



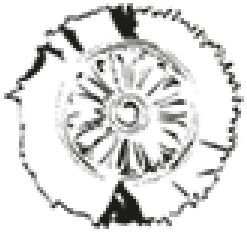
Hydrogen facilities and current EU Hydrogen projects

Dr Georgia Kastrinaki
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Thessaloniki, Greece



CERTH
CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

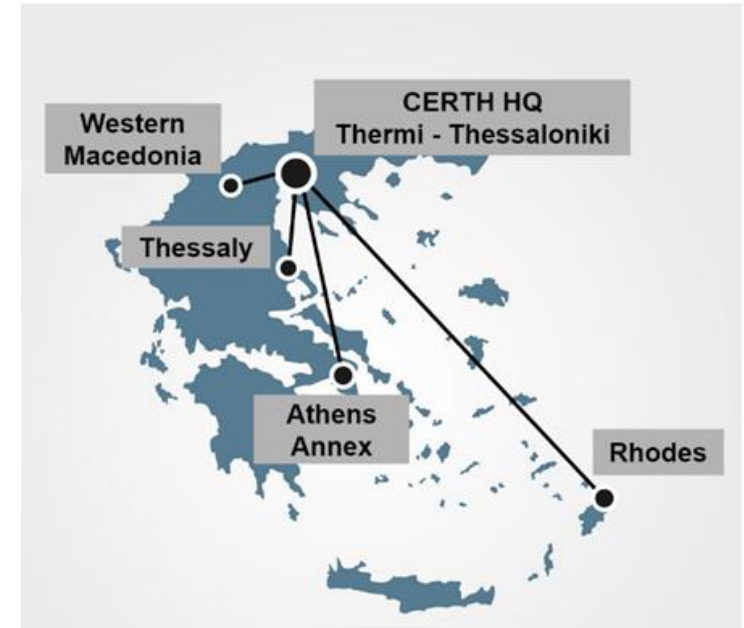




CERTH

CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

- Founding year: 2000
- 5 Institutes
- 1200+ employees (258 experienced researchers)
- Budget 45 M€ in 2021 (11% state funding, 75% European & National research projects, 14% industrial contracts)
- 18 spin-offs



Area of CERTH
Main Campus
44,000 m²

Institutes Area:
20,000 m²



H₂ research at CERTH



- More than 30 projects on hydrogen related technologies
- Thermochemical **Concentrated Solar Power** Hydrogen production
- Reactor ceramic **material design** and **validation for CSP and biogas reforming**
- **Simulation** tools for Hydrogen storage in porous media of pipelines
- **Membrane** technology for **H₂ recovery**
- **H₂ production and storage** testing facilities (up to 100 kW_e), **H₂ storage** integration on demonstration site & **hydrogen valley** opportunities

Demo and pilot plant infrastructure

Fuel cell-based H₂ energy storage solutions



Demonstrate technical and economic feasibility of two fuel cells-based H₂ energy storage solutions (integrated P2P system; non-integrated P2G+G2P system), deployed in 3 DEMOs (Greece, Norway and Gran Canaria), based on renewables, in isolated micro-grid or off grid remote areas.

Hydrogen production and storage facility at Agistro, Northern Greece.
Fuel cell 25kW, Electrolyzer 50 kW.

GA 779541



Solar Thermochemical Technology Projects

HYDROSOL I & II
(2002-2008)



Hydrogen via thermochemical water splitting



Redox coated ceramic monoliths

Partner DLR-Germany



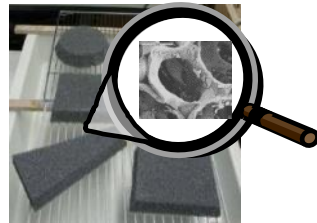
Solar water splitting reactor

Solar Hydrogen

SOLREF
(2004-2007)



Hydrogen via natural gas reforming



Catalytic ceramic foams

Partner WIS-Israel



Natural gas solar reforming reactor

Solar CH₄ Reformer

SOLHYCARB
(2006-2010)

