

Seville, April 4<sup>th</sup>, 2016



# The Spanish CO<sub>2</sub> Technology Platform

*F. Javier Alonso Martínez*  
**President**





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- **CO2 emissions in Spain**
- **Potential for CCS in Spain**
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# About PTECO2: Members

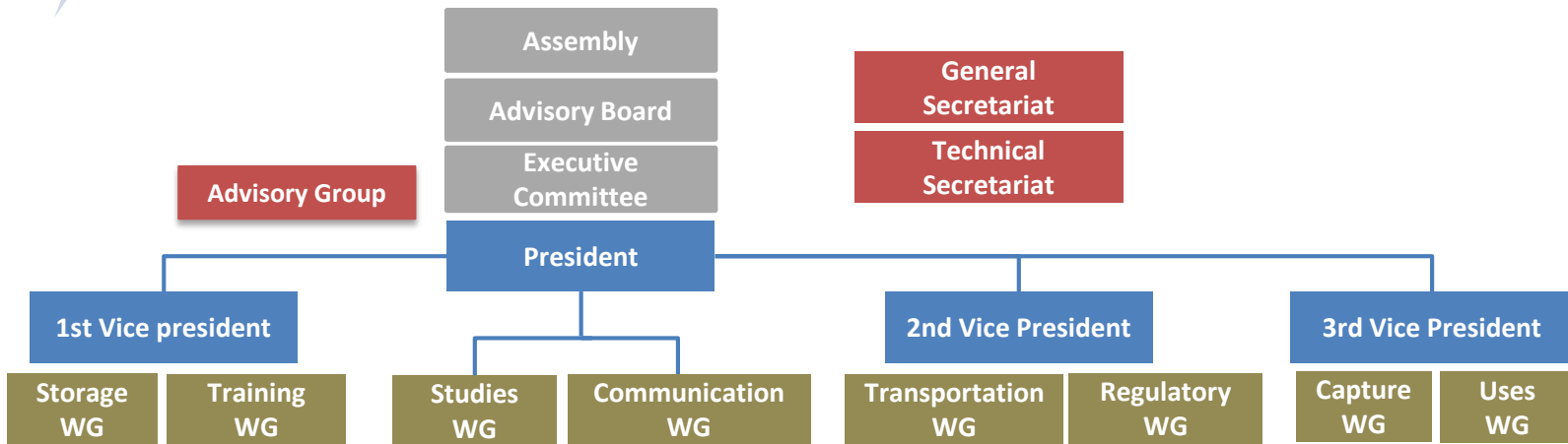
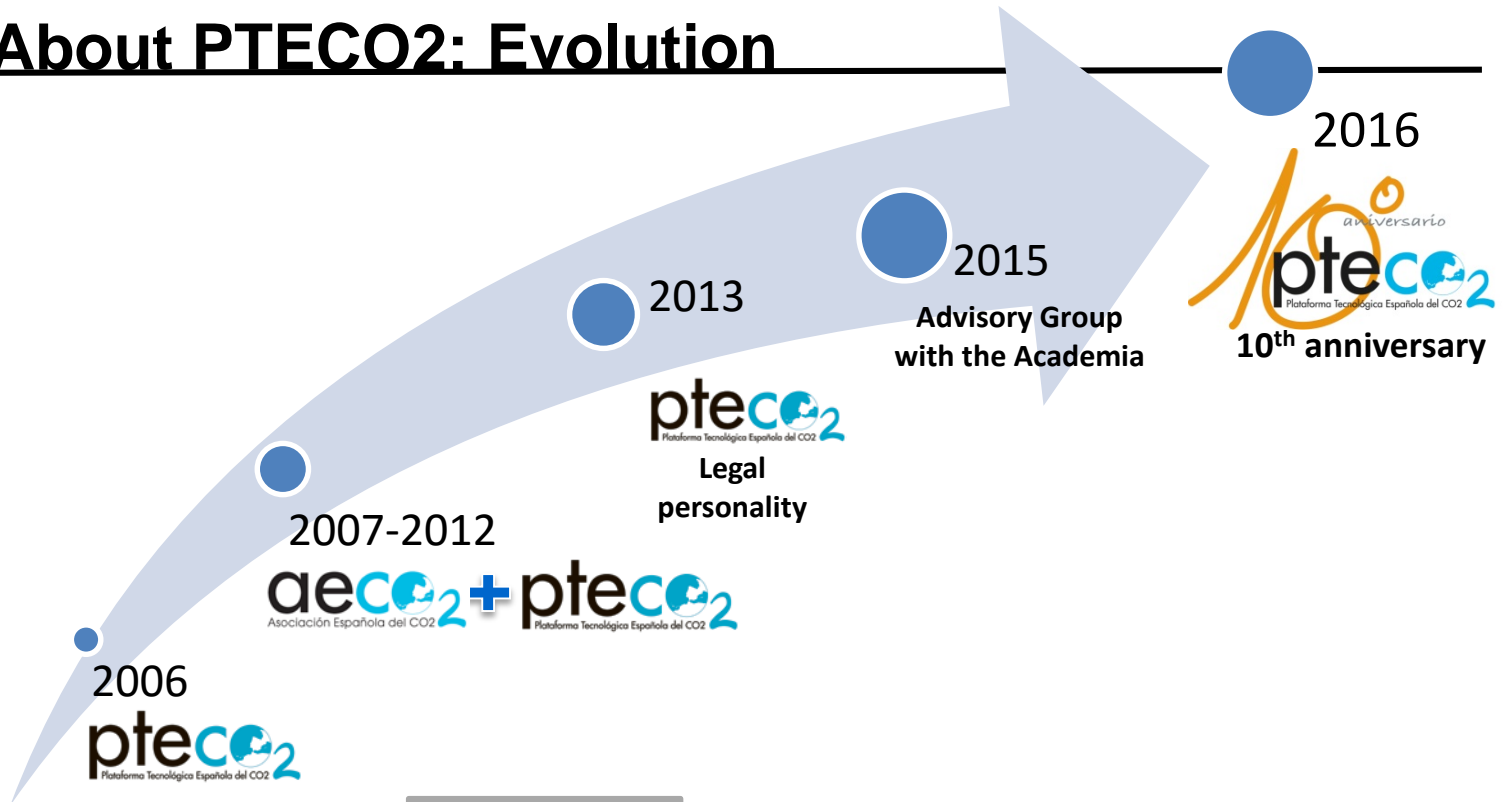
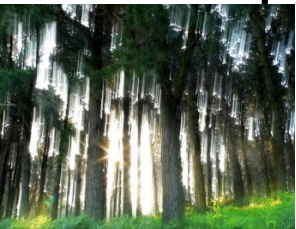


