



MemCCSea

Innovative membrane systems
for CO₂ capture and storage at sea

Deliverable D6.7

Workshop on Project's final achievements

WP6. Coordination, management and dissemination

Final Version

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Revision History

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<i>Evdokia Gkagkari (CERTH)</i>	<i>Draft deliverable (version 0.1)</i>	<i>20-10-2022</i>
<i>Akrivi Asimakopoulou (CERTH)</i>	<i>Final version</i>	<i>27-10-2022</i>
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1 Introduction

The maritime transport sector contributes significantly to the global anthropogenic release of gaseous and particulate pollutants. According to recent studies, exhaust emissions from ships contribute to 15% of global nitrogen oxide (NO_x) emissions and 3-7% of the corresponding sulfur oxide (SO_x) emissions. The shipping industry also contributes significantly to greenhouse gas (GHG) emissions. Currently 3% of the total global GHG emissions are attributed to the shipping industry and this share is expected to increase by 20 - 50% by 2050. As the shipping sector is growing rapidly - with Greek shipping playing a leading role – there is a tantamount need for strict measures to contain the environmental impact. In this context, both the European Union (EU) and the International Maritime Organization (IMO), through the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), have introduced stringent emission regulations.

The MemCCSea project is among the very few projects world-wide that aim to develop hyper-compact membrane systems for post-combustion CO₂ capture specifically designed and optimized for the maritime sector and define strategies for its integration in the ship powerplant (marinization). The developed membrane technology, incorporating advanced seawater based solvents and innovative membrane materials (ceramic, polymeric, graphenic), displays significant advantages over conventional scrubber technologies, such as substantially higher efficiency and reduced volume, issues that are crucial in the shipping industry. The MemCCSea technology aims for a 10 times smaller volume and 25% lower costs than conventional scrubbing systems with a recovery of more than 90% of the main engine CO₂ emissions.

MemCCSea is funded by the EU through the ACT (Accelerating CCS Technologies) ERANET program and is a consortium of leading universities, research centers and industrial partners from Europe and the USA under the coordination of CERTH. Consortium members include Fraunhofer-IKTS (Germany), NTNU (Norway), NETL/DoE (USA), DNV (Greece) and DBI-GUT (Germany). The leading shipping company EURONAV also participates as an associate consortium member. The project commenced in November 2019 and finishes in October 2022.

The MemCCSea project fittingly concluded with a dissemination and networking event which aimed to present the key project results in a wider audience while providing a forum for discussion in the general frame of shipping industry decarbonization. The event “Opportunities and Challenges for the Decarbonization of the Maritime Sector” aimed to bring together ship owners, classification societies, technology providers, marine engineers, policymakers and consisted of concise presentations of the MemCCSea technology and its marinization potential by project partners, followed by two round table discussions aiming to provide an expert forum for discussing the technical, environmental, financial and societal implications of integrating CCS and other decarbonization technologies in the shipping sector. The event was held in the Stavros Niarchos Foundation Cultural Centre in Athens on Friday 14 October 2022.

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2 Agenda of the final meeting of the MemCCSea project

Below is the agenda of the final meeting of MemCCSea project in Table 1.