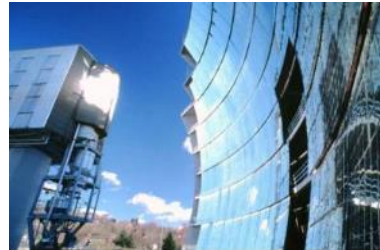


Hydrogen via natural gas cracking (together with carbon black nanoparticles)



Ceramic particulate filters

Partner PROMES-France



Solar cracking reactor and Carbon black filter

CH₄ Solar Cracking

HYDROSOL 3D
(2010-2013)



Scale Up of Thermochemical Hydrogen Production in a Solar Monolithic Reactor: a 3rd Generation Design Study



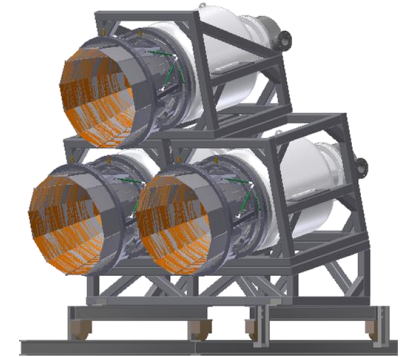
HYDROSOL plant design

Solar H₂ Plant Design

HYDROSOL-PLANT
(2014-2017)



Thermochemical hydrogen production in a solar monolithic reactor: construction & operation of a 750 kW_{th} plant



HYDROSOL plant construction

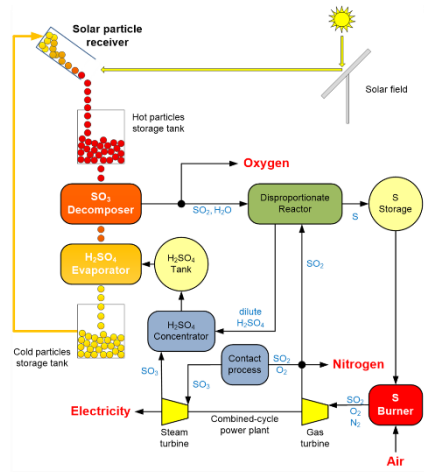
Scaling-up of HYDROSOL technology

Solar Thermochemical Technology Projects

PEGASUS
(2016-2021)



Renewable Power Generation by Solar Particle Receiver Driven Sulphur Storage Cycle



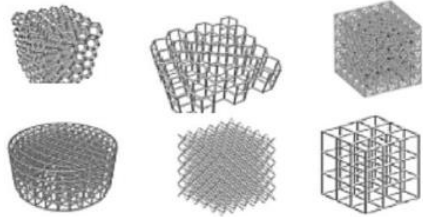
Storage of Solar Energy In Elemental Sulfur

Thermal Storage of Solar Energy

HYDROSOL-beyond
(2019-2022)



Thermochemical HYDROgen production in a SOLar structured reactor: facing the challenges and beyond



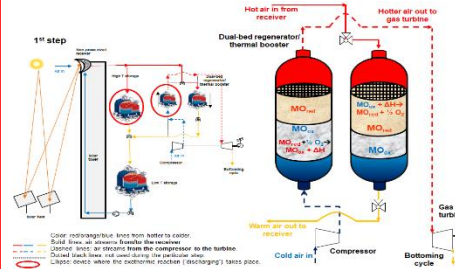
Moving beyond conventional structuring techniques

Continuation of HYDROSOL Technology

ABraytCSPfuture
(2022-2025)



Air-Brayton cycle Concentrated Solar Power future plants via redox oxides Based structured thermochemical heat exchangers/thermal boosters



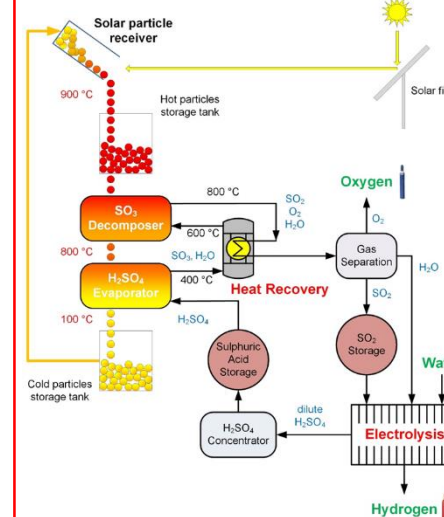
Thermochemical energy storage through redox cycles