- **Our membership complies all the actors with interest in these sectors:** Spanish Ministries, Energy sectors, Industry sectors, Research centers, Engineering, CCS professionals and others.
- Academia participates as collaborated members:





# About PTECO2: Evolution

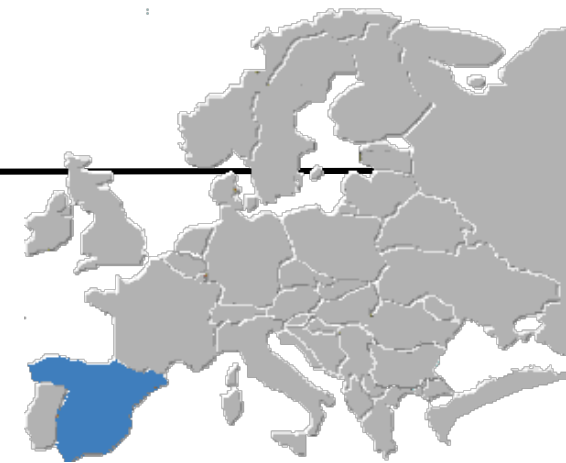




# About PTECO2

Besides the power sector, PTECO2 includes:

- Industry sectors
- CO2 uses as part of the scope of technologies to boost



1

**Industry:** We are working with industries which trying to help them applying not only BAT

**Cement sector**



**Mining industry**



**Refinery industry**



2

**CO2 uses:** We include the valorization of CO2 into the CCS chain

### Direct uses

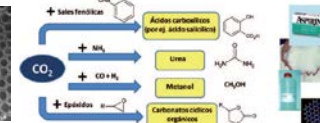
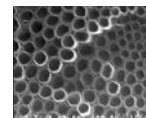
- Water Treatment
- Enhanced oil recovery (EOR)
- Processes which use supercritical carbon dioxide



- Waste carbonation
- Food & drinks

### Chemical/energy applications

- Artificial photosynthesis
- Chemical Conversion to Fuels or high value added products



### Biological applications

- Algal bloom
- CO2 fertilization



# About PTECO2: Activities 2016-2017

- Visit our website to learn more about our activities: [www.pteco2.es](http://www.pteco2.es)

Follow us on Twitter (@pteco2), Facebook and LinkedIn.

To launch new editions of **PTECO2's Awards**: the best thesis and best master on CCS.

- To preside and also participate in the **CTN 216/GT2 SG CTAGCO2**. AENOR is the secretary of this Committee.

- To participate in the **Energy Platforms Committee**.

- To collaborate with the **Alliance for Energy Research and Innovation (ALINNE)**.

- To celebrate technical events in different cities of Spain.

- To collaborate with the **Zero Emissions Platform (ZEP)** in Spain.

- To collaborate with the **Global CCS Institute**.

The screenshot shows the PTECO2 website interface. At the top, it says 'pteco2 Plataforma Tecnológica Española del CO2'. Below the navigation bar, there's a main banner with the text 'Captura, transporte, almacenamiento y usos del CO2' and 'Una vía eficaz para reducir las emisiones de CO2'. To the right, there are social media links and a section for 'ASAMBLEA GENERAL Madrid, 15 de diciembre'. Below the banner, there are sections for 'Noticias' (News) and 'Documentos' (Documents). The 'Noticias' section includes 'Asamblea General 2015 de PTECO2' and 'Padnet y PTECO2 firman un acuerdo para promover la investigación...'. The 'Documentos' section includes 'Captura de CO2: tecnologías para una captación a gran escala' and 'Usos del CO2: un camino hacia la sostenibilidad'. There are also sections for 'whec Zaragoza Spain' and '6TH CARBON DIOXIDE UTILIZATION SUMMIT'.

To work with **other technical platforms**:

- SusChem-Spain.
- PTE HPC.
- PACKNET.
- Food for Life-Spain.

To participate in **Transfiere - The European Meeting on Science, Technology and Innovation**.

To publish **studies**:

- Environmental impact on CO<sub>2</sub> transportation.
- CCS regulation.
- Public perception on CSS.

To publish **technical documents**:

The image shows four technical documents from PTECO2. From left to right: 1. 'Captura de CO2: tecnologías para una captación a gran escala' (2014), featuring a globe with a plant. 2. 'Almacenamiento de CO2: tecnologías, oportunidades y expectativas' (2015), featuring a globe with red dots. 3. 'Usos del CO2: un camino hacia la sostenibilidad' (2015), featuring a landscape with a red sun. 4. 'Transporte de CO2: estado del arte, alternativas y retos' (2015), featuring a globe with red dots and a pipeline.





