Aplicación de SIG para la exploración del subsuelo

Caso de estudio: Almacenamiento de aire comprimido en el subsuelo y almacenamiento de CO_2

Escuela Técnica Superior de Ingenieros de Minas y Energía
Universidad Politécnica de Madrid

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3. Herramienta CO2SITEASSESS
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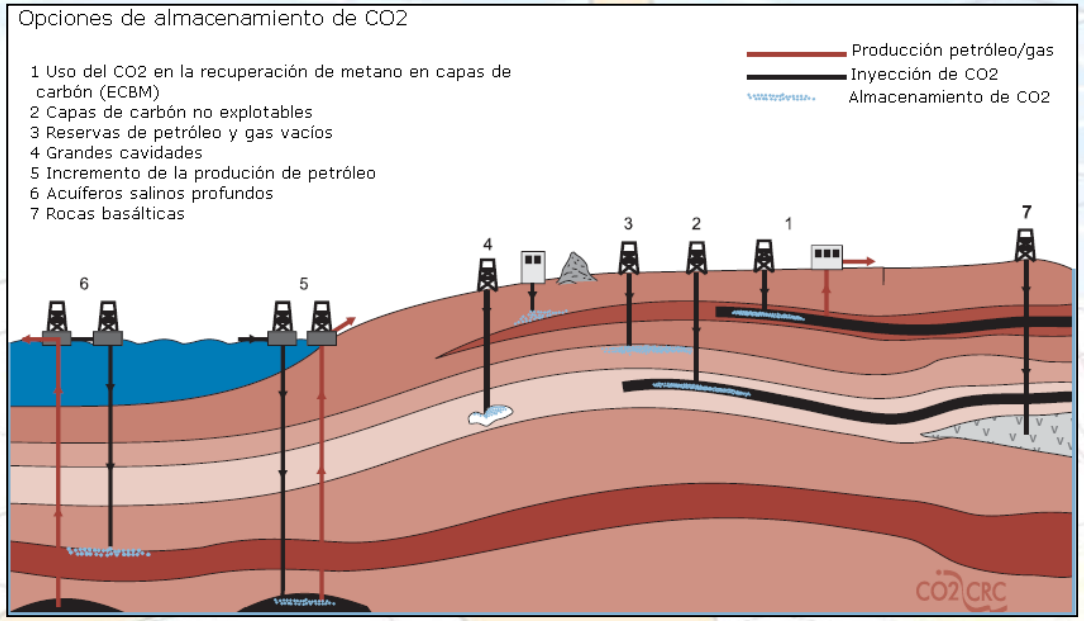
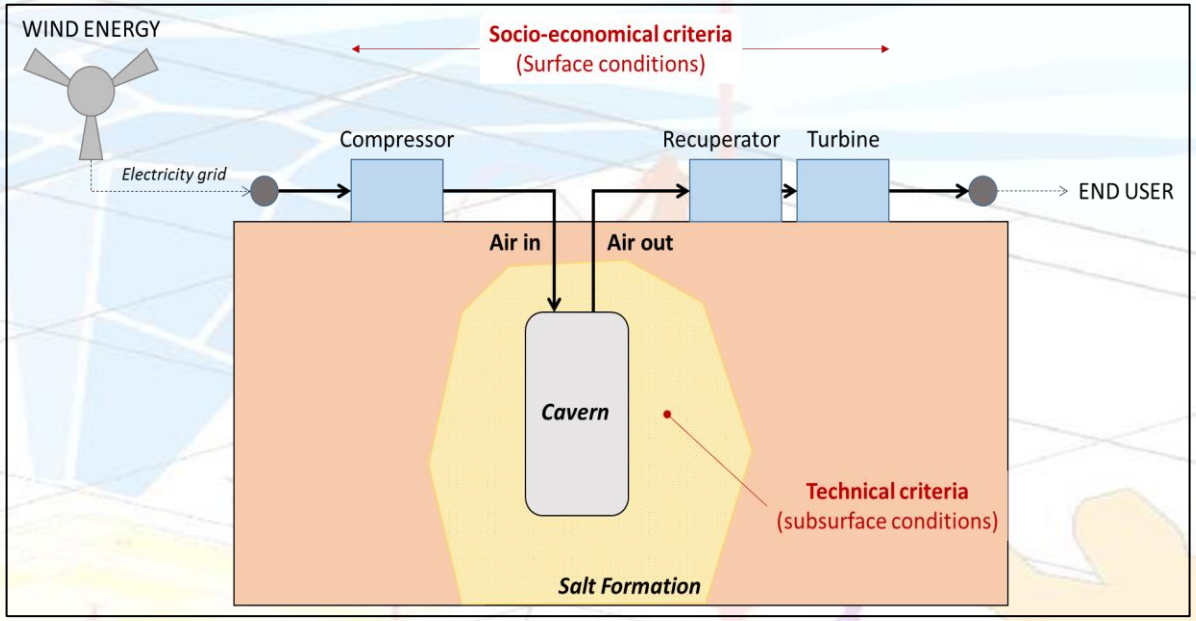
1. Necesidades iniciales

- El **sector energético** se encuentra en un profundo cambio. El fomento de las energías renovables y la necesidad de reducir las emisiones de CO2.
- El **subsuelo** ofrece oportunidades para apoyar las energías renovables (tecnología CAES) y reducción de emisiones de CO2 (CAC).
- La exploración del subsuelo reporta por tanto beneficios, pero existe un alto **riesgo exploratorio**.
- Es necesario establecer una correcta **estrategia de exploración** basada en criterios de selección técnico y socio-económicos.
- La utilización de herramientas **SIG** contribuye a esta exploración.

