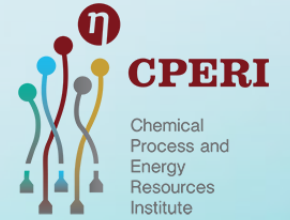


CERTH
CENTRE FOR
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HELLAS



Session V: Energy Efficiency and Hydrogen

Hydrogen & CCUS projects in Greece

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Athens, Greece
2024

Introduction – H₂ projects & current trends

European Projects

- ❖ The interest of the **private sector** and **public bodies** has shifted towards **hydrogen** and the potential for the development of its value chain due to:
 - the **potential** of hydrogen as an **energy source**.
 - its **ability** to be **stored** in order to **satisfy energy requirements** during high-demand periods.
- ❖ In recent years, an increasing number of **partnerships** have been established to **develop the various stages of the hydrogen value chain** through the **implementation of projects**.

- ❖ Some **H₂ projects** in Europe are:



H₂ geological storage



H₂ geological storage in porous formations



green H₂ geological storage in salt caverns



green H₂ generation using solar power and storage in salt caverns

Existing technologies and infrastructure for the implementation of CCUS and H₂ technologies in Greece include:

- 1. Infrastructure for CO₂ capture** in industry (cement, iron and steel industries) and in lignite plants (e.g. Ptolemaida V plant).
- 2. Infrastructure for CO₂ and H₂ transportation**, e.g. gas pipeline systems, ports & railways.
- 3. Geological storage sites for CO₂ and H₂.**

Hydrogen projects in Greece (1)

➤ HyStorIES - Hydrogen Storage In European Subsurface



- **Main focus:** possibilities of **H₂ geological storage** in porous reservoirs of the European subsurface, especially **aquifers** and **depleted hydrocarbon fields**.
- The project provided technical solutions for the effective and operational implementation of underground H₂ storage (UHS).
- These solutions were accompanied by socio-economic analyses.
- *Project duration:* 01/01/2021 to 30/06/2023.
- *Funded by:* the European Union via HORIZON 2020 (Fuel Cells and Hydrogen 2 Joint Undertaking – now Clean Hydrogen Partnership) under G.A. 01007176 EC.

*G.A. = Grant Agreement

Hydrogen projects in Greece (2)

➤ White Dragon – Important Project of Common European Interest HYDROGEN (IPCEI)

- **Main focus:** “White Dragon” project will use large-scale **renewable electricity** (GW) for the **production of green hydrogen by electrolysis in Western Macedonia**. It will include (a) **short-term (direct) H₂ storage** and (b) **indirect H₂ storage (streaming through DESFA’s natural gas pipeline)**.
- **Aim:** The gradual replacement of the lignite power plants of West Macedonia aiming to the de-carbonization of the country and the transition to clean energy.
- The renewable hydrogen that will be injected into the pipelines will be around 253,000 tons/year. Through high temperature fuel cells it will provide electricity to the grid.
- It will include **co-generation unit of green energy and heat** (as a by-product of green electricity production for complementary uses).

White Dragon key elements	
Hydrogen production:	250,000 tons / year
Hydrogen for other uses:	58,000 to 71,000 tons / year
Saving CO ₂ :	11.5 million tons / year
Job creation	18,000 direct jobs / 29,500 indirect jobs
Project duration	2022 – 2029 (R&D, FID and EET phases)
Investment cost	8.063 billion €

Hydrogen projects in Greece (3)

➤ Green HiPo – Complementary to White Dragon project

- **Main focus:** the development, design, and manufacturing of HT-PEM fuel cells for the heat and energy generation. The project is expected to take place mainly in Western Macedonia,
- **Aim:** The **transition** from a coal-based economy to a **green, decarbonised model**. It is a **complementary project to White Dragon** and will produce the fuel cells that **will power White Dragon's green energy plan**.
- The electricity and heat provided by Advent's fuel cells will be integral for Greece's energy transition as the country plans to decommission all coal-fired power plants by 2028. The facility in Western Macedonia will be home to the production of fuel cells and will contribute to the economic development of the region.

Green HiPo key elements	
initial fuel cells capacity	15kW/units
2 nd stage fuel cells capacity	120kW/units
3 rd stage fuel cells capacity	1MW scale single units
Final stage fuel cells capacity	multi-MW platform
Job creation	approximately 1,400 jobs in innovative sustainable technology

Hydrogen projects in Greece (4)

➤ CRAVE-H2 – Crete Aegea Hydrogen Valley of Crete

- **Main focus:** development and operation of hydrogen technologies in the island of Crete and creation of a hydrogen valley, in order to reduce the use of fossil resources.
- CRAVE-H2 covers all the steps of the **H₂ value chain: production** (securing dedicated renewable electricity production from the 582 MW Aigaio project), high-pressure **storage**, and **dissemination** to a hydrogen filling station and other off-takers.
- Safe use of H₂ on a large scale with **social and environmental impact** on the local community. It will provide **employment opportunities, environmental and health benefits** for the island of Crete.
- Challenges: to **design, permit, build, operate & trade H₂** for the first large-scale **commercial** hydrogen application in Greece.