Table 1. Agenda of the final MemCCSea meeting

Friday 14 October 2022, 12:00 – 17:30 Book Castle Stavros Niarchos Foundation Cultural Centre		
12:00 – 13:00	Light Lunch	
13:00 – 13:15	Welcome	Dr George Skevis (CERTH)
13:15 – 13:30	The ACT Initiative: A successful funding scheme for CCUS projects	Dr Ragnhild Ronneberg (RCN, ACT Coordinator)
13:30 – 13:50	The MemCCSea Project: An overview	Dr Akrivi Asimakopoulou (CERTH)
13:50 – 14:10	Membrane-based Carbon Capture and Storage	Dr Dimitrios Koutsonikolas (CERTH)
14:10 – 14:30	Innovative Membrane Materials for Onboard CCS	Dr David Hopkinson (NETL)
14:30 – 14:50	Membrane CCS Marinization and Onboard Integration	Dr Chara Georgopoulou (DNV)
14:50 – 15:30	Coffee Break	
15:30 – 16:30	Panel 1 Decarbonizing Shipping: Technologies	
	Dr George Dimopoulos, <i>Head, Maritime Advisory Greece</i>	DNV
	Mr Konstantinos Bougiouris, <i>Projects & Energy Performance Manager</i>	EURONAV
	Mr Konstantinos Karathanos, <i>Chief Operating Officer</i>	GasLog
	Dr Leonidas Ntziachristos, <i>Professor, Mechanical Engineering Department</i>	AUTH
	Mr Antonios Trakakis, <i>Technical Director, Marine</i>	RINA
	Mr Panos Yannoulis, <i>President</i>	Oceanking
16:30 – 17:30	Panel 2 Decarbonizing Shipping: Logistics, Policy & the Environment	
	Dr George Skevis, <i>Principal Researcher, CPERI</i>	CERTH
	Dr Evangelos Gerasopoulos, <i>Research Director, IERSD</i>	NOA
	Mr Constantinos Papalucas, <i>Energy Expert, Coordinator</i>	National Hydrogen Committee
	Dr Ragnhild Ronneberg, <i>ACT Coordinator</i>	RCN, ACT
	Prof Dr-Ing Orestis Schinas, <i>Partner</i>	HHXBlue
	Mr Dimitrios Spyrou, <i>Strategic Development and Marketing Department</i>	Piraeus Port Authority
17:30	Closure & Farewell Drink	

At first, Dr. Skevis addressed greetings and marked the start of the event. The subjects that presented were “The ACT Initiative: A successful funding scheme for CCUS projects” (Dr. Ragnhild Ronneberg from RCN, ACT Coordinator), “The MemCCSea Project: An overview” (Dr. Akrivi Asimakopoulou from CERTH), “Membrane-based Carbon Capture and Storage” (Dr. Dimitrios Koutsonikolas from CERTH), “Innovative Membrane Materials for Onboard CCS (Dr. David Hopkinson from NETL) and “Membrane CCS Marinization

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and Onboard Integration” (Dr Chara Georgopoulou from DNV). Then, a discussion followed, by the existence of two panels and public participation.

3 Speakers’ and panellists’ CVs

Below are the biographies of the speakers in the order in which they made their presentations and the CVs of the panel participants follow.


3.1 Dr. George Skevis

Dr. George Skevis is a Principal Researcher at the Chemical Process and Energy Resources Institute of the Centre for Research and Technology Hellas (CERTH) where he is leading a Research Group on Carbon Circular Economy. He holds a Bachelor's Degree (BEng, First Class Honors) in Mechanical Engineering from Imperial College London, a Master's Degree in Mechanical Engineering from Stanford University and a Ph.D. in combustion chemistry from Imperial College London. He is a Visiting Professor in the Agricultural University of Athens and the International Hellenic University.

His expertise lies in the science and technology of conventional and alternative fuels combustion and the mitigation of its adverse environmental effects, including carbon capture utilization and storage. Dr Skevis has more than 120 publications in archive journals and international conference proceedings and a long experience in managing multinational R&D projects as well as providing consulting services to the industrial, transportation and agricultural sectors. He is the Vice-Chair of the EU SMARTCATS Network on Smart Energy Carriers and serves in the Board of the Federation of the European Sections of the Combustion Institute.



Figure 1. Dr. George Skevis

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3.2 Dr. Ragnhild Ronneberg

Ragnhild has her PhD in biochemistry (1985) and has held several positions as manager within pharma, food and biotech industries in Norway. In 2001 she joined the Research Council of Norway (RCN) and has since been lead for national and international funding programs. Between 2010 and 2014 she was on leave from RCN and worked at the University Centre at Svalbard, and was the coordinator for an EC funded project on research in infrastructures for earth observing systems (SIOS), and at the same time she was the manager for the Longyearbyen CO₂- lab., a national research initiative having a special focus on geological storage of CO₂ and possible capture of CO₂ from the only one coal fired plant in Norway- there in the vulnerable area of the high Arctic. That really kicked off the interest for CCUS as a climate mitigation tool.

Back at RCN in 2014 she was offered the position as lead for establishing a new transnational project for CCUS cofounded by EC. This initiative was named ACT- AcceleratingCCUS- technologies. ACT is a transnational initiative with the aim for funding projects and knowledges having in the CCUS domain. The last years Ragnhild has also had a significant role in the establishment of the new Clean Energy Transition Partnership (CETP) under Horizon Europe, which also has implemented CCUS- technologies as well as Hydrogen & renewable fuels in their calls.