1. Necesidades iniciales



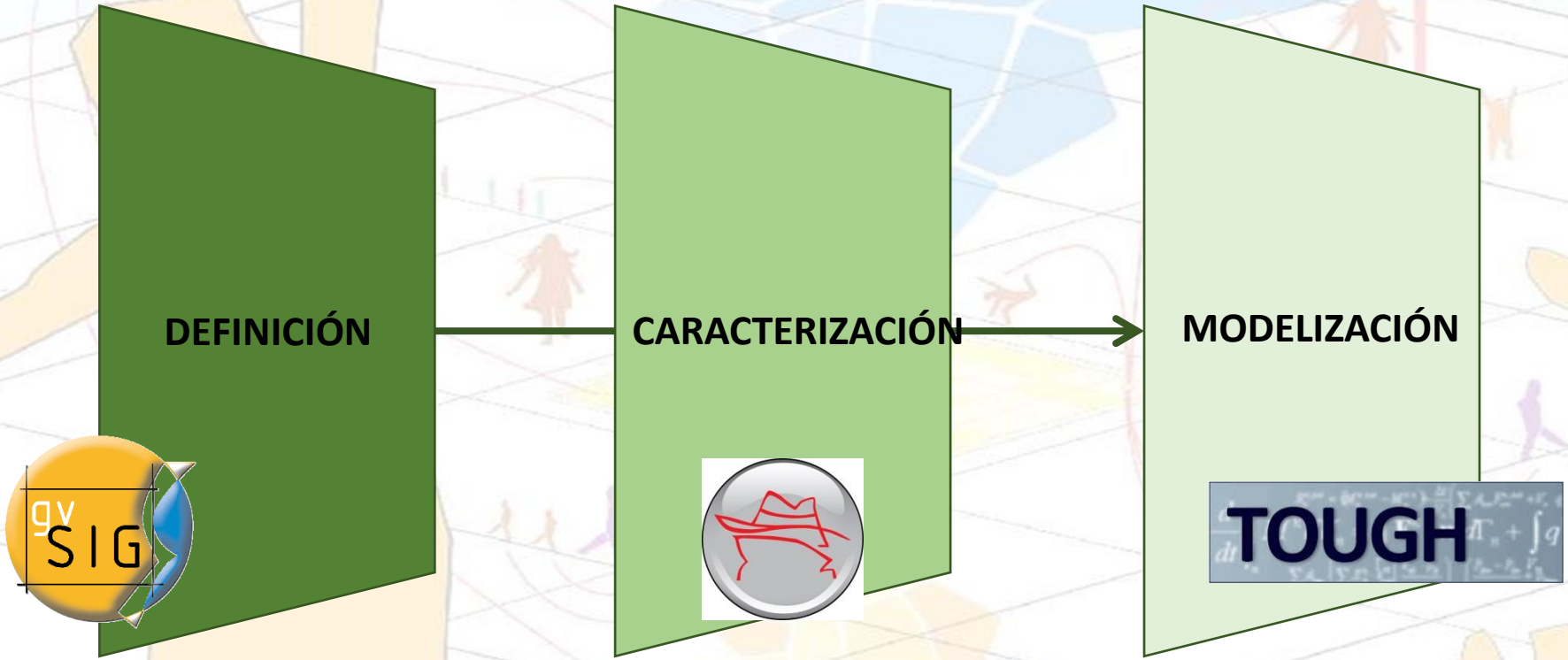
Almacenamiento Geológico de CO2



CAES Compressed Air Energy Storage

1. Necesidades iniciales

- Etapas contempladas en la caracterización del subsuelo **(>600m)**



2. Soluciones adoptadas

DEFINICIÓN

gvSIG

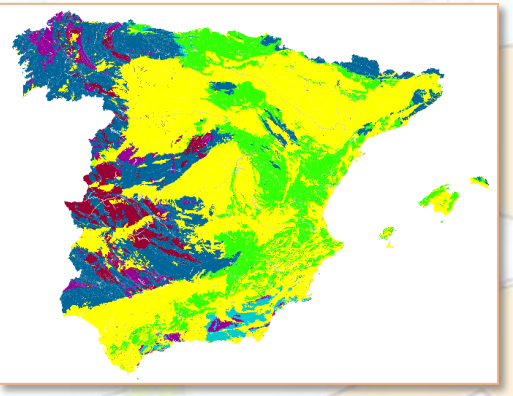
CO2SiteAssess

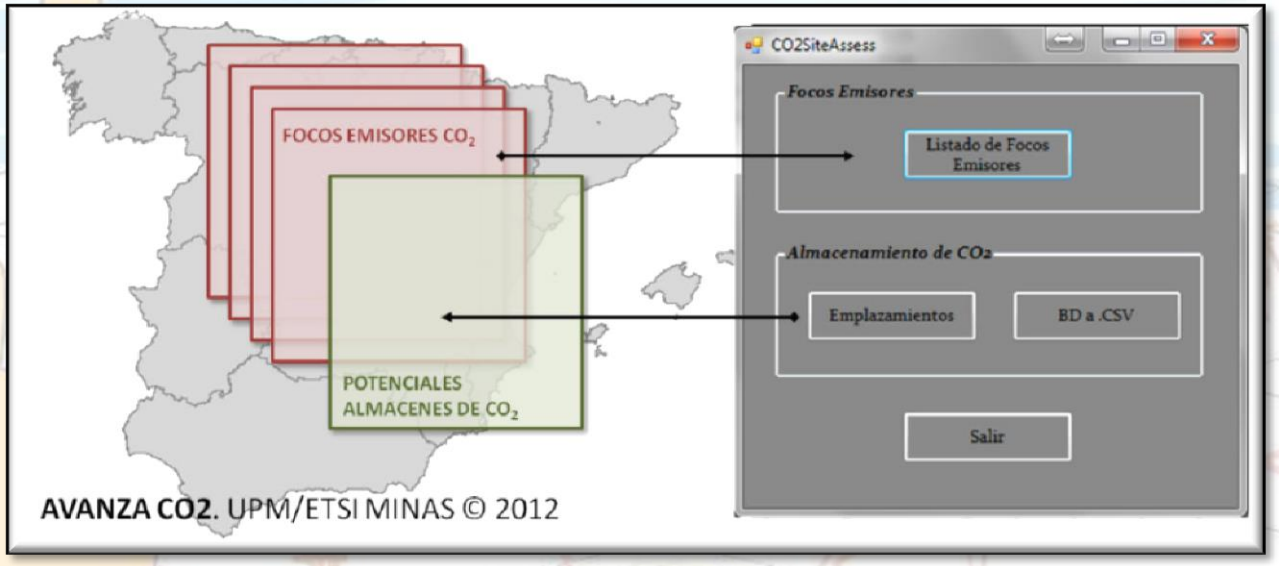
Herramienta de caracterización de alternativas susceptibles de ser consideradas almacén geológico de CO2

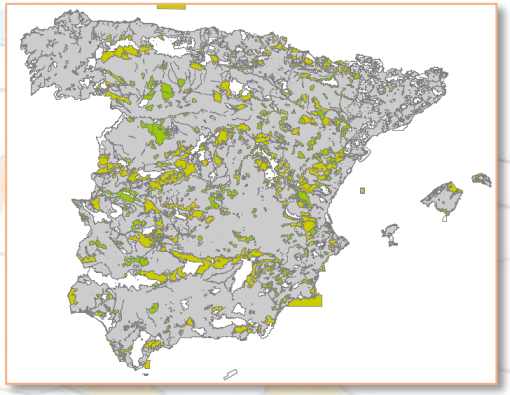
sigCAES

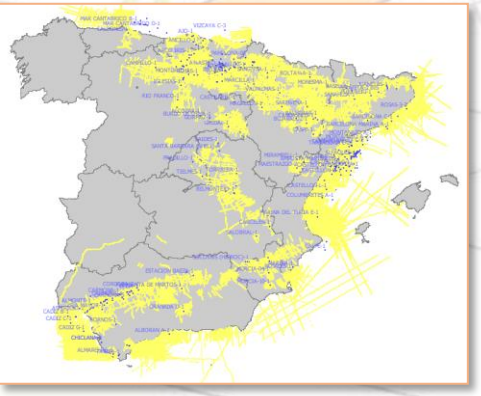
Herramienta de caracterización de alternativas susceptibles de ser consideradas almacén de aire comprimido en el subsuelo.

