysis (MCDA) problems with uncertainties. The approach has been developed using the concepts from several disciplines, including decision sciences, artificial intelligence, statistical analysis, fuzzy set theory, and computer technology [1].

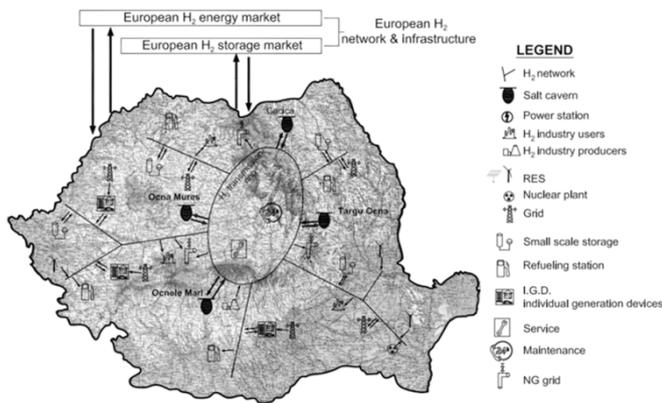
In the situation when there is need to decide which location or sub-locations are the best choice for hydrogen underground storage placement, it is inevitable to deal with both quantitative and qualitative information under uncertainty. Evidence-based reasoning within a multiple criteria decision analysis framework provides an alternative way of handling such information systematically and consistently. In this paper, the evidential reasoning approach is used in order to analyses both quantitative and qualitative data regarding hydrogen underground storage in salt caverns in Romania. This is a part of a comprehensive study performed by the authors using data obtained from the HyUnder European project.

## II. RESULTS AND DISCUSSIONS

Hydrogen storage at large scale can be expected to support the integration of intermittent renewable energy sources in the current energy system. Figure 1 provides a picture for the potential hydrogen infrastructure in Romania where four possible locations for hydrogen underground storage can be identified: Cacica, Targu Ocna, Ocnele Mari and Ocna Mures. A detailed study about these locations and afferent infrastructure was described by authors in other paper [2]. The



studies were conducted according with HyUnder project criteria, which refer to the evaluation of a set of locations, like: good geological conditions and cavern field in conservation.

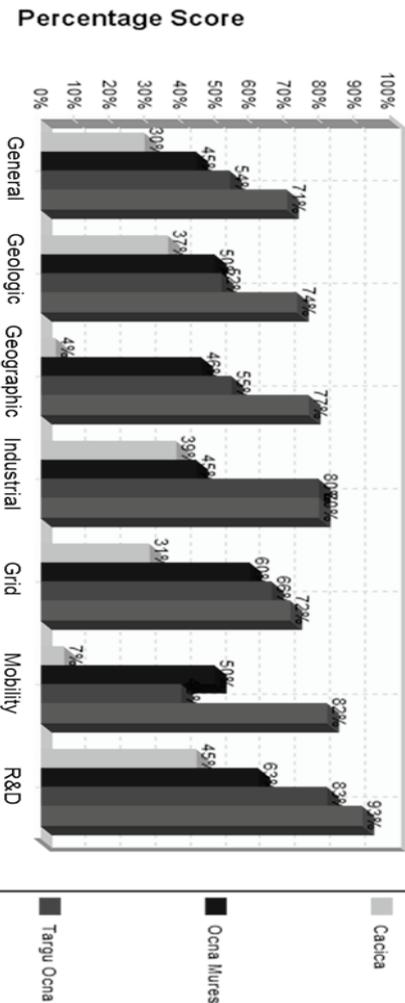


**Fig. 1. Locations for hydrogen underground storage in salt cavern in Romania, source [2].**

The studies were conducted according with HyUnder project criteria, which refer to the evaluation of a set of locations, like: good geological conditions and cavern field in conservation. The sites were multi-criterial analyzed. The driver for potential utilization of hydrogen underground storage in Romania is the steep gradient of introducing renewable electricity and time lagged also in other energy sectors such as mobility, chemical industry and the natural gas industry. The multiple criteria decision analysis (MCDA) of hydrogen underground storage in salt caverns offer more sensitive scenarios where more details or differences can be visualized. In Figure 2, the authors provide an example of analysis of general, geologic, geographic, industrial, grid, mobility and development aspects [3].

### III. CONCLUSIONS

The extended abstract shows the collective efforts of researchers from National Research and Development Institute for Cryogenics and Isotopic Technologies - ICSI Rm.Valcea (National Hydrogen and Fuel Cell Center) to highlight potential in Romania in terms of hydrogen storage. This presentation provides a picture of the insights, perspectives and referrals for hydrogen underground storage in salts caverns in Romania, using multiple criteria decision analysis (MCDA).



**Fig. 2. Example of multiple criteria decision analysis of hydrogen underground storage in salt caverns.**

### ACKNOWLEDGMENT

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### REFERENCES

- [1] Xu Dong-Ling, Yang Jian-Bo, Intelligent decision system based on the evidential reasoning approach and its applications, J. of telecommunication and information technology, 3 (2005) 73-80.
- [2] Ioan Iordache, Dorin Schitea, Adrian Gheorghe, Mihaela Iordache, Hydrogen underground storage in Romania, potential directions of development, stakeholders and general aspects, International Journal of Hydrogen Energy, 39 (2014) 11071-11081.
- [3] Ioan Iordache, PhD Thesis, University "Politehnica" from Bucharest, Bucharest, June, 2015.