3.3 Dr. Akrivi Asimakopoulou

Dr. Akrivi Asimakopoulou (Chemical Engineering - AUTH 2001, Dr. Chemical Engineering - AUTH 2006) is a fellow Researcher in the Chemical Processes and Energy resources Institute (CPERI) of the Centre for Research and Technology Hellas (CERTH).

She has significant experience in a) the membrane-based physico-chemical processes (liquid-liquid, gas-liquid, gas) design and development; b) membrane-based carbon capture and utilization; c) the design and development of various types of reactors, bioreactors and separators for energy and environmental and medical applications; d) the design and development of ceramic biomaterials, scaffolds and organoids; e) the design, development and evaluation of automotive exhaust after-treatment systems and the relevant health effects studies. She has participated in 25 National & European and Industrial Research Projects. She has been an Affiliated Lecturer, teaching the course of Technoeconomic analysis in Mechanical Engineering Department of University of Western Macedonia and the Chemical Engineering Laboratory in Chemical Engineering Department of University of Western Macedonia and she has been a scientific advisor for more than 5 undergraduate, postgraduate and doctoral theses. She is the main author of 17 full-length publications in reputable scientific journals (8), conference proceedings (8) and book chapters (1) with more than 100 heterocitations.


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Figure 2. Dr. Akrivi Asimakopoulou


3.4 Dr. Dimitris Koutsonikolas

Dr. Dimitrios Koutsonikolas is a Chemical Engineering Diploma from AUTH since 2004 and a PhD on Chemical Engineering from AUTH since 2010. His main field of expertise is on gas separation and reaction processes.

Since 2004 he has worked as an affiliated Researcher in numerous National and European R&D projects in AUTH and CPERI/CERTH (current position), as process engineer for hydroprocessing catalyst testing in C Solutions Ltd, as Scientific advisor for environmental issues in Municipality of Pavlos Melas and as an Affiliated Lecturer, teaching the course of Chemical Plants Design, in Chemical Engineering Department of University of Western Macedonia. He is the main author or co-author of more than 20 publications in international scientific journals and more than 60 publications in national and international congress proceedings. He is also the main author or co-author in 4 book chapters and co-inventor in a Greek and a European patent related to a membrane gas separation technology.



Figure 3. Dr. Dimitrios Koutsonikolas

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3.5 Dr. David Hopkinson

Dr David Hopkinson is currently leading a research portfolio at the National Carbon Capture Center in Wilsonville, Alabama in carbon capture technologies with a diverse team of researchers under his guidance including materials scientists, engineers, atomistic modelers, and systems and economic analysts.

His personal research is focused on materials development, and includes novel concepts for membranes, solvents, and sorbents for gas separations at all stages of development, from concept to synthesis, from laboratory to small pilot scale testing. He holds a B.S and an M.S. from the Georgia Institute of Technology in Mechanical Engineering and a Ph.D. from Virginia Polytechnic Institute and State University also in Mechanical Engineering. He holds numerous patents related to material and separation technologies.



Figure 4. Dr. David Hopkinson

3.6 Dr. Chara Georgopoulou

Dr. Chara Georgopoulou is Senior Engineer at DNV Maritime R&D and Advisory, Greece. She has experience in modelling and simulation of ship machinery systems with focus on decarbonization technologies, fuel cells, hybrid systems and hydrogen.

From 2009 to 2012, Chara was project manager of the DNV Maritime CCS project, co-funded by the Research Council of Norway. Maritime CCS was one of the first studies to assess carbon capture technologies for ships using modelling and simulation of the integrated ship and CCS systems.

Chara is currently project manager for DNV for the EC-funded eSHYIPS project on the definition of new guidelines for an effective introduction of hydrogen in maritime passenger transport sector. She holds a Honors Diploma (Bachelor and M.Sc. equivalent) in Mechanical Engineering and a PhD degree in Mechanical Engineering from the National Technical University of Athens.