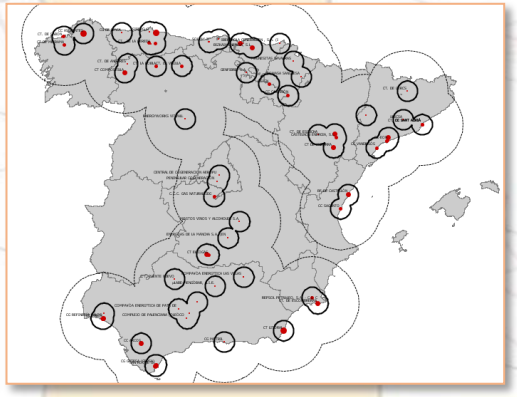
3. Herramienta CO2SITEASSESS

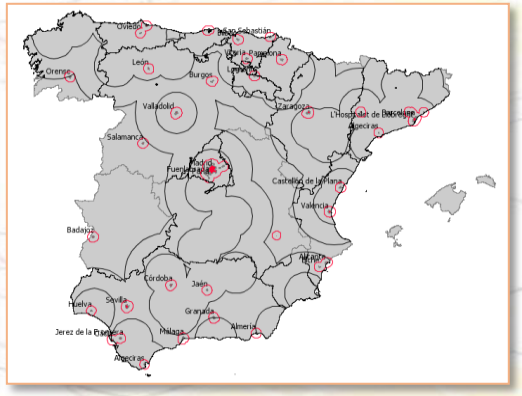


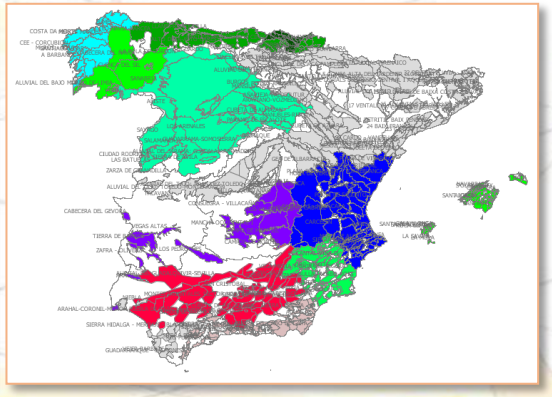


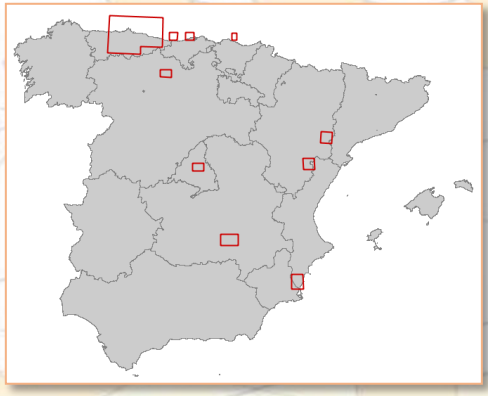






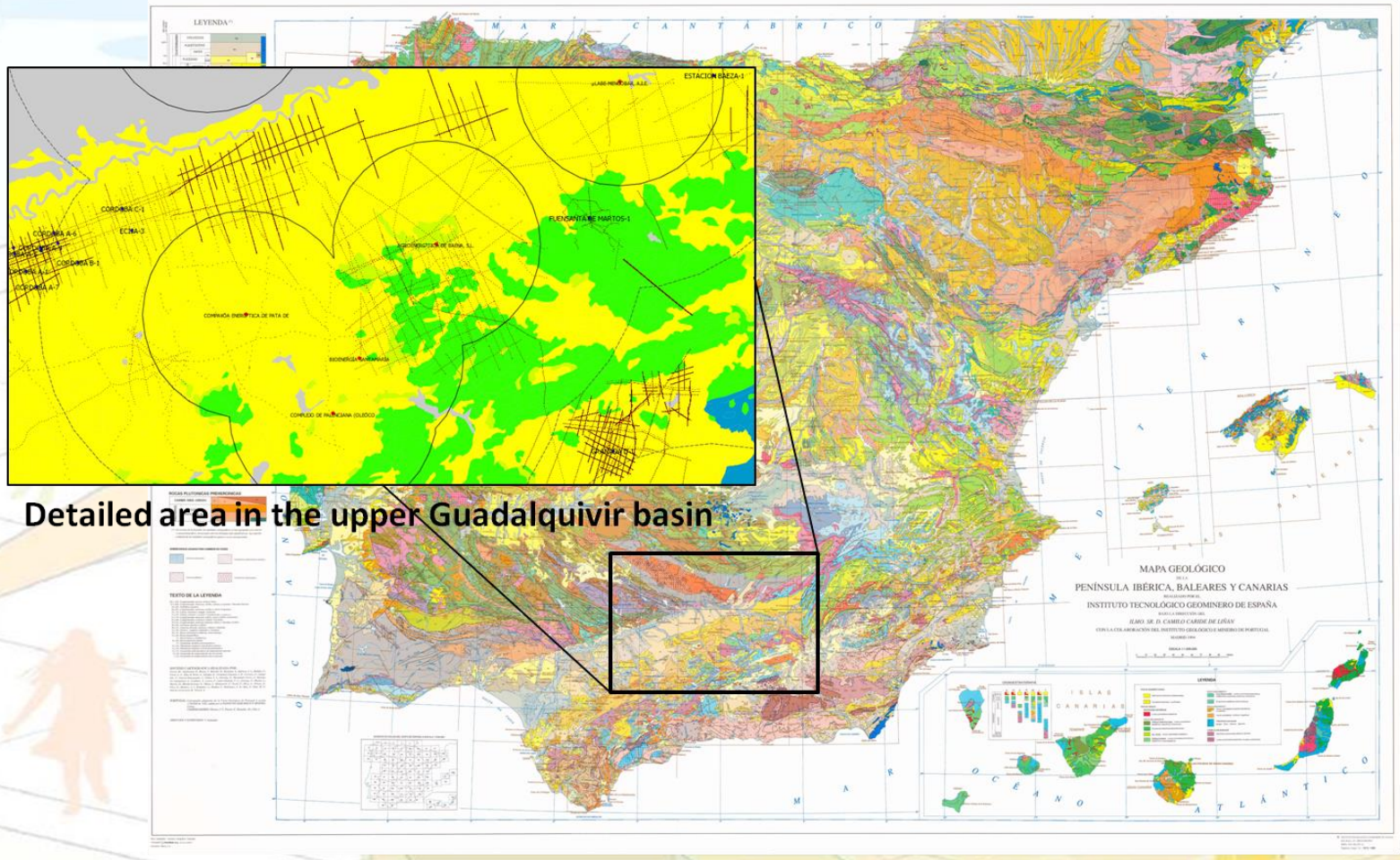






3. Herramienta CO2SITEASSESS

AVANZA CO2: area under evaluation



Detailed area in the upper Guadalquivir basin

Herramienta de evaluación de estructuras para almacenamiento geológico de CO2

Aplicación en la Cuenca del Guadalquivir

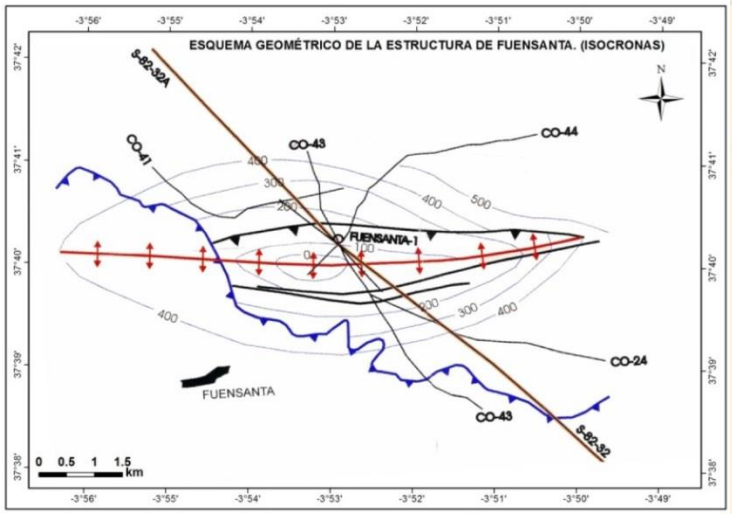
Proyecto AVANZACO2

3. Herramienta CO2SITEASSESS

CASO DE ESTUDIO. Guadalquivir

- Evaluación de hasta tres estructuras geológicas a profundidades superiores a 800m
- Evaluación técnica y socio-económica