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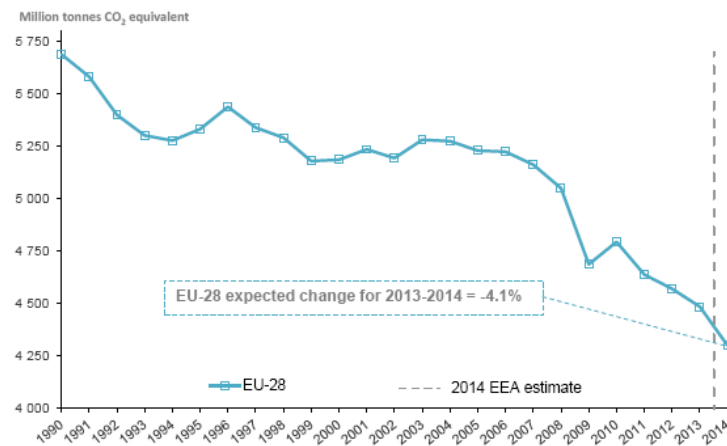
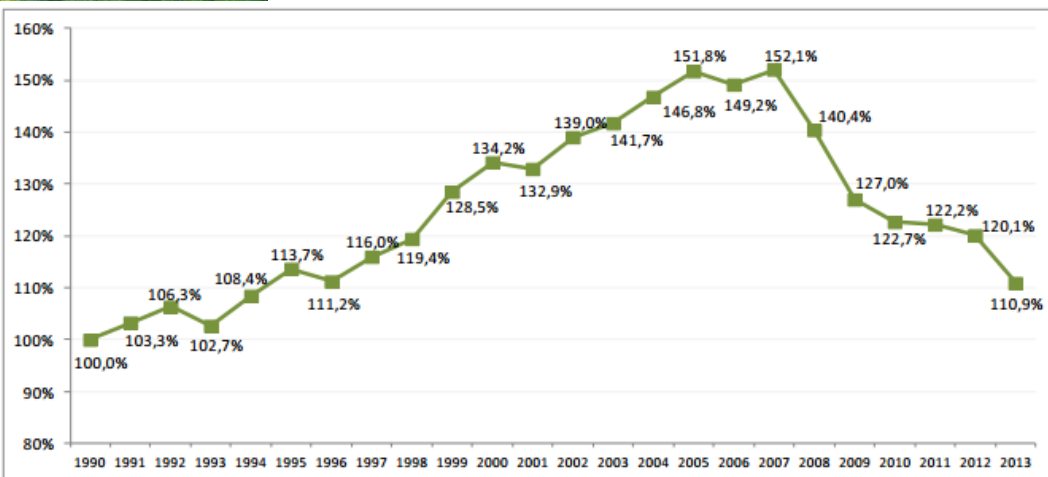
# CO<sub>2</sub> emissions in Spain

## GHG emissions

Key data on GHG emissions	2005	2011	2012	2013	EU 2012
Total GHG emissions (UNFCCC, Kyoto Protocol) (Mt CO <sub>2</sub> -eq.)	431.4	345.9	340.8	315.6	4 544.2
GHG per capita (t CO <sub>2</sub> -eq./cap.)	10.0	7.4	7.3	6.8	9.0
GHG per GDP (g CO <sub>2</sub> -eq./PPS in EUR)	434	310	302	281	350
Share of GHG emissions in total EU-28 emissions (%)	8.3 %	7.5 %	7.5 %	7.1 %	100 %
EU ETS verified emissions (Mt CO <sub>2</sub> -eq.)	183.6	132.7	135.6	122.8	1 848.6
Share of EU ETS emissions in total emissions (%)	43 %	38 %	40 %	39 %	41 %
ETS emissions vs allowances (free, auctioned, sold) (%)	+ 6.7 %	- 12.4 %	- 12.0 %	- 20.5 %	- 14.1 %
Share of CERs & ERUs in surrendered allowances (%)	0.0 %	20.7 %	28.0 %	n.a.	26.4 %
Non-ETS (ESD) emissions, adjusted to 2013-2020 scope (Mt CO <sub>2</sub> -eq.)	229.1	201.6	194.0	189.7	2 566.6

European Environment Agency (EEA)  
Climate and energy profiles 2014. Spain

- Total GHG emissions in 2014 are estimated to be -24.4 % below 1990 emissions.



The Spanish Ministry of Agriculture, Food and Environment (MAGRAMA)  
GHG emissions inventory in Spain. 1990-2013