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Figure 5. Dr. Chara Georgopoulou

3.7 Dr. George Dimopoulos

Dr. George Dimopoulos is a Principal Specialist in DNV and Head of the Maritime R&D and Advisory unit in Piraeus, Greece. His field of expertise is the modelling and optimization of complex ship machinery systems in all ship segments, including oil tankers, bulk carriers, gas carriers and FSRUs; with aim to improve the overall competitiveness of maritime assets.

He is lead researcher or project manager in various R&D, ship concept design and advisory projects working closely with major international ship owners, yards and manufacturers. He holds a PhD. in Marine Engineering and a Diploma in Naval Architecture and Marine Engineering both from National Technical University of Athens, Greece. George has authored more than 50 peer-reviewed papers in scientific conferences and journals.



Figure 6. Dr. George Dimopoulos

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3.8 Mr. Konstantinos Bougiouris

Konstantinos Bougiouris is a licensed Mechanical Engineer from the National Technical University of Athens. After completing his military service joined Ceres Hellenic as an Apprentice and later as a Third Engineer. In 1997, he became a member of the technical department of the company as Junior Superintendent in a fleet of six ULCCs and in 2000 he joined the New Building department.

In 2001, he and his team built a 160,000 tons dwt Crude Oil Ice class tanker. Till today he has participated in the construction of thirty-five tankers, Suezmaxes (160,000 tons dwt) or VLCCs (300,000 tons dwt). In 2005 he transferred to Euronav Ship Management (Hellas) continuing the construction of new buildings as Project Manager. Except for this title he also was Procurement Manager for a short period while his current title is Projects & Energy Performance Manager.

3.9 Mr. Konstantinos Karathanos

Konstantinos Karathanos was appointed Chief Operating Officer in February 2022, following his last appointment as our Deputy Chief Operating Officer from November 2021. He has also served as the General Manager Innovation and Technology from 2019. He first joined the group in 2000 when it was operating as Ceres Hellenic Shipping Enterprises, Ltd. and from then until 2017, has held several positions during his years within the group of companies such as Fleet Manager, Project & Site Manager and Ship Manager. Prior to re-joining GasLog, he was holding the position of the Technical Manager at Minerva Marine from 2017 to 2019.

Konstantinos has over 20 years of experience in the shipping industry specializing on LNG Carriers design and construction, Technical & Operational management as well as focusing on Energy & Performance with emphasis on the Energy efficiency and Decarbonization of the fleet.

Mr. Karathanos has an Executive MBA from ALBA, The American College of Greece, an MSc in Thermal Power and Fluid Mechanics from the University of Manchester and a B.Eng. in Mechanical Engineering from Manchester Metropolitan University.



Figure 7. Mr. Konstantinos Karathanos

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3.10 Dr. Leonidas Ntziachristos

Leonidas Ntziachristos is Professor of Mechanical Engineering at the Aristotle University Thessaloniki, Greece and Visiting Professor at Tampere University, Finland. His research interests include clean combustion and pollutants formation, exhaust aerosol characterization, environmental sensors and emission models. He is responsible for the development of COPERT software, on behalf of the European Environment Agency and the EU Joint Research Centre.

He co-chairs the transport expert panel of the UNECE Task Force on Emission Inventories and Projections and he is member of the steering committee of the European Research Group on Mobile Emission Sources. He has been consulting the European Commission on a number of regulatory initiatives including Euro-standards for emission control of cars, energy efficiency and CO₂ control technologies. He serves as Associate Editor of Atmospheric Environment: X journal. His teaching duties include pollution control, greenhouse gas control and sustainability courses (ORCID-ID: 0000-0002-5630-9686, 149 papers, h:46, >6100 citations as of Sept 2022).

3.11 Mr. Antonios Trakakis


Antonios Trakakis graduated from the Mechanical Engineering Dept of National Technical University of Athens in 1989 and carried out graduate studies at von Karman Institute for Fluid Dynamics in the field of Turbomachinery.

He started his professional career as Cadet Engineer in 1989 and continued in 1993 as 3rd Engineer. He worked as spare parts operator and Assistant Superintendent Engineer in ANEK Lines from 1994 to 1997 when he joined Superfast Ferries. He became Technical and Environmental Manager in 2000, and in 2006 he joined Kristen Marine and afterwards the newly established Soloi. In 2008 he moved to Hellenic Seaways and in 2010 to Arista Shipping, an emerging company in the bulk carrier sector. In October 2020 he joined RINA as Technical Director Marine, Greece.

