

Accelerating CCS Technologies



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“CCUS in Greece: potential, development and status”

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RIS3 : Research & Innovation for Smart Specialization Strategy

Priority for 8 domains

- ❑ A place-based strategy that focuses efforts on specific Sectors and Activities resulting from the analysis of the characteristics of the economy with a view to transforming the Sector
- ❑ It uses the Entrepreneurial Discovery Process with a wide involvement of Businesses, Research Centers, Academia, National, Regional and Local Authorities, Civil Society etc.
- ❑ It is applicable at National and Regional level

- **ENERGY**
- **ENVIRONMENT & SUSTAINABLE DEVELOPMENT**
- **TRANSPORT & LOGISTICS**
- **HEALTH & PHARMACEUTICALS**
- **INFORMATION & COMMUNICATION TECHNOLOGIES**
- **AGRI-FOOD & FOOD INDUSTRY**
- **MATERIALS & CONSTRUCTIONS**
- **TOURISM, CULTURE & CREATIVE INDUSTRIES**

Specific topics concerning fossil based energy technologies

- 7.7.1 Effective technologies for converting CO₂ to chemicals / fuels. Enhancement of technology availability, allowing periodic operation, cost reduction, and the integration of products in the chemical industry, ability to operate in areas with low carbon emission profile and integration with RES.
- 7.7.2 Flexible and efficient fossil fuel based power plants. (a) Flexible power production systems; (b) Energy storage systems.
- 7.7.3 Reduce the CO₂ footprint of energy intensive industries either with CO₂ capture systems or by process intensification. Change of production schemes, CO₂ capture with provision for use / storage. Measures to avoid carbon leakage.
- 7.7.4 Innovative processes for intensifying the use of fossil fuels. Changing production schemes, new processes, maximizing the yield of added-value products , Utilizing heavy oil cuts for synthesis gas production ,etc.



ENERGY : Collaborative PROPOSALS BY INTERVENTION AREA

• 7.1 Energy Efficiency	46
• 7.2 Energy from Renewable Sources	36
• 7.3 Energy and the Agricultural Env.	22
• 7.4 Energy Storage	21
• 7.5 Hydrogen Technology	8
• 7.6 Smart Grids Technology	32
• 7.7 Focil Fuels	19
TOTAL proposals (first call)	184
Approved projects	42
 TOTAL proposals (second call)	 172

Specific CCS/U topics on National Funding Scheme (ΕΔΚ)

	Received proposals A	Received proposals B	Total
7.7	12	19	31
7.7.4	4	9	13
7.7.1 (CCU)	4	7	11
7.7.2	3	2	5
7.7.3 (CCS)	1	1	2
7.5	10	8	18

Power Production

Energy intensive industries

- Iron and Steel industry
- Aluminum industry
- Cement Industry
- Calcination processes
- Oil refineries – Petroleum Industry





CO₂ amine based : Orfeas Unit



PUBLIC POWER CORPORATION S.A.