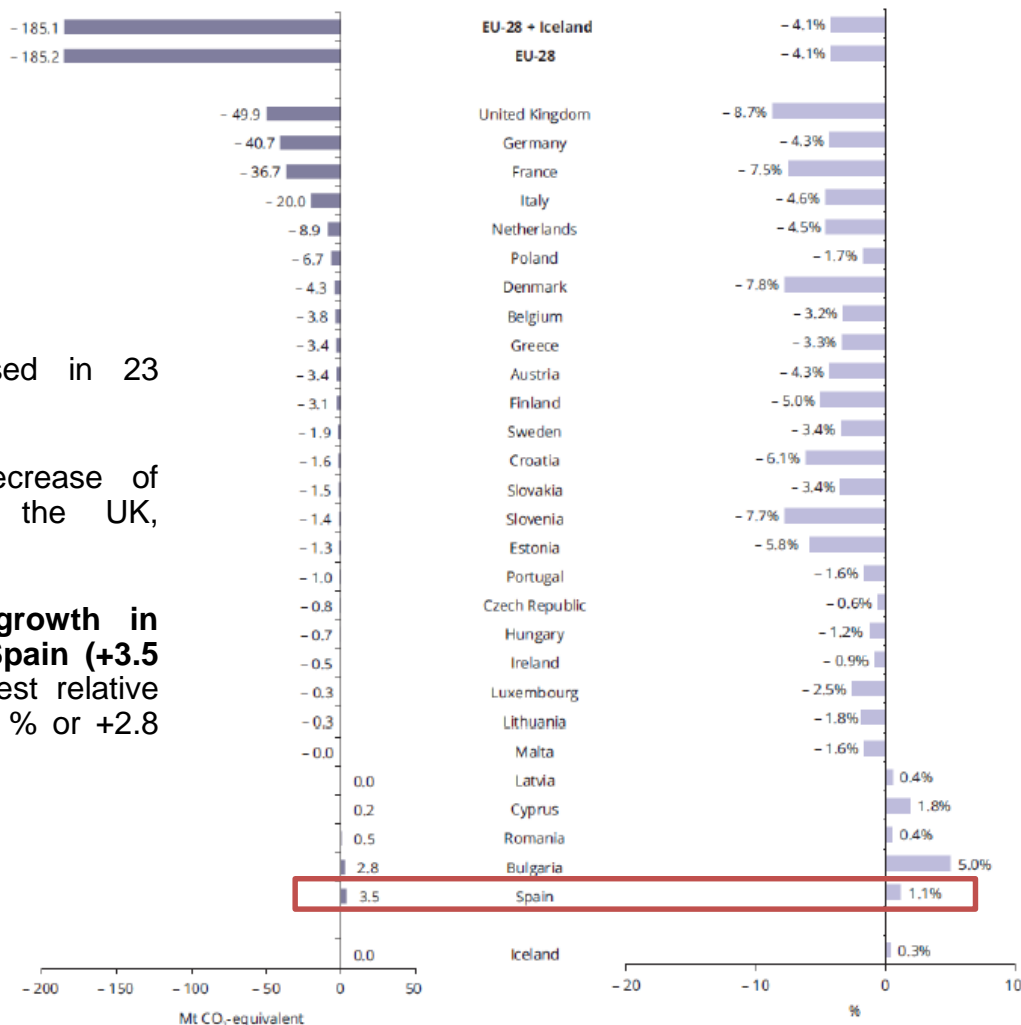
Approximated EU GHG inventory:  
Proxy GHG emission estimates for 2014



# CO<sub>2</sub> emissions in Spain

## Member States emissions, change 1990-2014

- GHG emissions decreased in 23 Member States.
- The largest absolute decrease of emissions occurred in the UK, Germany, France and Italy.
- **The largest absolute growth in emissions occurred in Spain (+3.5 Mt CO<sub>2</sub>-eq) and the largest relative increase in Bulgaria (+5.0 % or +2.8 Mt CO<sub>2</sub>-eq).**



Approximated EU GHG inventory:  
Proxy GHG emission estimates for 2014

# CO<sub>2</sub> emissions in Spain

## Spain 2014

- **Spain's emissions were +3.5 Mt CO<sub>2</sub>eq or +1.1 % higher in 2014 compared to 2013.** While total fossil energy consumption fell by -3.9 %, the increase in emissions reflects a change to more emissions intensive fuel mix.
- Liquid fossil fuel consumption decreased by -1.7 % and natural gas consumption by -9.3 %, however solid fossil fuel consumption increased by +8.0 %.
- **The largest increase in energy emissions were in Energy Industries.** According to Spain's own reported information, this increase is related to increased coal (+7 %) and natural gas (+17 %) in the electricity generation mix and in-creased emissions from refineries.
- Emissions in the Industrial Processes and Product Use sector increased by 1.7 Mt or 6.2 %, mainly from a +17 % increase in the cement industry. Emissions from Agriculture increased by +1.7 Mt CO<sub>2</sub>-eq or +4.4 % due to cattle rise.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	ETS	NON ETS
				CO <sub>2</sub> equivalent (Gg )	
Energy	234 832.21	2 989.16	2 052.94	107 831	132 043
Industrial processes and product use	18 755.56	169.76	863.40	17 016	11 805
Agriculture	39.19	20 526.39	20 166.20	0	40 732
Waste	3.43	14 758.02	1 360.15	0	16 122
<b>Total CO<sub>2</sub> equivalent emissions without land use, land-use change and forestry</b>				<b>124 847.05</b>	<b>200 701.96</b>