A



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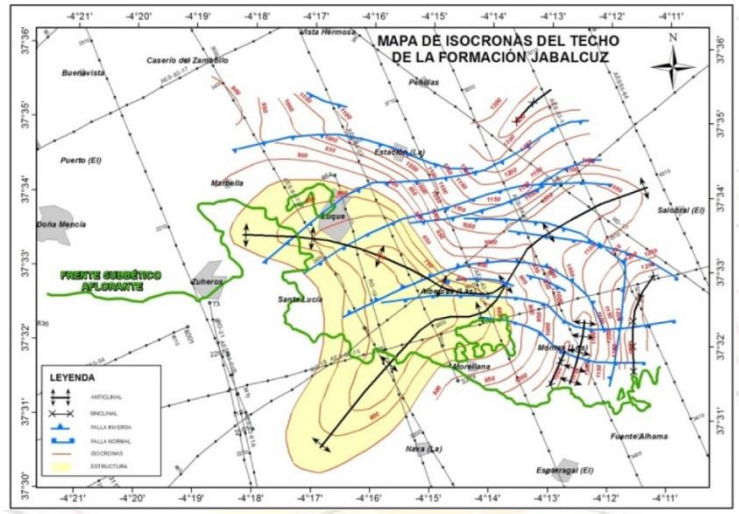

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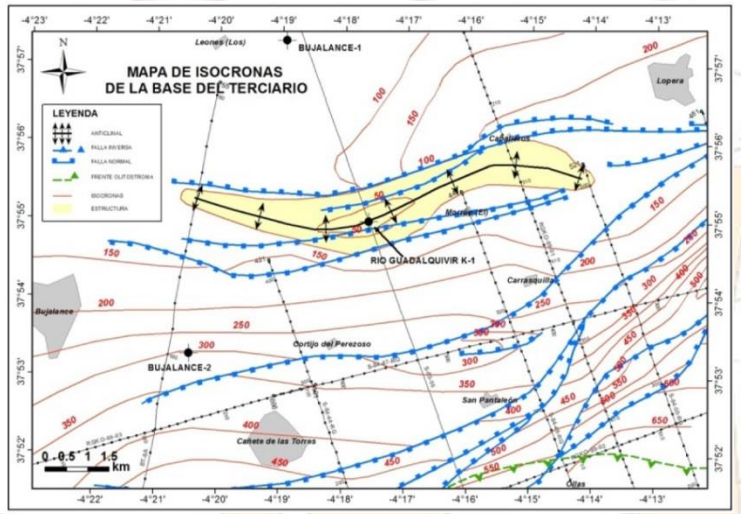
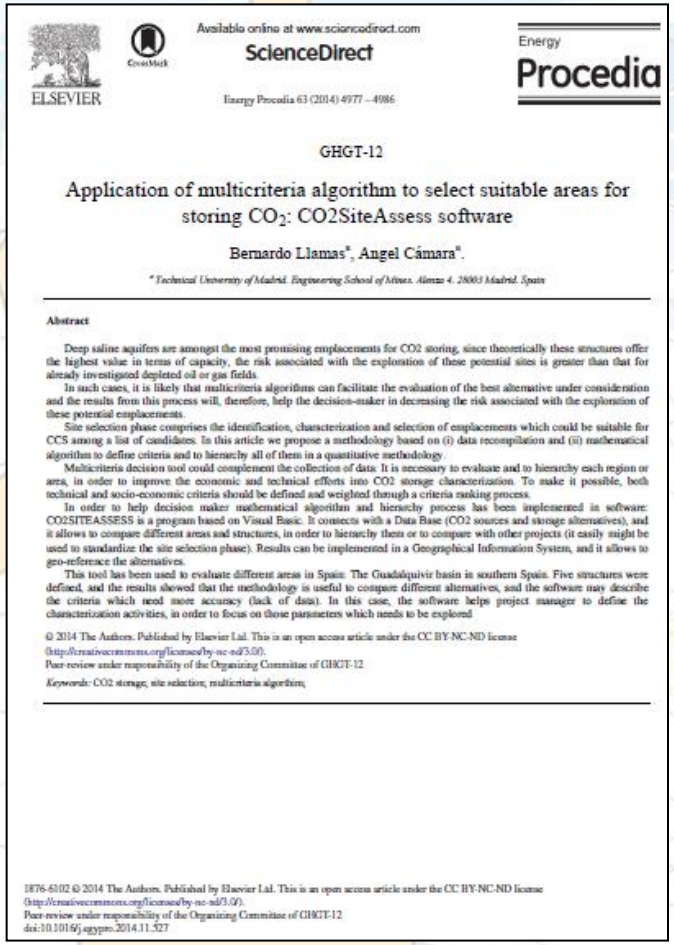


3. Herramienta CO2SITEASSESS

	Level / Criteria	I	II	III	IV	V
	(math) VALUE	1	3	5	7	9
Tectonic, structural	Geo-mechanical		Unstable domain		Stable domain	
	Lateral continuity	Convergent Basins. Volcanic Activity	Convergent Basins. Neo tectonics		Divergent Basins.	
			Syncline		Horizontal or sub horizontal	Anticline
	Fractures		Strongly fractured. Many faults		Weakly fractured. Few faults	
Storage	Porosity (%)	< 20 (2.0)		20-25		>25
	Permeability	< 1 mD		1-100 mD		> 1 D
	Thickness (m)		< 10	10-100		>100 (500)
	Lithology		Other		Carbonates	Sandstone
Caprock	Plasticity	Fragile		Intermediate		Ductile
	Thickness (m)	< 10		Active region 10-100 (50)	Stable region 10-100	> 100
	Porosity	> 10		10 - 5		< 5
Hydrogeology	TDS	< 3.000		3.000-10.000 >260.000		> 10.000 100 gr/L
	Hydro-dynamic	Local < 100 years		Area 100-1000 years		Regional >1.000 years
	Deep (m)	< 600		600-900	> 2.000	900-2.000 (1220 a 1380 m)
	Temperature		Warm basin	Mild temperate basin	Cold basin	
	Capacity ($MtCO_2$)	< 10	10-50	50-100	100-150	> 150
Other boundaries	Oil or gas		NO	Yes, small volume	Yes, Medium volume	Yes, huge volume
	Coal beds		NO	Yes. No methane presence	Yes; deep > 800m	Yes; deep 200-800m
	Massive saline		NO	Domes	Beds	
	Other	Exploration		Evidence. Exploration or research permits		Exploitation permits

	Class / Criteria	I	II	III	IV	V
	(math) VALUE	1	3	5	7	9
	Quality of the information	No data. It isn't possible to make any geological interpretation	Few data. It's possible to make an interpretation based on adjacent regions	Detail data and enough deep. General or shallow data.	Digital regional data (GIS).	Detail data (GIS) based on deep data (well and seismic data)
	Distance (km)	> 250	250-100	100-50	50-25	< 25
	CO_2 Quality	Impurity content up to 2%		Impurity content between 1-2%		Impurity content less than 1%
	Population (km)	< 10	10-25 Unfavorable topography	10-25 Favorable topography	25-50	>50
	Environmental resources (km)	0		10-20		>20
	Cultural resources (km)	0		10-20		>20
	Location		Offshore (deep)	Offshore (shallow)	Onshore	
Maturity	Climatology		Extreme		Warm	
	Affected Infrastructure		None	Little		All
	New infrastruture		All	Little		None

3. Herramienta CO2SITEASSESS



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Energy Procedia

GHGT-12

Application of multicriteria algorithm to select suitable areas for storing CO_2: CO2SiteAssess software

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Abstract

Deep saline aquifers are amongst the most promising emplacements for CO2 storing, since theoretically these structures offer the highest value in terms of capacity, the risk associated with the exploration of these potential sites is greater than that for already investigated depleted oil or gas fields.