Solar TC Energy Storage

HySelect
(2023-2026)



Efficient water splitting via a flexible solar-powered Hybrid thermochemical-Sulphur dioxide depolarized Electrolysis Cycle

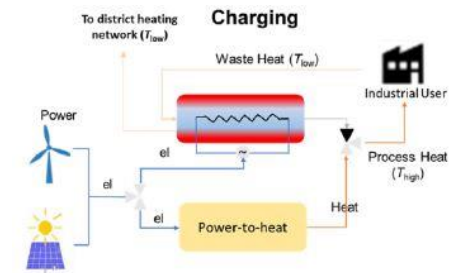


HyS scheme for H₂ Production

H₂ Production Through TC Sulphur Cycle

HERCULES
(2023-2027)

High-Temperature Thermochemical Heat Storage Powered by Renewable Electricity for Industrial Heating Applications



Novel Thermochemical Heat Storage Concept

TCS Through Renewable Electricity

Technology and Infrastructure

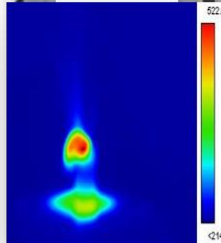
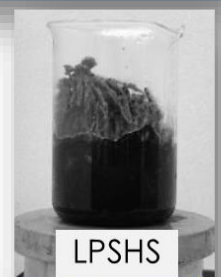
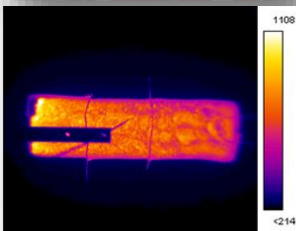
Material Synthesis

- Paste formulations
- Shaping by extrusion, pressing, casting
- Variety of shapes & forms, including honeycombs

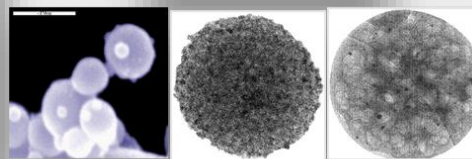
Solid State Synthesis (SSS)



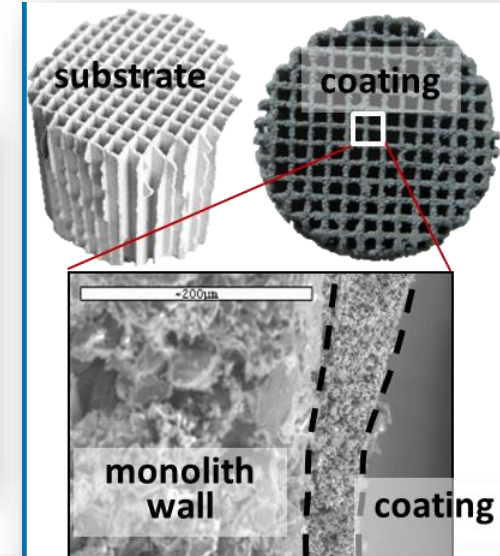
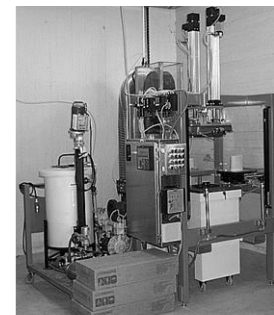
Self-propagating High-temperature Synthesis (SHS)



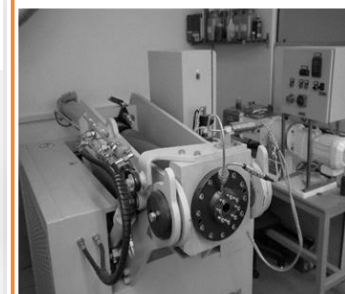
Aerosol Spray Pyrolysis (ASP)