**Approximated EU GHG inventory:  
Proxy GHG emission estimates for 2014**



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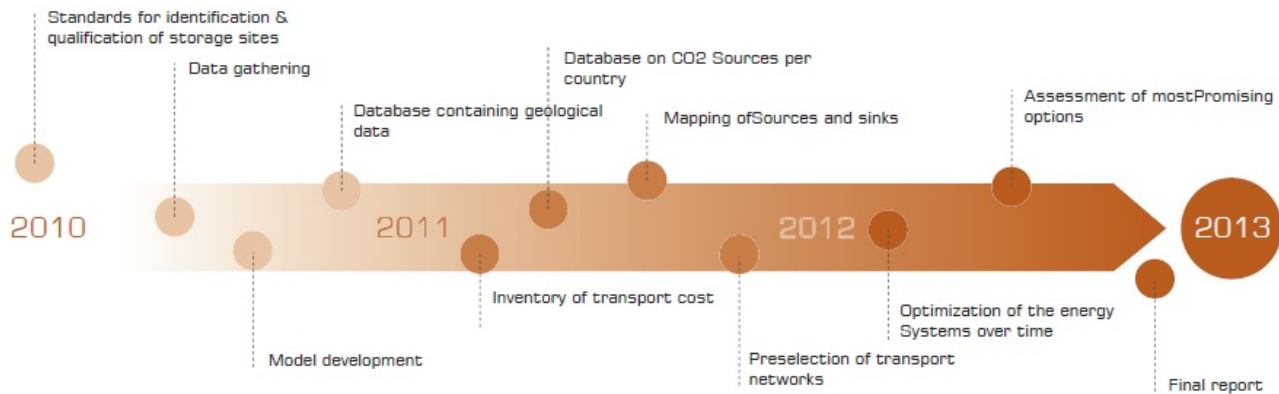
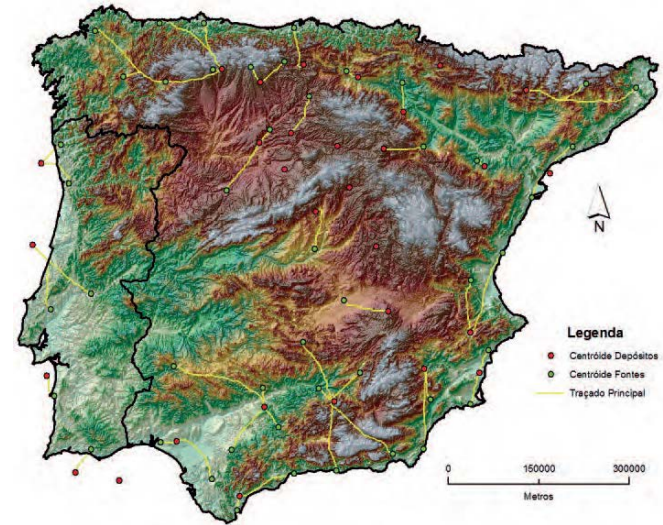


# Potential for CCS in Spain



## COMET

- The overall objective of COMET was to study the techno-economic feasibility of integrating carbon dioxide transport and storage infrastructures in the West Mediterranean area, Portugal, Spain and Morocco.
- The study take into account several factors:
  - Spatial data.
  - Terrain factors.
  - Cluster delimitation.
  - Least cost routes.



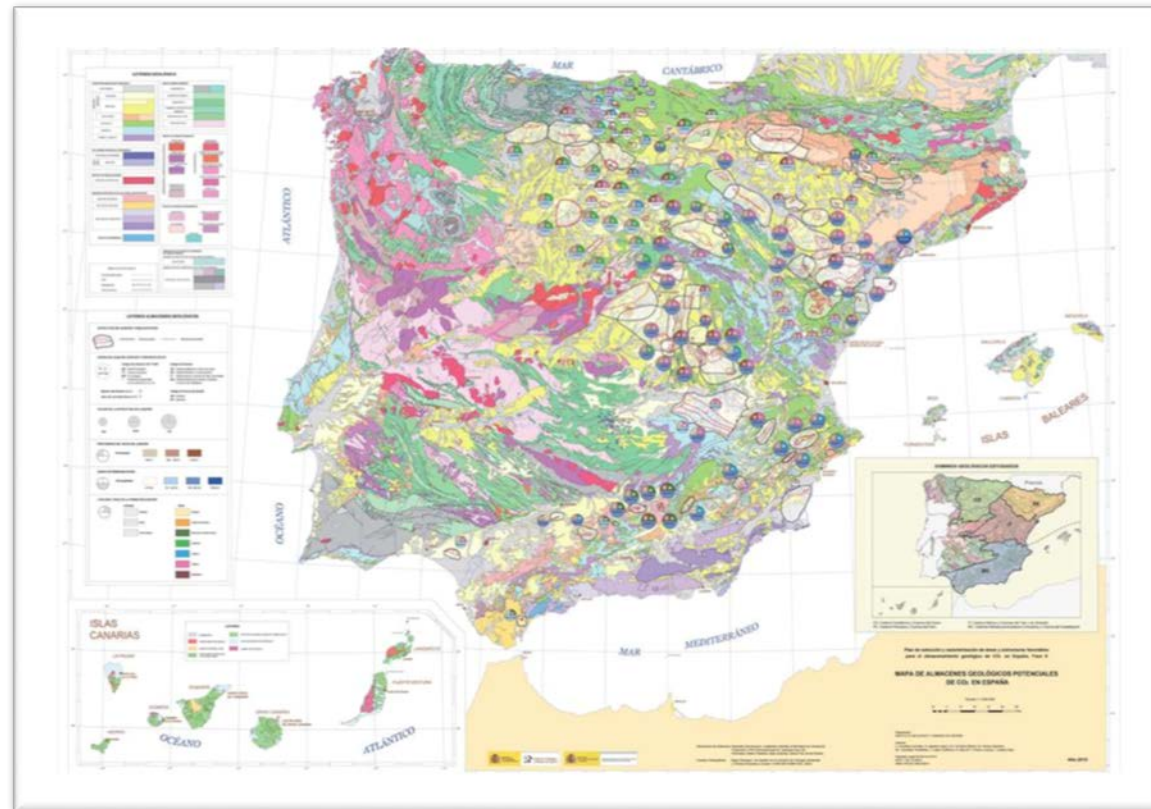
# Potential for CCS in Spain

## Capacity for geological storage of carbon dioxide



- The Spanish Geological Survey (IGME) has developed a national screening, selecting available geological storage sites in Spain. They identified **103 onshore available storages** keeping in mind to continue the study on the offshore.