3.12 Mr. Panos Yannoulis

Mr. Yannoulis has graduated from the University of Genoa, Italy, in 1970. His post-graduate studies include specialization in advanced structural analysis techniques, welding technology, computer applications in ship design and construction, marketing and management. He has taught Finite Element Analysis, Theory of Plates and Welding Technology at the Ship Design and Technology Dept. of the National Technical University of Athens.

His professional experience covers research, ship design, shipbuilding and project management. During his career, he was in charge, as a designer, project manager or divisional director, of multimillion dollar projects for a variety of ship types, such as cruise vessels, high speed motor yachts, bulk carriers, tankers, reefer vessels, patrol boats, etc. He started his career as research engineer for ship structural analysis at the Italian Ship Research Center (CETENA), Genoa, Italy, then he was designer naval architect

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at Italian and Greek shipyards and since 1985 he covered top technical managerial positions, namely Newbuilding's Manager at Hellenic Shipyards, Skaramanga, Greece and Technical Director at Avlis Shipyards, Chalkis, Greece. He is a member of the Technical Chamber of Greece and the Hellenic Association of Naval Architects & Marine Engineers. Furthermore, he is a fellow member and ex-President of the Hellenic Institute of Marine Technology, as well as ex-President of the International Maritime Association of the Mediterranean (IMAM).

He is author of technical papers in technical publications and presented papers in various international and national conferences and seminars on ship design and/or construction matters.



Figure 8. Mr. Panos Yannoulis

3.13 Dr. Evangelos Gerasopoulos

Dr. Evangelos Gerasopoulos is a Research Director at the Institute for Environmental Research and Sustainable Development of the National Observatory of Athens (NOA). With a background in Environmental Physics he is active in the fields of Earth observation, atmospheric composition, Earth system process and climate, climate change and relevant synergistic interactions, policy and urban perspectives.

He serves as the Director of the Greek GEO Office, represents Greece in the relevant international bodies in the field of Earth observation (i.e GEO, EuroGEOSS) and he is Member of the Special Scientific Committee on Climate Change of the Ministry of Environment and Energy of Greece, among other positions. Since September 2020 he is co-chairing together with UNESCO's World Heritage Center, the Community Activity entitled "Earth Observations for Climate Change Impacts on World Heritage Cities (CCI-WHC)", and since March 2021 he has been elected as co-chair of the GEO Programme Board.

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3.14 Mr. Constantinos Papalucas

Constantinos Papalucas is an Energy Policy/EastMed Specialist. He served as a Senior advisor to the Greek Minister of Environment and Energy and is currently leading the National Hydrogen Committee. He coordinates the Greek participation in the Important Projects of Common European Interest (IPCEIs) on Hydrogen putting the first Greek hydrogen projects in the pipeline. He also led the joint task force between the Greek Ministry and the U.S. Department of Energy that jointly developed a regional CCUS concept in Greece. During his tenure he has landed several world class major energy corporations to assess various upstream and midstream opportunities in Greece and invest in green technology ventures. In the past he served as an Associate at Harvard's Belfer Center and at the U.S. Congress Energy & Commerce Committee.

Upon his return from the United States, Constantinos founded EastMed Energy Hub, an advisory platform that advocates for a regional energy hub in the Eastern Mediterranean through joint infrastructure and investments and that help its partners to grow in the region. He is also a member of the United Nations Group of Gas Experts (UNECE), Group of Experts on CMM and the Task Force of Hydrogen. He has written several Policy Papers and has been a member of the authoring team of the Greek National Energy and Climate Plan. His work has been hosted/featured in mainstream journals and magazines such as the Washington Times, S&P Global Platts, NAPE — Magazine for Dealmakers, Times of Israel, Egypt Oil & Gas, Hipporeads and others.


3.15 Prof. Dr-Ing Orestis Schinas

Orestis Schinas is founding partner of HHX.blue (<https://hhx.blue/>) and Professor of Shipping & Ship Finance and Head of the Maritime Business School at the Hamburg School of Business Administration (HSBA).