Conventional Coating



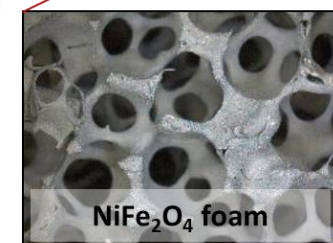
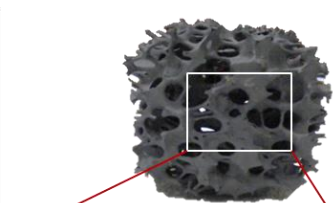
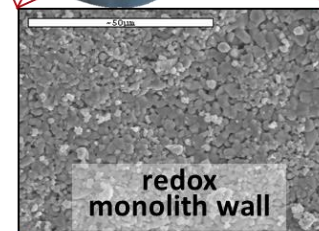
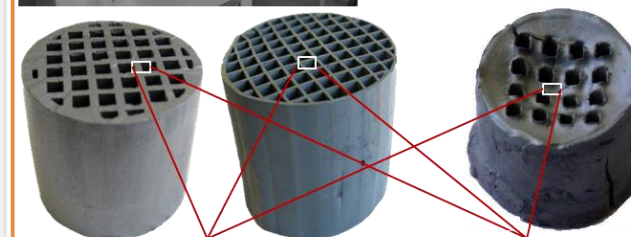
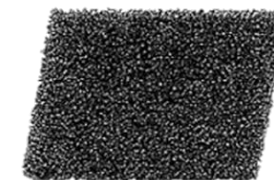
Extruded



Cast

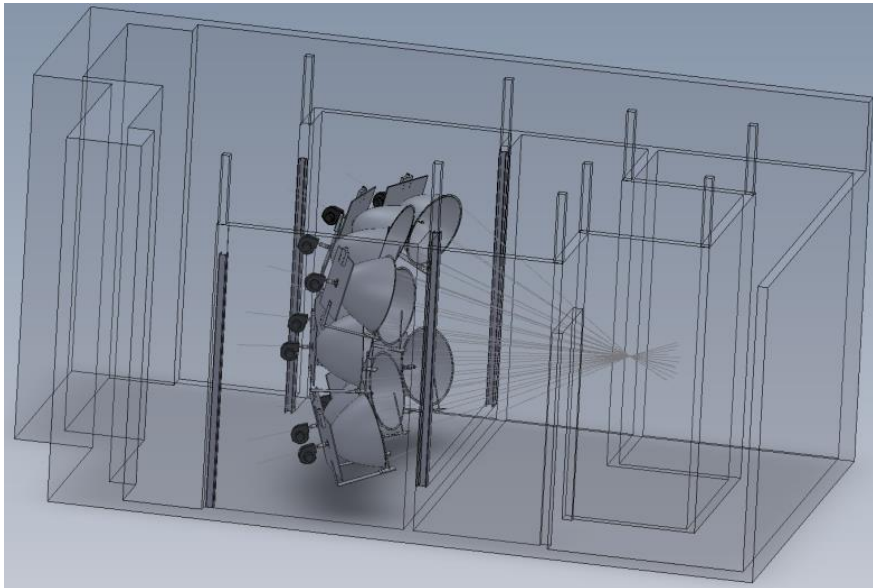
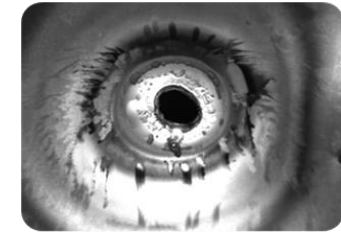
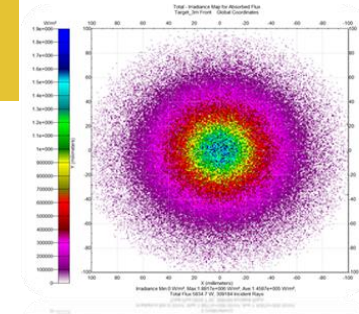
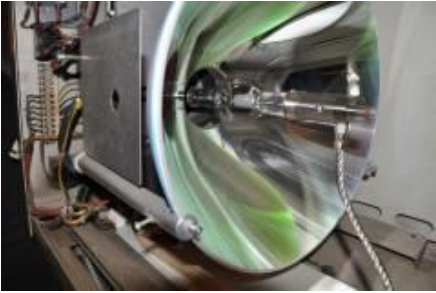