Map of potential geological storage sites in Spain (IGME)





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# CCS initiatives in Spain

## Key singular scientific infrastructures



### CIUDAD DE LA ENERGÍA FOUNDATION, CIUDEN

- The Foundation was established in 2006, under the authority of the Government of Spain, to implement R&D&I energy and environment programmes, and contribute to the economic development in El Bierzo region.
- It is run by a board of governors with the participation of the ministries related to Energy, Science and Environment.
- CIUDEN has 3 facilities:



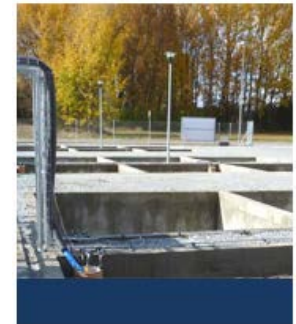
#### Cubillos

The Technology Development Centre is located in the municipality of Cubillos del Sil in El Bierzo (León). The main CO<sub>2</sub> capture process in the centre is oxycombustion.



#### Hontomín

The Geological Storage Technology Development Plant of CO<sub>2</sub> is located in Hontomín (Burgos). It is under construction and instrumentation to develop technologies associated with geological storage of CO<sub>2</sub>.



#### PISCO2

The Pilot Plant for CO<sub>2</sub> Injection in Soils is located in the surroundings of es.CO<sub>2</sub>. This installation monitors bioindicators which are sensitive to CO<sub>2</sub>. Small amounts of CO<sub>2</sub> are injected into different types of soil in order to assess their effects on bacteria, fungi, insects and plants.





# CCS initiatives in Spain

## Key singular scientific infrastructures



**The National Institute of Coal (INCAR-CSIC):** CO<sub>2</sub> capture using carbonate looping cycle:

- The research activities cover at present several key aspects of these processes: including the determination of fundamental kinetics and CaO deactivation rates, the effect of impurities on the flue gas (SO<sub>2</sub>), and a small pilot demonstration of the process in a **30kW pilot test facility** built at INCAR-CSIC involving two interconnected circulating fluidized bed reactors (6 m height and 0.1 m diameter). We also conduct modeling work at particle level, reactor level, full process level and basic economics.



**The IMDEA Energy Institute:** Photochemical valorisation of CO<sub>2</sub> and study of techniques for CO<sub>2</sub> capture and storage

- The specific objectives of this research line are:
  - Analysis of techniques for CO<sub>2</sub> capture and storage: life cycle, environmental and techno-economic studies.
  - Catalysts for photocatalytic reduction of CO<sub>2</sub>.



**Others:** CO<sub>2</sub> capture, storage and uses.



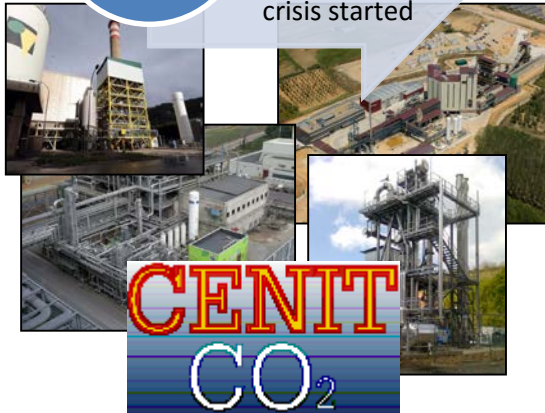
# CCS initiatives in Spain

## CCS Evolution & Achievements



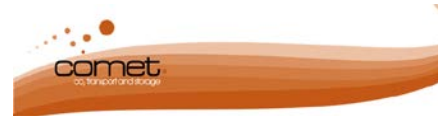
2006-2011

- Big initiatives with project pilots
- Spanish economical crisis started



2011-2014

- Reduced funding
- The end of big projects

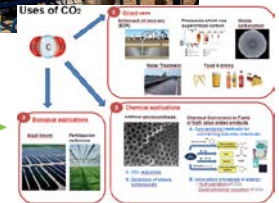


2014-2016

- Trend to R&D again with a worldwide portfolio initiatives (new absorbents, CO2 uses...)



HiPerCap  
CO<sub>2</sub>



### Main achievements, 2006-2016:

- One of the first countries to launch a pilot plant which develops the concept of “negative emissions”
- Application of carbonation and calcination as one of the 2<sup>nd</sup> generation CCS technologies to most take into account
- COMET: The first study to analyze the techno-economic feasibility of integrating CO<sub>2</sub> transport and storage infrastructures in the West Mediterranean area, Spain, Portugal and Morocco.
- Hontomin: one of the first facilities to use low-cost prospective mining techniques.
- Boosting uses of CO<sub>2</sub>: direct uses; chemical/energy applications; biological applications



# CCS initiatives in Spain

## CCS projects in Spain: CO<sub>2</sub> Capture



### Pre-Combustion: IGCC pilot plant of ELCOGAS (\*)

- The **14 MWt pilot plant** in an existing IGCC of **Puertollano** (Pre-Combustion technology) was settled in 2010.
- Mandatory Characterization Tests were fully accomplished. These tests included capture efficiency and costs.



### Oxy-Combustion: OXYCFB300

- A CCS integrated project supported by the **PEER Program**: one of the 6 selected CCS demonstration projects by the European Commission (EC) for the construction of capture plants in Europe in 2009.
- The construction of a **circulating fluidized bed plant with integrated transport and storage (30 MW)** ended in 2010. This project was supported by Endesa, CIUDEN and Foster Wheeler.
- CIUDEN is now developing different projects as ECCSEL and looking for other ways to maintain their infrastructures.