Megalopolis IV – PPC
Μεγαλόπολη

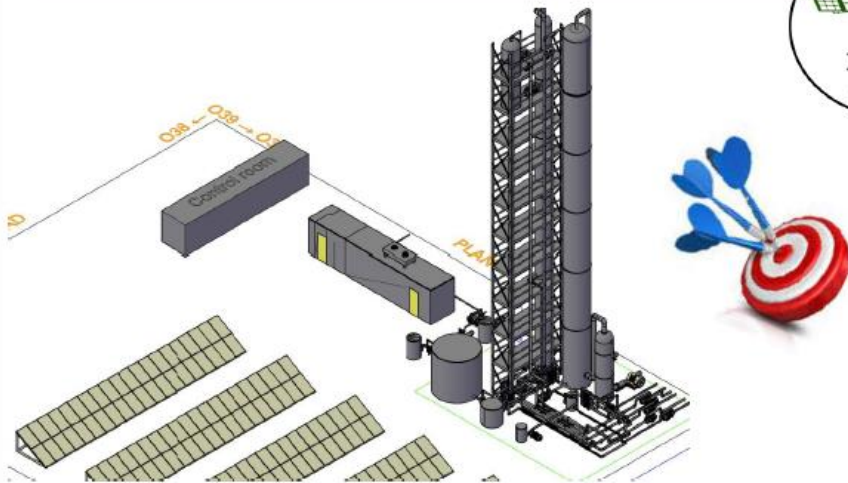
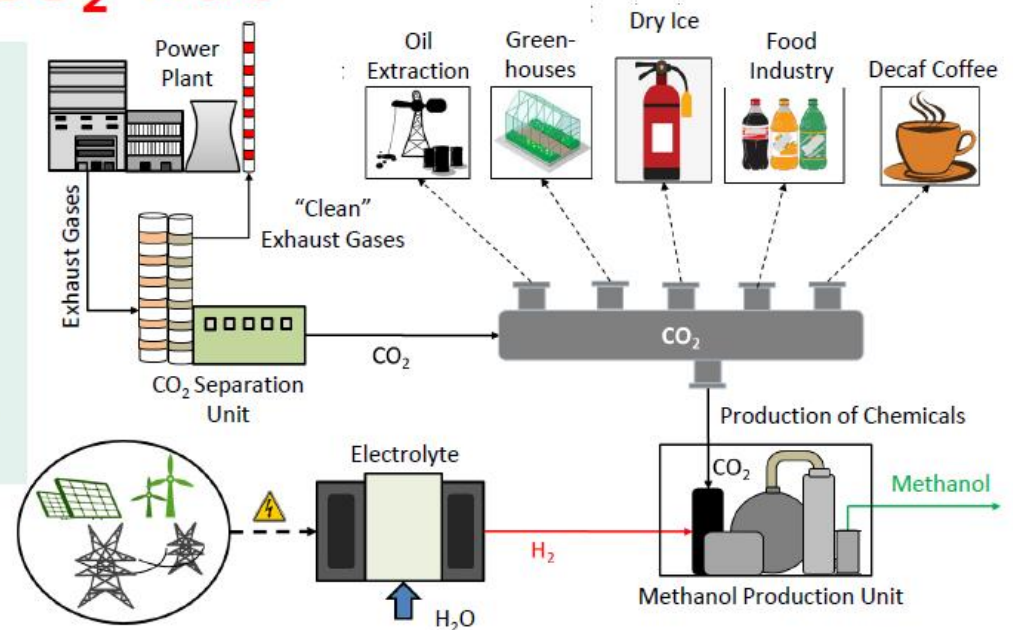
5000 Nm³/h. Capture 20t/day CO₂



CO₂ Sequestration and Utilization by Lignite-fired Power Plants

CO₂-Hub

- ❑ Installation of a pilot CO₂ sequestration and reuse unit next to Agios Dimitrios Power Plant (DEI SA).
- ❑ Appropriate CO₂ purity for **numerous applications**.
- ❑ CO₂ node (CO₂-Hub) in Western Macedonia.
- ❑ Reduction of greenhouse gas (GHG) emissions from power plants – development of a novel value chain.
- ❑ Demonstration of CO₂ utilization **through the production of methanol using H₂** that will be produced in an electrolyte unit.



Project objectives:

1. Demonstration of the CO₂ sequestration technology with cost reduction by **<25 €/tone**
2. Effective (> 90%) CO₂ sequestration
3. **Sequestration of 5500 tones CO₂/year.**
4. Production of high purity methanol from CO₂ and H₂.
5. Technical-economic and environmental assessment of the CO₂ sequestration and recovery technology



Representative power plant CCS projects



Πρόγραμμα / Αρχή	Τίτλος Έργου	Διάρκεια
EC DG Research / FP7	Research into Impacts and Safety in CO ₂ Storage (IMPACT)	01.01.10 - 31.12.13
EC DG Research / RFCS	Methane recovery and harnessing for energy and chemical uses at coal mine sites (METHENERGY)	01.07.17 - 30.06.20
Horizon 2020 - Research & Innovation Actions (RIA)	European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL INFRADEV)	01.09.15 - 31.08.17
EC DG Research / RFCS	Enhanced Coal Exploitation through UCG Implementation in European Lignite Mines (COAL2GAS)	01.07.14 - 30.06.17
EC DG Research / RFCS	Study of Deep Underground Coal Gasification and the Permanent Storage of CO ₂ in the Affected Areas (UCG-CO₂)	01.07.10 - 30.06.13
ERANET-COFUND	Accelerating CCS technologies as a new low-carbon energy vector (ACT)	01.02.16 - 31.01.21
FP7-SCIENCE-IN-SOCIETY-2011-1	Research and Civil Society Dialogue towards a low-carbon society (R&Dialogue)	01.01.12 - 30.11.15
EC DG Research / RFCS	Innovative Management of COAL BY - PROducts leading also to CO ₂ emissions reduction (COALBYPRO)	01.07.17 - 30.06.20
HORIZON 2020	STRATEGY CCUS - STRATEGIC PLANNING OF REGIONS AND TERRITORIES IN EUROPE FOR LOW-CARBON	01.05.18 – 29.04.2022



Petroleum Industry

MOH :

energy efficiency improvement investment program with innovative technologies (electricity, steam, gas, oven upgrades, Advanced Process Control, Power Management System Predictive Maintenance, etc.), continuously improving open annual CO₂ emissions and energy consumption

Carmof project H2020 - <https://carmof.eu/>

New process for efficient CO₂ capture by innovative adsorbents based on modified carbon nanotubes and MOF materials.