Foam



Solar Thermochemical Technology Infrastructure

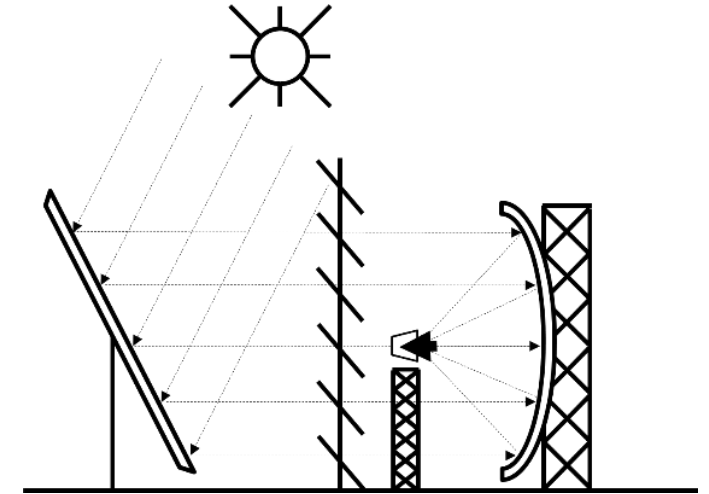
Indoor High-Flux Solar Simulator



- Solar-like Concentrated Radiation
- Novel research for **solar chemistry, solar fuels & solar receiver designs**
- Accelerated **aging** of materials, material properties, **thermal shocks**

Solar Thermochemical Technologies Infrastructure

Field large scale solar dish

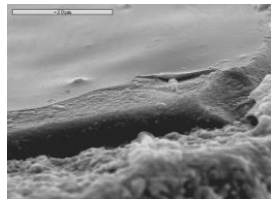
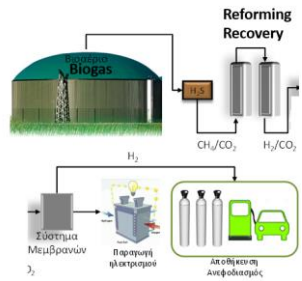


- Platform for testing **solar chemistry** related receiver-reactors & materials
- First of its kind in Greece
- Nominal power: **50 kW**

H₂ related Projects

PUREHy (2020-2024)

Development of a biogas reformer using stand-alone membrane systems for the production and recovery of high

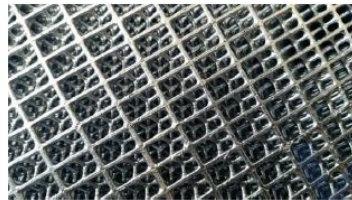
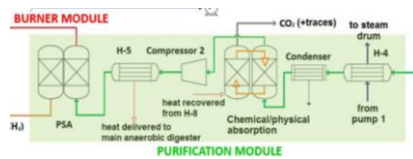


Membrane technology for H₂ recovery

Biogas reforming

BioRobur plus (2017-2022)

Advanced direct biogas fuel processor for robust and cost-effective decentralized hydrogen production