CIUDEN's Technology Development Centre for CO<sub>2</sub> Capture (es.CO<sub>2</sub>)

# CCS initiatives in Spain

## CCS projects in Spain: CO<sub>2</sub> Capture



### Post-combustion: La Pereda

- Settled in Mieres (Asturias), La Pereda is a **demonstration Post-Combustion Capture plant which works with a carbonation-calcination technology process (1.7 MW)**. Business'partners are Endesa, Hunosa and CSIC.
- Several projects have been developed in this plant:
  - CaOLing, a 3 years project to develop and demonstrate post-combustion calcium looping in a pilot-scale unit which is fully integrated with a power plant
  - CaO<sub>2</sub> & ReCal, 2 projects related to the Research Fund for Coal and Steel Programme (RFCS)
  - ECOCAL, Economic optimization of carbon sequestration, improving the terms for limestone supply and taking into account other pollutants which intervene in the process



### Carbonation and calcination: La Robla

- A **300 kWt plant with a carbonation/calcination process**. The plant is connected to a 655 MWe coal power plant call La Robla, property of Gas Natural Fenosa.
- This plant develops the “negative emissions” concept and was built thanks to CENIT CO<sub>2</sub>.





# CCS initiatives in Spain

## CCS projects in Spain: CO<sub>2</sub> Transportation



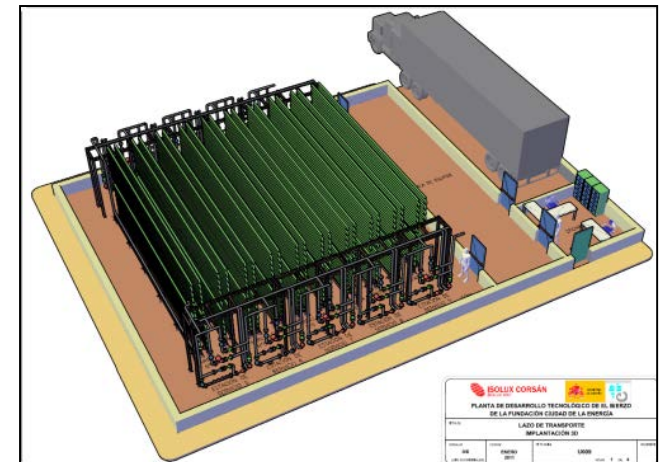
### COMET

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- The study take into account **several factors**:
  - Spatial data.
  - Terrain factors.
  - Cluster delimitation.
  - Least cost routes.



### Transport test rig of CIUDEN

- This facility can operate with CO<sub>2</sub> captured from the CPU (Compression and Purification Unit) or operate with commercial CO<sub>2</sub>, which **can be doped to simulate CO<sub>2</sub> captured** from pre, post or oxy-combustion, or NG combustion.
- CIUDEN's CO<sub>2</sub> Transport Test Rig has a semi-industrial size, 3km. This infrastructure will allow testing the effects on pipeline performance of the following parameters: CO<sub>2</sub> composition, materials behaviour and process performance (corrosion, pressure and temperature changes, pressure drops in pipelines and accessories, etc).



# CCS initiatives in Spain

## CCS projects in Spain: CO<sub>2</sub> Storage



### Pilot plant and R&D Lab (Hontomín)

- CIUDEN built a new experimental plant in Hontomín (Burgos). This plant was built to a **real geological scale with three computing potholes**. A lab for characterization and geochemistry with rocks has been launched too.

Hontomín. CIUDEN



### Map of available geologic storage in Spain (IGME)

- The Institute of Geology and Mineral Exploration of Spain (IGME) has realized a first work selecting available geologic storage in Spain with other firms. IGME has identified **103 onshore available storages** keeping in mind to continue the study offshore.

PISCO2's general view. CIUDEN



### PISCO2

- The PISCO2 project starts its operational phase with 12 cells (16m<sup>2</sup> each). **The cells are equipped with systems for controlled CO<sub>2</sub> injection** at different depths and devices for sampling groundwater and gases (CO<sub>2</sub>, CH<sub>4</sub>, O<sub>2</sub>).

### CARBOLAB

- HUNOSA started a **pilot project in coal caps**.



# CCS initiatives in Spain

## CCS projects in Spain: Uses of CO<sub>2</sub>



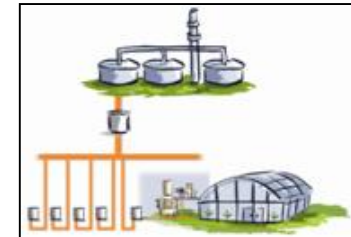
### CENIT SOST-CO<sub>2</sub>

- This project develops new processes for industrial uses, including the manufacture of new materials, food preservation, water treatment, biofuel synthesis, the conversion of CO<sub>2</sub> into value-added products (artificial photosynthesis, electrochemical reduction) and biomass growth (algae).
- It was led by Air Products and technically coordinated by MATGAS.



### CO<sub>2</sub>FUNNELS

- The project tries to prove the possibility of CO<sub>2</sub> capture through carbon fertilization energy crops, obtaining biomass, which in turn can be used to produce energy. Coordinated by Repsol, members are the CSIC, the National Center for Biotechnology, Institute of Molecular and Cell Biology of Plants and CIEMAT. It is settled in Puertollano Refinery.