His professional career includes large corporate projects, such as IPO and advanced research and business development assignments with a focus on the finance of shipping and related port infrastructure; he has provided his services to private and public entities in Europe, PRC, Africa and the GCC, as well as to international organizations, such as the IMO and the EC. HHX.blue is based in Germany, is active in ship financing and especially in the financing of greening of shipping. Last but not least, Schinas is also the Head of the Delegation of a Member State to the IMO and the IMSO, since 2017.

3.16 Mr. Dimitrios Spyrou

Dimitrios Spyrou is an educated Physicist (AUPh) with an MSc degree in e-Commerce he has been employed at PPA for more than 35 years, most of them in its IT Directorate as System Analyst and Systems Admin. He is specialized in Integrated Information Systems, Project Management in IT systems, BPR and IT Training.

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He is Consultant in the Strategic Development and Marketing department of the Piraeus Port Authority S.A. (PPA) while from 2012 to 2017 he was the head of the Administration Directorate of the PPA. From 2010 to 2015 he was member of the Board of NAFSOLP S.A. (PPA ship repair subsidiary). From 2016 he is the Head of the section for the EU co-funded projects in which PPA participates.



Figure 9. Dimitrios Spyrou

4 Dissemination and promotion activities for the Final Event

The Final dissemination and networking event was organized in Athens on 14/10/2022 on the Opportunities and Challenges for the Decarbonization of the Maritime Sector. The event aimed to present the key project results to a wider audience while providing a forum for discussion on the technical, environmental, financial and societal aspects of integrating CCS and other decarbonization technologies in the shipping sector. The event took place in the Stavros Niarchos Foundation Cultural Centre in Athens and was open to the public. High participation (~100 participants) has been achieved. Dr George Skevis, Principal Researcher in CERTH, Dr Chara Georgopoulou, Senior Engineer - DNV Maritime R&D and Advisory in Greece, Dr Akrivi Asimakopoulou, fellow Researcher in CERTH and Solon Oikonomopoulos, Associate Professor, Department of Chemistry in the Faculty of Natural Sciences -NTNU spoke about the development of new decarbonization technologies, being developed in Greece, which are applicable to the shipping sector. The Interviews are published in maritimes.gr in Greek language. In addition, a radio interview was given by Dr. A. Asimakopoulou (in Greek) in Channel One of Piraeus on the highly impactful results of the MemCCSea project. All related material is available on project's website.

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Figure 10. Snapshots from the MemCCSea Final dissemination and networking event that took place in Athens, Greece on 14/10/2022

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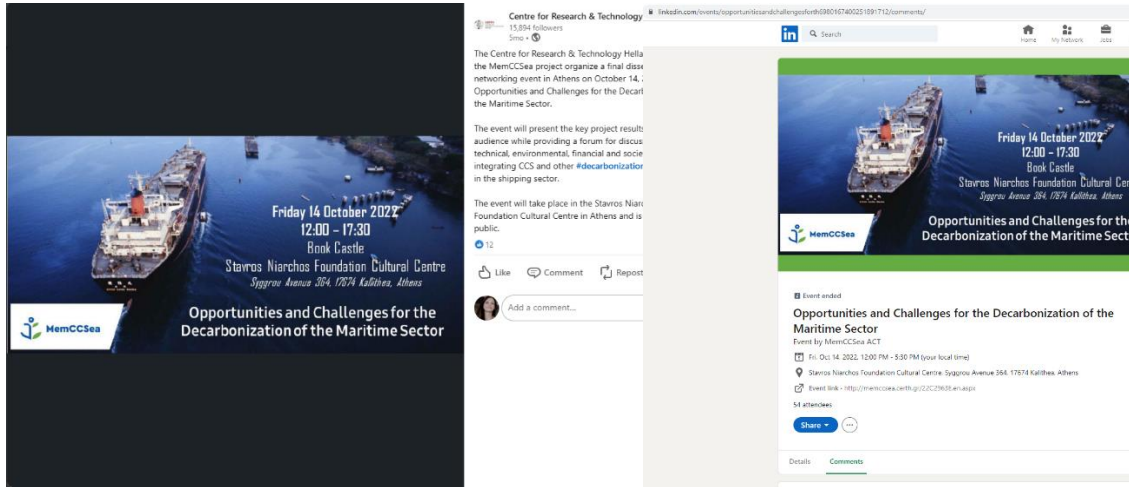