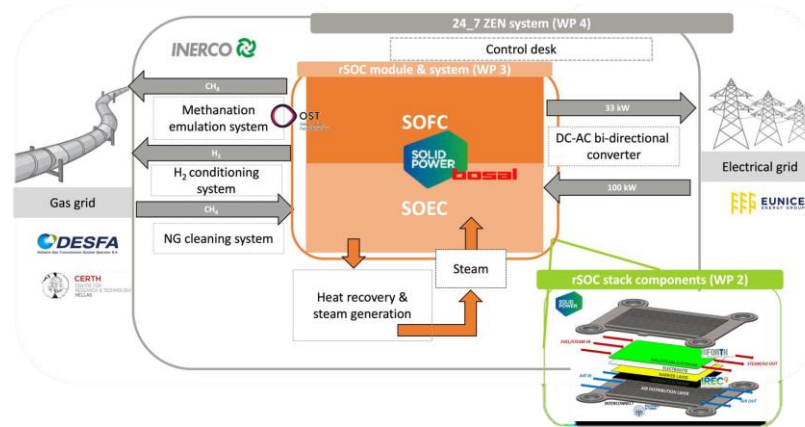
Structured cellular ceramics for increased heat recovery

Biogas reforming

24/7 ZEN (2023-2026)



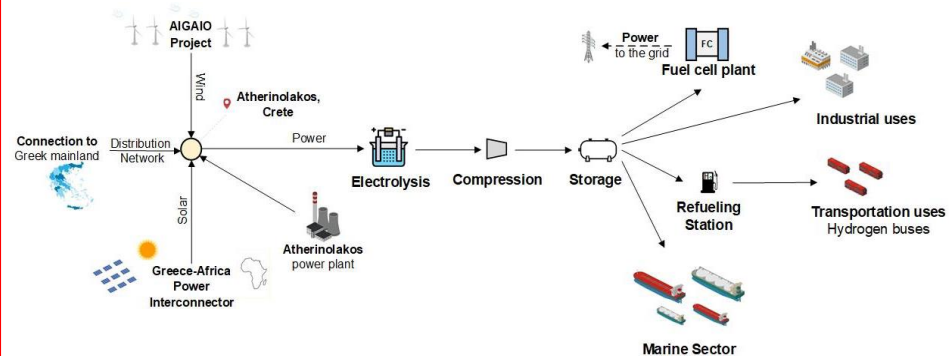
Reversible SOEC/SOFC System for a zero emissions network energy system



Efficient routes of Power to Gas to Power

CRAVE-H₂ (2023-2026)

Hydrogen Valley Project



Contribution to current calls

Waste to Hydrogen demonstration plant

TOPIC ID: HORIZON-JTI-CLEANH2-2023-01-05



Development of a Mobile system for processing and energy exploitation of recovered industrial materials, Bioliquids, biological resources, waste/rejections utilizing Solar thermochemical technology

- **Largest solar liquefaction pilot plant**

Poravou et al, *Valorization of Plastic Waste: A Lab-Scale Approach with the Aid of Solar Hydrothermal Liquefaction Technology*, Waste Biomass Valorization 13 (2022) 3835-3844.

Tsongidis et al, *Valorization of organic waste with the aid of solar hydrothermal liquefaction technology*, AIP Conf Proc 2303 (2020) 170015.



Simulation and Modelling of porous materials and MOFs for Hydrogen Storage

Contribution to current calls

Large-scale demonstration of underground hydrogen storage

TOPIC ID: HORIZON-JTI-CLEANH2-2023-02-01

Hydrogen use by an industrial cluster via a local pipeline network

TOPIC ID: HORIZON-JTI-CLEANH2-2023-01-07

- **Simulation tools** on optimization studies elaborating on the detailed transportation cost function elements and pathways
- **Technoeconomic analysis** of the spanning routes identified for the H₂ carrier under consideration and the H₂ superstructure optimization
- **MINLP* generic model**, development and solution exploiting previously developed methodology and software tools, incorporating novel approaches and adjusting to each H₂ carrier's properties and features of an optimal H₂ supply chain network.

*Mixed integer non-linear programming problems

Tsongidis et al, *Transportation and solar-aided utilization of CO₂: Technoeconomic analysis of spanning routes of CO₂ conversion to solar fuels*, J. CO₂ Util. 30 (2019) 142-157.

Lemontzoglou et al, *Analysis of CO₂ transport including impurities for the optimization of point-to-point pipeline networks for integration into future solar fuel plants*, Int. J. Greenh. Gas Con. 66 (2017) 10-24.