In such cases, it is likely that multicriteria algorithms can facilitate the evaluation of the best alternative under consideration and the results from this process will, therefore, help the decision-maker in decreasing the risk associated with the exploration of these potential emplacements.

Site selection phase comprises the identification, characterization and selection of emplacements which could be suitable for CCS among a list of candidates. In this article we propose a methodology based on (i) data recompilation and (ii) mathematical algorithm to define criteria and to hierarchy all of them in a quantitative methodology.

Multicriteria decision tool could complement the collection of data. It is necessary to evaluate and to hierarchy each region or area, in order to improve the economic and technical efforts into CO2 storage characterization. To make it possible, both technical and socio-economic criteria should be defined and weighted through a criteria ranking process.

In order to help decision maker mathematical algorithm and hierarchy process has been implemented in software: CO2SITEASSESS is a program based on Visual Basic. It connects with a Data Base (CO2 sources and storage alternatives), and it allows to compare different areas and structures, in order to hierarchy them or to compare with other projects (it easily might be used to standardize the site selection phase). Results can be implemented in a Geographical Information System, and it allows to geo-reference the alternatives.

This tool has been used to evaluate different areas in Spain: The Guadalquivir basin in southern Spain. Five structures were defined, and the results showed that the methodology is useful to compare different alternatives, and the software may describe the criteria which need more accuracy (lack of data). In this case, the software helps project manager to define the characterization activities, in order to focus on those parameters which needs to be explored

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Peer-review under responsibility of the Organizing Committee of GHGT-12

Keywords: CO2 storage; site selection; multicriteria algorithm;

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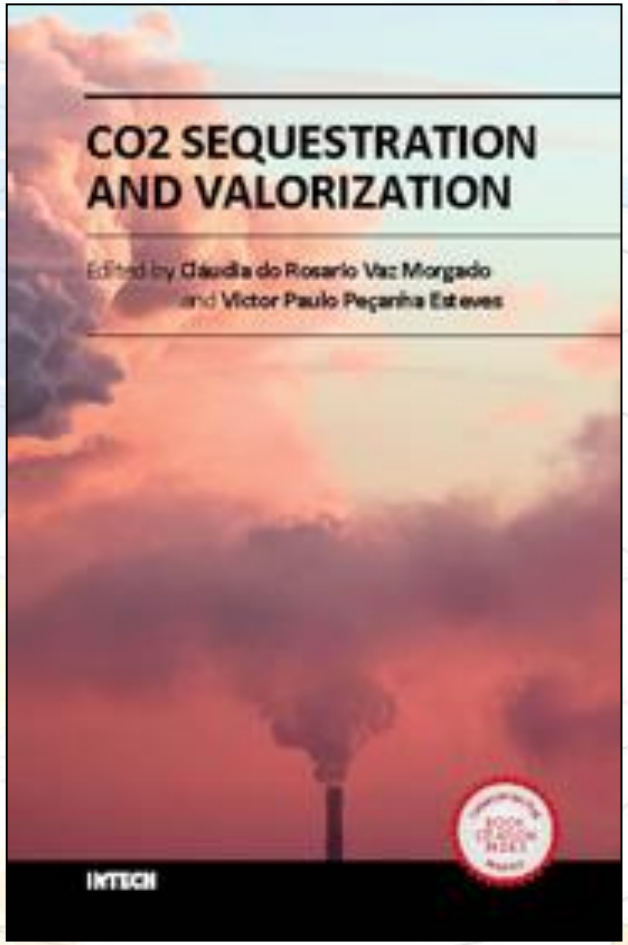
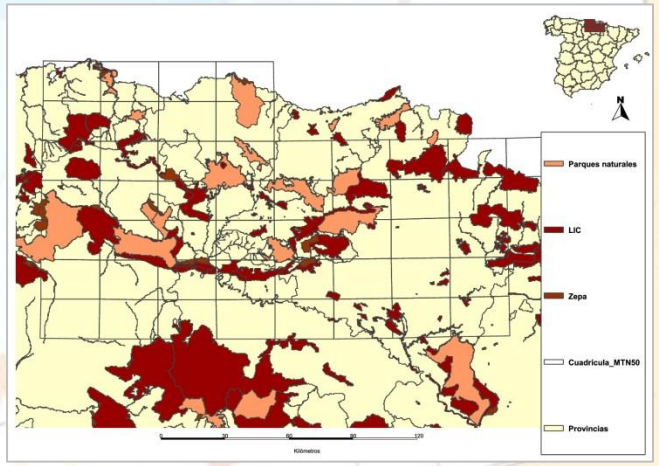
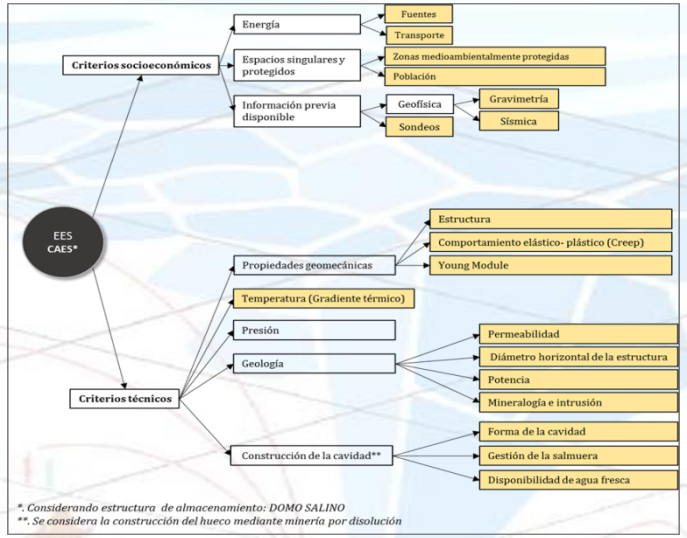
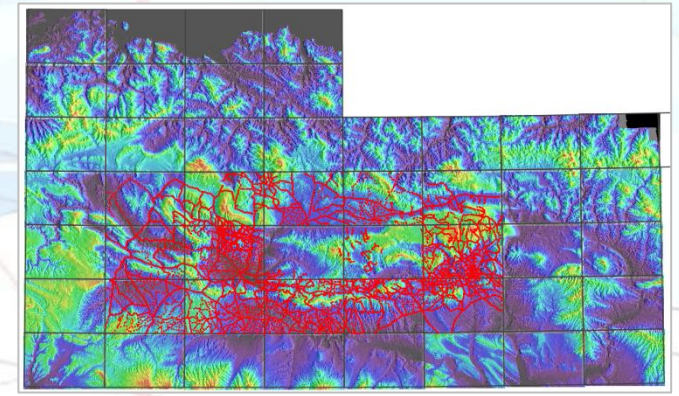
Peer-review under responsibility of the Organizing Committee of GHGT-12
doi:10.1016/j.egypro.2014.11.527