### CENIT BIOSOS

- Objectives:
  - To develop technologies for designing integrated biorefinery concepts, combining energy production and bioproducts.
  - To face the mission of covering the entire value chain of biomass resource from generation to final products market.
  - To use the CO<sub>2</sub> in the growth of biomass and its transformation.







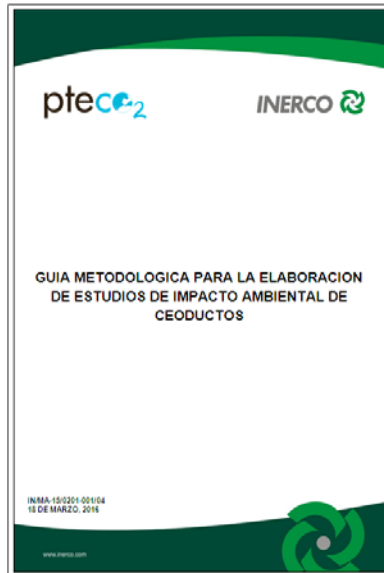
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# PTECO2's studies

## Methodological guide for environmental impact study on CO2 transportation



- Some of the actions related to CO2 transportation have different levels of impact as the environmental value of the area where the CO2 pipeline will run. It should be noted that the Spanish territory is home to a large number of protected environmental legislation due to environmental values that have spaces.
- The guide aims to:
  - Accurately define the technical to be included in such studies details.
  - Identify significant environmental aspects that should be evaluated.
  - Establish criteria for how these should be evaluated.
  - Propose objective evidence that define corrective measures.
  - Propose the technical criteria for defining how to monitor environmental effects during construction and operation of the facility.

- This study aims at the establishment of uniform criteria for the preparation of environmental impact studies of CO2 pipelines they are able to comply with the provisions of the Spanish 21/2013 Law, environmental assessment.

# PTECO2's studies

## Public perception on CCS

- The purpose of this study is to characterize the attitude of public to CCS technology and, specifically, to estimate indicators, examine attitudinal differences and identify differences in perception.
- Some of the main conclusions:
  - Reactions before receiving information:
    - The level of familiarity with the problem of climate change can be considered half
    - There is a low level of familiarity with CCS, only 14%
    - The initial attitude to CCS is positive, 62%
  - Reactions after receiving technical information:
    - The usefulness in reducing emissions and the possibility to use local coal are the main perceived benefits. However, cost increasing, need of new pipelines and possible negative effects on the environment are the main negative consequences.
    - CCS technologies receive an average overall evaluation of 3.10 on a scale of 1 to 5 so it is considered an appropriate technological option for addressing climate change.





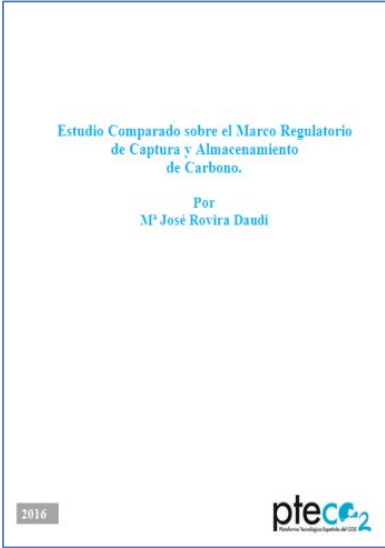



# PTECO2's studies



## CCS regulatory compared

- In this study will analyze in a comparative way the different legal regimes capture, transport and storage of carbon that have adopted certain elected or countries belonging to our environment (European Union ) or outside the scope of EU state maturation of the regulation of any activity of the CAC.

- 
- Some of the main conclusions:
    - Transport activity is the least developed by the regulations of the countries covered by this study.
    - At EU level, Directive 2009/31/EC provides ample technical detail but the application of national laws are really different with extreme examples as Romania.
    - Outside EU, Australia, Canada and the US, have preferred to amend existing legislation on hydrocarbons, mining and groundwater respectively but CCS.
    - These regulations considerer the pre existing or potential effects on the area in which the storage place uses, promoting the formalization of private agreements.

- 
- European standards are characterized by the Administration recognize arbitral powers to solve issues that may arise in areas where they attend various titles or rights.



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# Some recommendations

## Some questions from our perspective for the European level:

- **NER-300 didn't include some key industries for projects of scaling-up CCS**

To ensure that these industries are included in the **NER 300+ and the Fund of Innovation** with the aim that allows this route of CCUS development in Europe.

- **Network for transport and storage**

While capture seems to be clearly responsibility of emitting facilities, transportation and storage should be considered as so-called singular scientific and technical infrastructures (ICTS) to be developed under public or private-public partnerships. We recommend **re-evaluating all the situation of these areas in Europe** under this approach to ensure that the whole frame is on time for the application of CCUS, taking into account the worldwide progress of these technologies. It would also be necessary to strengthen ICTS for the purposes for which they were created. Taking into account this approach; consider the application of some European instruments such the Structural Funds to this new infrastructure.

- **Industrial first-of-a-kind European technology CCUS projects**

**To allocate public funds** for covering the difference between CO<sub>2</sub> market prices (or CO<sub>2</sub> commercial CCUS cost after FOAK project) and CO<sub>2</sub> real cost of CCUS during the technical amortization of the CCUS FOAK European technology project, in such a way that competitiveness of the emitting facility is not hurt.

- **Support of CO<sub>2</sub> usage**

To support **specific lines for technological development in new potential areas of massive usage of CO<sub>2</sub>**, such solar fuels (liquid and gas), construction new materials and chemical products.





# Thank you for your attention!

Contact us here:



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