Figure 11. Posts on LinkedIn to the accounts of Centre for Research & Technology Hellas and of MemCCSea project (screenshot at 10-3-2023)



Figure 12. Posts on Facebook by official account CERTH (screenshot at 06-10-2023)



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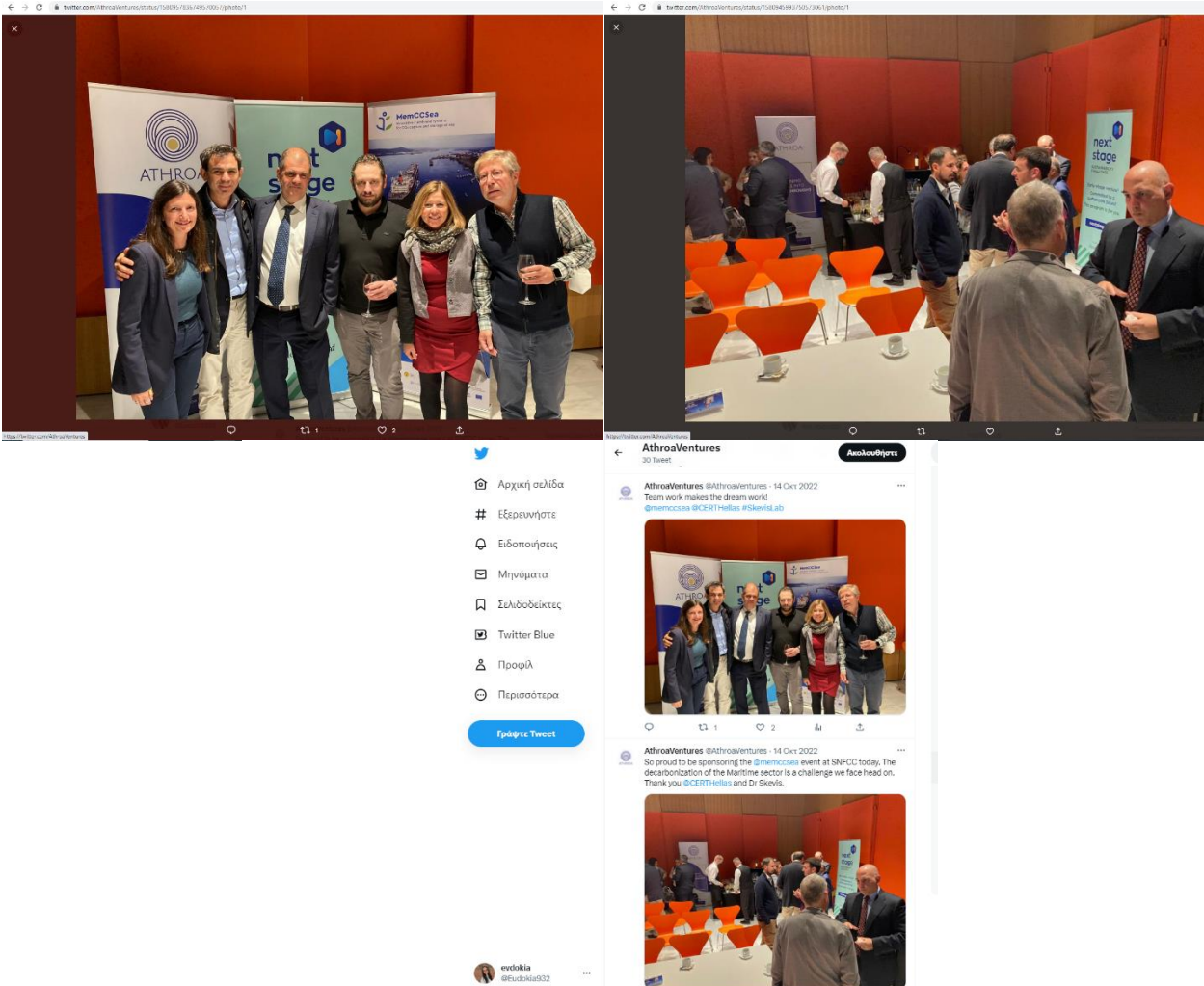


Figure 13. Posts about MemCCSea Final Dissemination Event on Twitter in accounts of other people.