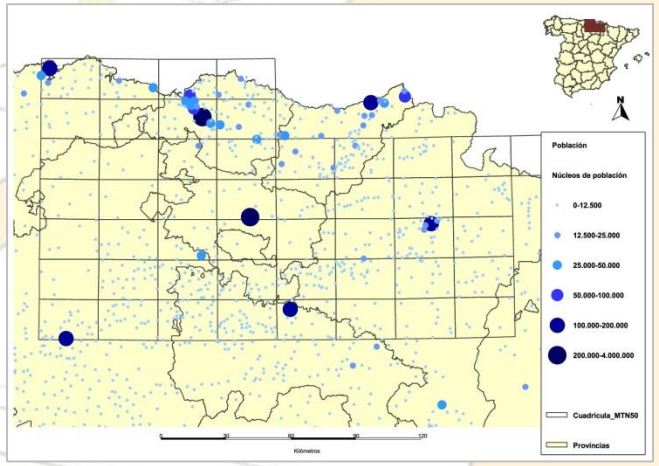


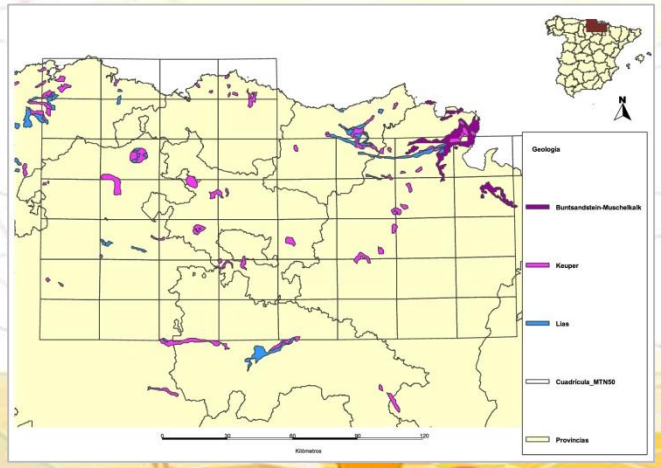
4. Herramienta sigCAES

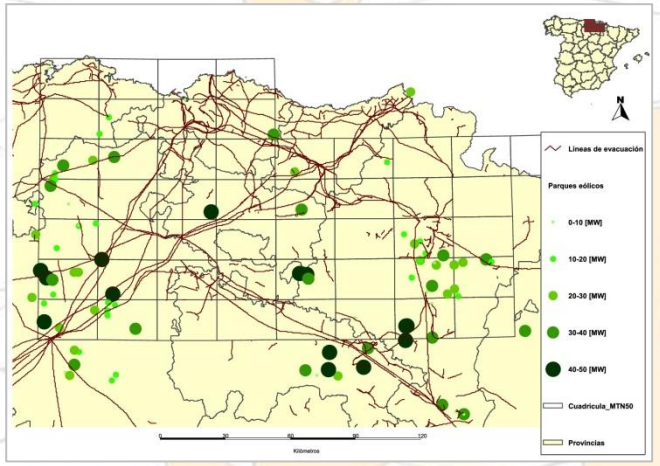




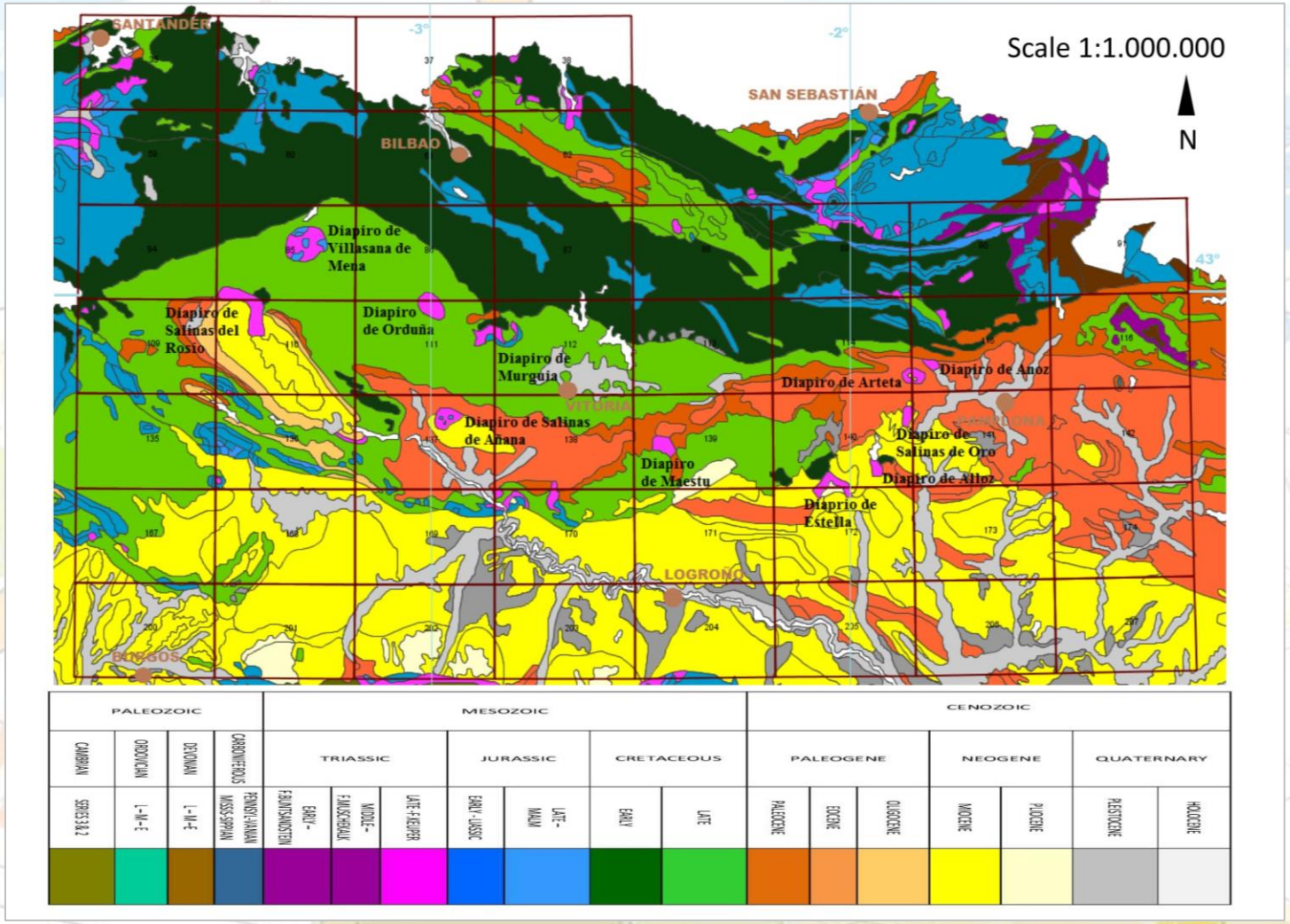








4. Herramienta sigCAES

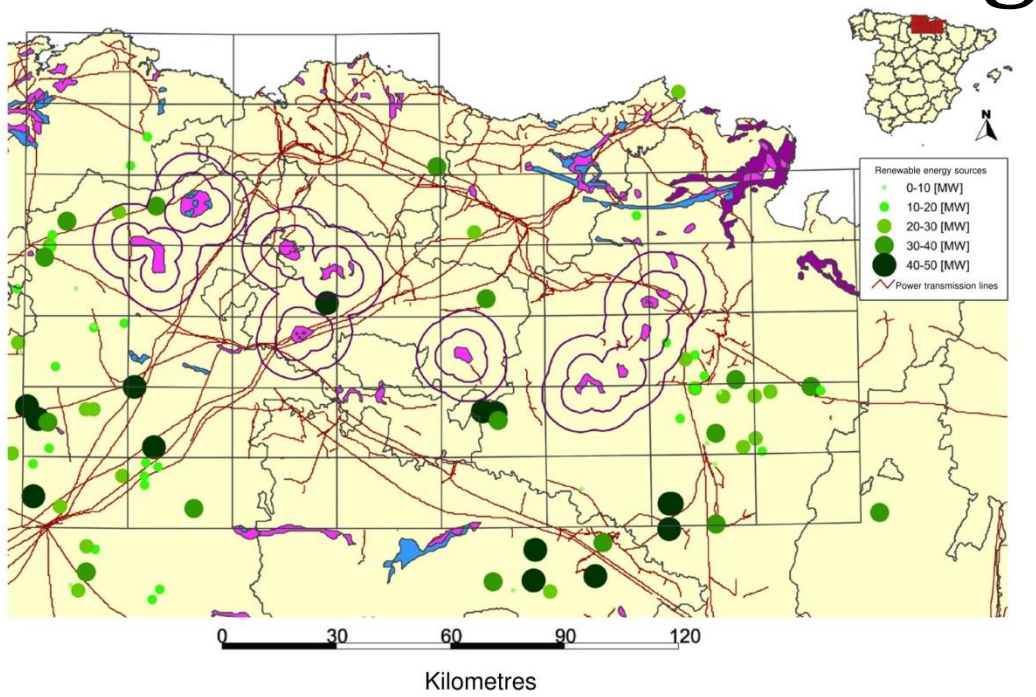


Herramienta de evaluación de estructuras para almacenamiento de aire comprimido en el subsuelo