CRAVE-H2 main assets:

1. Creation of the 1st Green Hydrogen hub in Greece at the Atherinolakos Area
2. Initiating the off-take for green electricity imports from the GAP Interconnector
3. Alkaline Electrolyser with maximum production of 500 tons/year H₂
4. PEM Fuel Cell: 0.4 MWel, which will consume 100 tons of H₂ and act as powerful daily/weekly energy storage tool
5. Hydrogen buses and additional transportation vehicles
6. Re-use of water produced from the FC to partially cover the electrolyser requirements and increase circularity
7. All required AC/DC rectifier and DC/AC converters
8. Study of potential further H₂ uses in power plants, industry and maritime applications

Hydrogen projects in Greece (5)

➤ Hydrogen Innovation Hub – H2HUB

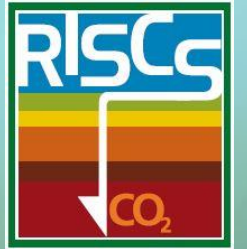
- **Main focus:** the independent research and the development of pilot-scale applications of hydrogen technologies including **H₂ production, storage and utilization** in Greece and South-Eastern Europe.
- **Further objective:** the utilization of research results (R&D) to contribute to strengthening the competitiveness of these regions.
- As part of the research project, the H2-HUB includes a **Pilot Unit for the production of Green H₂ and its applications**.

Research actions that will be developed:

1. Evaluation of energy flows, energy consumption of facilities
2. Creation of **basic pilot unit operation scenarios**
3. Determination of **optimal pilot unit operation scenario**
4. **Optimization** of the installations' automation for **better energy management** and more **effective response to emergency security incidents**
5. Evaluation of the energy efficiency of electrolytes, batteries, H₂ injection in a transport pipe, fuel cells of different sizes with the aim of choosing the best technology for each case.

CCUS projects in Greece (1)

Project Title	Start Date	End Date	Description
UCG & CO2 STORAGE - Study of deep underground coal gasification and the permanent storage of CO2 in the affected areas	01-07-10	31-12-12	Evaluation of the potential of deep lying coal seams for UCG and CO ₂ storage via using the same boreholes with technical modifications for CO ₂ injection. Study of factors determining the technical, environmental, and economic feasibility of the scheme. Study areas: Dobrudzha Coal Deposit (Bulgaria), Florina Basin (Greece), El Tremedal (Spain)
RISCS - Research into Impacts and Safety in CO2 Storage	01-01-10	31-12-13	Evaluation of the potential environmental impacts of CO ₂ leakage from geological storage sites. Assessed the probable impacts on groundwater resources and the impacts of leaks on near surface ecosystems, onshore and offshore. RISCS informed policy makers, politicians and the general public of the feasibility, long-term benefits and consequences of large-scale CCS deployment.
THALES - Geomechanics and environment of CO2 geological Storage	2012	2015	
R&Dialogue - Research and Civil Society Dialogue towards a low-carbon society	01-06-12	30-11-15	Promotion of collaboration between R&D organisations (RDOs) and civil society organisations (CSOs) for a shared vision on the development of renewable energies and CCS, to develop dialogue and joint learning.
ECCSEL - European Carbon Dioxide Capture and Storage Laboratory Infrastructure	01-09-15	31-08-17	Aim & Outcome: to make accessible ECCSEL as a distributed research infrastructure system for European CCUS. ECCSEL gained recognition as a non-profit organisation and a central pivot for the coordinated operation of multiple research facilities .



R&Dialogue



CCUS projects in Greece (2)

Project Title	Start Date	End Date	Description
COALBYPRO - Innovative management of COAL BY-PROducts leading also to CO ₂ emissions reduction	01-07-17	30-09-20	Industrial and laboratory research for the mineral sequestration of CO ₂ in fly ash and zeolites produced from it. Assessment of the possibility of utilisation of post-sequestration products. Outcome: the minimization of the influence of hard coal combustion processes on the environment, and the environmental management of coal mines following their closure.
STRATEGY CCUS - Strategic planning of regions and territories in Europe for low-carbon	01-05-19	30-04-22	Involvement of promising regions across Southern and Eastern Europe that corresponds to 45% of the European CO ₂ emissions from the industry and energy sectors, in order to elaborate strategic plans for CCUS development at short (<3 years), medium (3-10 years) and long term (>10 years).
LEILAC2 - Low emissions intensity lime and cement 2: demonstration scale	01-04-20	31-03-25	Pilot a new technology that captures CO ₂ emissions of the European cement and lime industries. The project seeks to scale-up to ~20% of a typical cement plant's CO ₂ emissions. For this purpose, a demonstration plant alongside an operational cement plant in Europe will be built, capturing 100ktpa of CO ₂ .
PilotSTRATEGY - CO ₂ Geological Pilots in Strategic Territories	01-05-21	30-04-26	Understanding further the deep saline aquifers as means of CO ₂ storage in five European industrial regions in Southern and Eastern Europe. The new data that will be acquired will increase the maturity and confidence level of understanding a deep saline aquifer.
ConsenCUS - CarbOn Neutral cluSters through Electricity-based iNnovations in Capture, Utilisation and Storage	01-05-21	30-04-25	Delivery of an industrial plan for a net-zero carbon EU via the utilization of 3 electricity-based innovations: carbon capture based on alkali absorption, methods for conversion of CO ₂ to formate and formic acids for market uses and finally a safe cyclic loading system of CO ₂ into salt formations and aquifers for storage purposes.



Current trends in Greece and EU

What is going on in EU now:

- The general shift to renewables and decarbonisation solutions of the EU
- The increasing H₂ and CCUS applications
- The creation of H₂ & CCUS hubs in EU

Gives a positive motion towards H₂ & CCUS in Greece:

- ✓ Encouragement of the Greek government to set helping Regulations & Policies.
- ✓ Project initiatives for H₂ and CCUS applications in Greece.

However, Greece:

- ❖ Needs to **update its Regulations & Policies** in order to **align with the EU Regulations &** actively participate in more H₂ & CCUS activities & projects



**Thank you for
your attention**