Helpe :

Investments in the development of renewable energy generation,
Research support for the development of next generation biofuels,
Increase efficiency with digital transformation applications

Cement industry – Production of CaO / MgO – Non metallic minerals

HIGH-TEMPERATURE PROCESSING

INDUSTRY	TEMPERATURE	GHG EMISSIONS	
		FUELS COMBUSTION	PROCESS EMISSIONS CO ₂
CEMENT	1500 °C	CO ₂ NOX	From the Decomposition of Carbonates in the Raw Materials
LIME	1100-1200 °C		
MAGNESIA (DBM) SINTERED DOLIME	>1800 °C		
CERAMICS	1200-2000 °C		
GLASS	1400 °C		Mainly from C as Reducing Agent
STEEL	1600 °C		



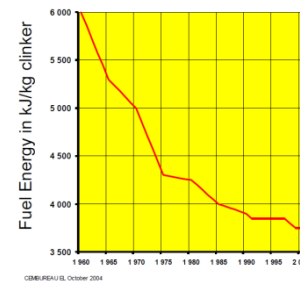
ROTARY KILN



GLASS FURNACE

Cement Industry - Overall Target

Fuel energy demand of clinker burning (as a global weighted yearly average) may decrease from 3,690 MJ/t clinker in 2006 to a level of 3,300 to 3,400 MJ/t clinker in 2030 and to 3200 to 3,300 MJ/t clinker in 2050.



CEM/AREA/IL, October 2004

Cement industry – Production of CaO / MgO – Non metallic minerals

PRIORITY 1 : Use of waste as substitutes for fossil fuels and raw materials in the EU cement industry – co-processing

- **Thermal energy needs constitute more than two thirds of the overall energy consumed in the cement industry.**

PRIORITY 2 – Cross sectoral Reduce Electricity loads

Priority 3 – Cross sectoral Waste heat recovery in the cement industry

Priority 4 - Cross sectoral - Carbon capture and storage (CCS) and carbon capture and use (CCU) in the cement industry

Some indicative projects

ANICA: Advanced Indirectly Heated Carbonate Looping Process Partners: TUDA, FAU Erlangen, ESTRA, VDZ, CERTH and ULSTER, Dyckerhoff, Calix, LHOIST, **CaO-Hellas**, TKIS, SUEZ Budget Total: 3,150,227 €

AC²OCem: Accelerating Carbon Capture using Oxyfuel technology in Cement production Partners: USTUTT, VDZ, SINTEF, CERTH and NTNU, HeidelbergCement, **LafargeHolcim** and **TITAN**, TKIS, Air Liquide Budget Total: 3,712,547 €

ROLINCAP - H2020 - <http://www.rolincap-project.eu/> (**CaoHellas**)

"Systematic Design and Testing of Advanced Rotating Packed Bed Processes and Phase-Change Solvents for Intensified Post-Combustion CO₂ Capture (ROLINCAP)", H2020-LCE-2016-2017/H2020-LCE-2016-RES-CCS-RIA (2016-2019)

Carmof project H2020 - <https://carmof.eu/> (**MoH, Titan**)

New process for efficient CO₂ capture by innovative adsorbents based on modified carbon nanotubes and MOF materials.

Some indicative projects

Nanocap – (Grecian Magnesite – CaoHellas) – ΕΔΚ - <http://nanocap.cperi.certh.gr/>

"Design and experimental assessment of innovative processes for CO₂ capture and use in industrial production of carbonated salts (NANOCAP)", GSRT, T1EDK-02472 (2018-2021)

CO₂FUELS - "Scaling-up of electrochemically supported catalytic hydrogenation of CO₂ to fuels (CO₂FUELS)", T1EDK-01631 (2018-2021)

NANOCO₂ στο πλαίσιο του ΕΔΚ (<http://nanoco2.tuc.gr/>) – (PPC)

"BIOCON-CO₂: <http://www.biocon-co2.eu> (NTUA)

BIOtechnological processes based on microbial platforms for the CONversion of CO₂ from the ironsteel industry into commodities for chemicals and plastics"

ReCO₂DE project – Spire H2020 - <https://www.recodeh2020.eu/> (Titan)

Recycling carbon dioxide in the cement industry to produce added-value additives: a step towards a CO₂ circular economy

Conclusions

- Cement and calcination processes Industry
- Oil Refinery
- CCU is gaining greater interest
- Power production – older focus on coal lignite must be transformed into NG based CCS/U
- A lot of primary research on advanced CCU

Thank you for your attention!