Aplicación en la Cuenca Vasco-Cantábrica

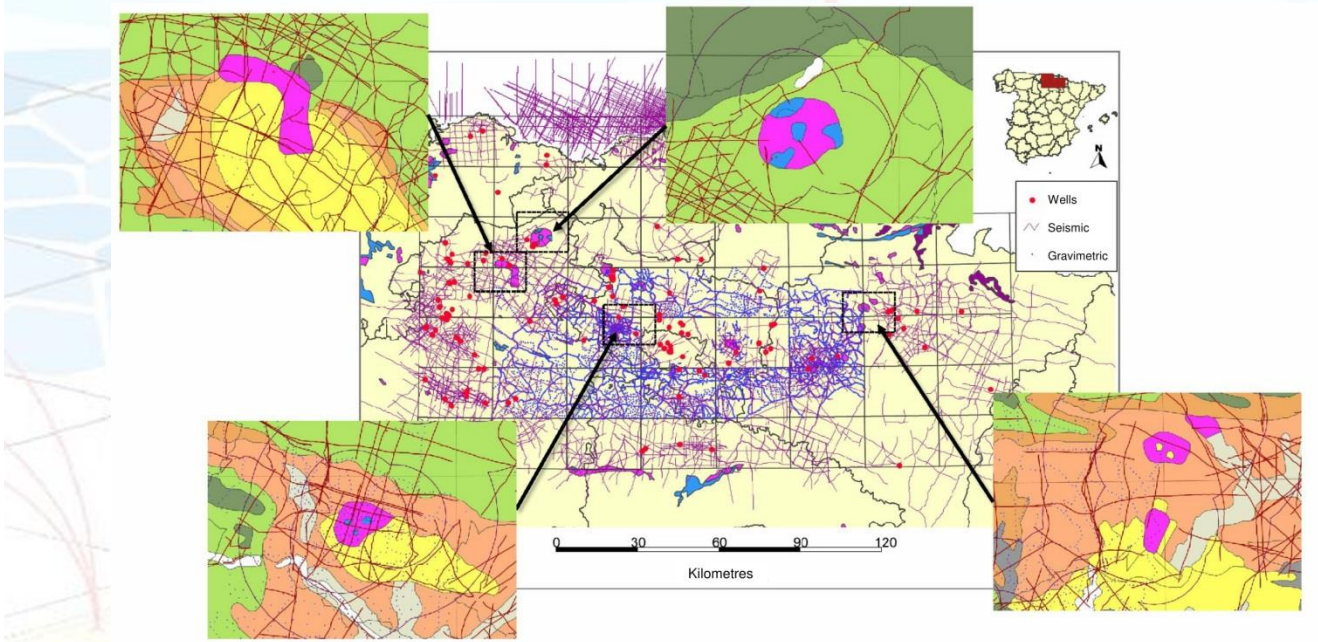
Proyecto TECFUTURA

4. Herramienta sigCAES



Criterio energía

Evaluación de parques eólicos y redes principales de transporte eléctrico



Criterio información previa disponible

Geofísica (sísmica de reflexión y gravimetría) y sondeos

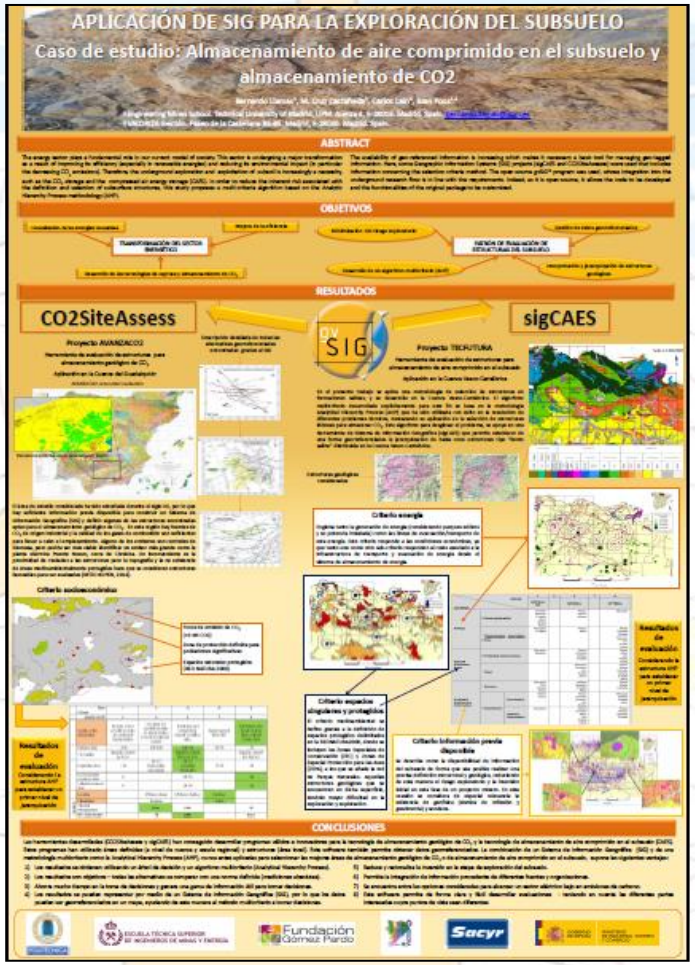
4. Herramienta sigCAES

Resultados de evaluación de todas las alternativas

Considerando la estructura AHP para establecer un primer nivel de jerarquización

CRITERIOS / VALOR			1 PESIMO	3	5 NORMAL	7	9 ÓPTIMO
Energía	Generación de energía		Orduña Maestu Estella Alloz Arteta Anoz		Rosio Mena Añana		Murguia
	Transporte - líneas de evacuación		Murguia Estella		Rosio Alloz		Mena Orduña Añana Maestu Oro Arteta Anoz
Espacios singulares y protegidos	Entornos naturales protegidos		Murguia Maestu		Mena Orduña Añana Estella		Rosio Alloz Oro Arteta Anoz
	Población				Murguia Maestu Oro Arteta Anoz		Rosio Mena Orduña Añana Estella Alloz
Información previa disponible	Sondeos		Murguia Oro Arteta Anoz		Añana Maestu Estella Alloz		Rosio Mena Orduña
	Geofísica	Gravimetría	Mena Anoz		Rosio Orduña Maestu Oro Arteta		Murguia Añana Estella Alloz
		Sísmica	Murguia		Mena Orduña Alloz Oro Arteta Anoz		Rosio Añana Maestu Estella

4. Herramienta sigCAES



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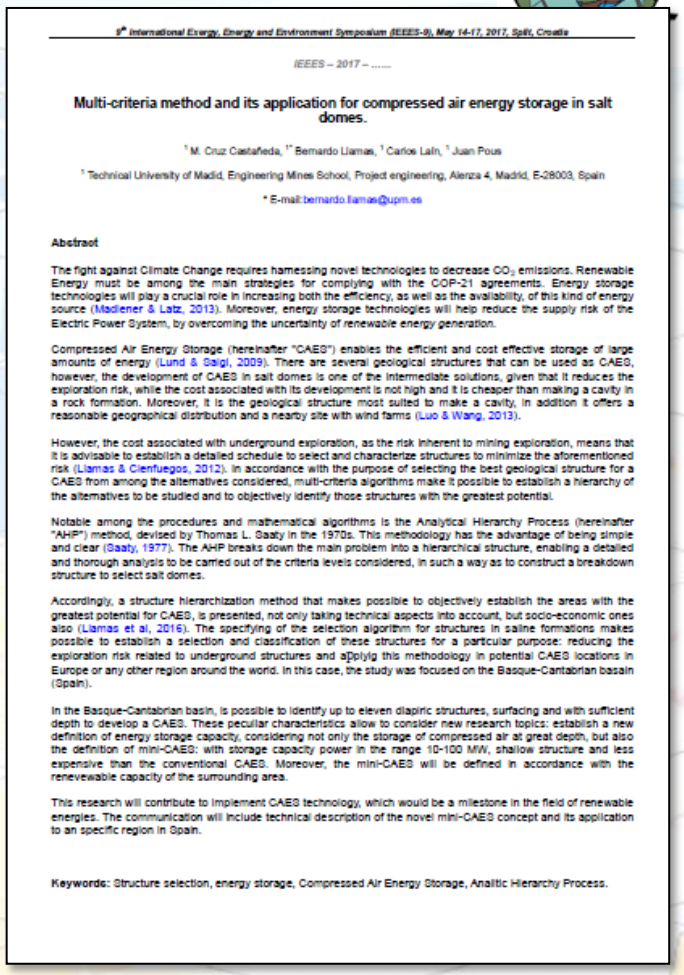

9th International Exergy, Energy and Environment Symposium (IEEES-9), May 14-17, 2017, Split, Croatia

IEEES – 2017 – .....

Multi-criteria method and its application for compressed air energy storage in salt domes.

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Abstract

The fight against Climate Change requires harnessing novel technologies to decrease CO_2 emissions. Renewable Energy must be among the main strategies for complying with the COP-21 agreements. Energy storage technologies will play a crucial role in increasing both the efficiency, as well as the availability, of this kind of energy source (Madlener & Latz, 2013). Moreover, energy storage technologies will help reduce the supply risk of the Electric Power System, by overcoming the uncertainty of renewable energy generation.

Compressed Air Energy Storage (hereinafter "CAES") enables the efficient and cost effective storage of large amounts of energy (Lund & Salgi, 2009). There are several geological structures that can be used as CAES, however, the development of CAES in salt domes is one of the intermediate solutions, given that it reduces the exploration risk, while the cost associated with its development is not high and it is cheaper than making a cavity in a rock formation. Moreover, it is the geological structure most suited to make a cavity, in addition it offers a reasonable geographical distribution and a nearby site with wind farms (Luo & Wang, 2013).