Pantoleonos et al, *Development of transportation cost functions and optimization of transportation networks for solar-aided utilization of CO₂*, Int. J. Greenh. Gas Con. 112 (2021) 103528.

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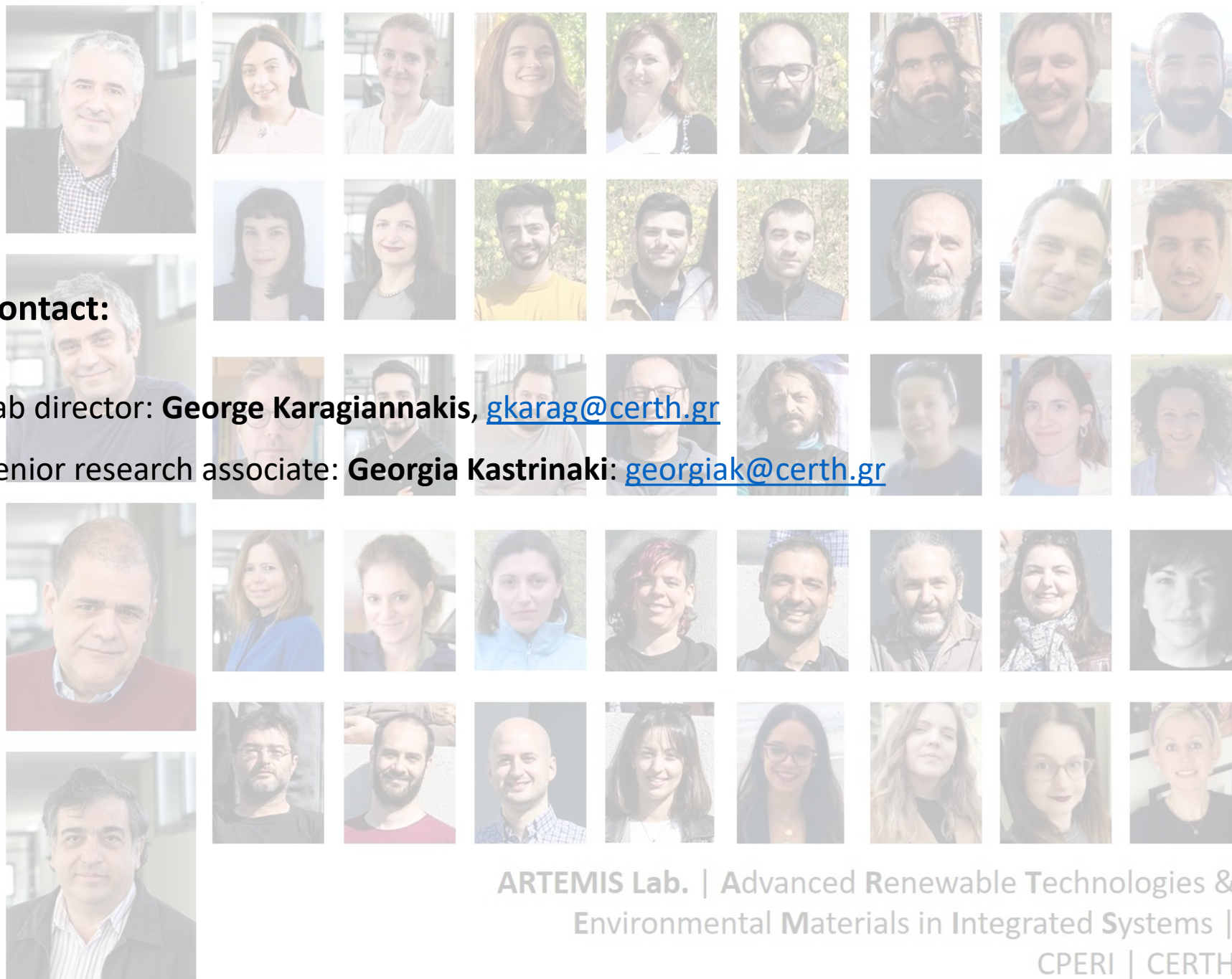


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