However, the cost associated with underground exploration, as the risk inherent to mining exploration, means that it is advisable to establish a detailed schedule to select and characterize structures to minimize the aforementioned risk (Llamas & Cienfuegos, 2012). In accordance with the purpose of selecting the best geological structure for a CAES from among the alternatives considered, multi-criteria algorithms make it possible to establish a hierarchy of the alternatives to be studied and to objectively identify those structures with the greatest potential.

Notable among the procedures and mathematical algorithms is the Analytical Hierarchy Process (hereinafter "AHP") method, devised by Thomas L. Saaty in the 1970s. This methodology has the advantage of being simple and clear (Saaty, 1977). The AHP breaks down the main problem into a hierarchical structure, enabling a detailed and thorough analysis to be carried out of the criteria levels considered, in such a way as to construct a breakdown structure to select salt domes.

Accordingly, a structure hierarchization method that makes possible to objectively establish the areas with the greatest potential for CAES, is presented, not only taking technical aspects into account, but socio-economic ones also (Llamas et al, 2016). The specifying of the selection algorithm for structures in saline formations makes possible to establish a selection and classification of these structures for a particular purpose: reducing the exploration risk related to underground structures and applyig this methodology in potential CAES locations in Europe or any other region around the world. In this case, the study was focused on the Basque-Cantabrian basain (Spain).

In the Basque-Cantabrian basin, is possible to identify up to eleven diapiric structures, surfacing and with sufficient depth to develop a CAES. These peculiar characteristics allow to consider new research topics: establish a new definition of energy storage capacity, considering not only the storage of compressed air at great depth, but also the definition of mini-CAES: with storage capacity power in the range 10-100 MW, shallow structure and less expensive than the conventional CAES. Moreover, the mini-CAES will be defined in accordance with the renewewable capacity of the surrounding area.

This research will contribute to implement CAES technology, which would be a milestone in the field of renewable energies. The communication will include technical description of the novel mini-CAES concept and its application to an specific region in Spain.

Keywords: Structure selection, energy storage, Compressed Air Energy Storage, Analitic Hierarchy Process.

5. Beneficios

GESTIÓN Y MANEJO DE INFORMACIÓN (SIG)

EVALUACIÓN DE ALTERNATIVAS

DE APLICACIÓN A NIVEL INTERNACIONAL

TOMA DE DECISIÓN EN LA INVERSIÓN

REDUCCIÓN DEL RIESGO EXPLORATORIO

INTEGRACIÓN DE INFORMACIÓN

MUCHAS GRACIAS

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