



NanoMaterials Enhanced
Membranes for Carbon Capture



Horizon 2020
European Union Funding
for Research & Innovation

Project acronym: NANOMEMC²

Project full title:

NanoMaterials Enhanced Membranes for Carbon Capture

*Nanomaterial based membranes and processes for improved
pre/post combustion Carbon Capture*



Grant Agreement Number: 727734

Date of approval of Annex I by Research Executive Agency (*final version*): 02.09.2016

Project start date: 01.10.2016

Deliverable D7.1

Title:	
Project Website	
Author(s):	CIAOTECH (PNO)
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Date:	30/12/2016

Dissemination Level: Public

TABLE OF CONTENTS

List of abbreviations and definitions	3
Disclaimer	3
Executive Summary	4
1. Introduction.....	5
2. Web site structure	6
2.1 Home Page.....	7
2.2 ABOUT NANOMEMC ² PROJECT	8
2.3 PARTNERS	13
2.4 NEWS & EVENTS	15
2.5 Section “LINKS”	16
2.6 Section “Contacts”	17
2.7 Section “Private Area”	18

TABLE OF FIGURES

Figure 1a: Header of the website	7
Figure 1b: Footer	7
Figure 2: Home page.....	9
Figure 3: about NANOMEMC ² project.....	13
Figure 3b: about NANOMEMC ² (project objectives)	14
Figure 3c: about NANOMEMC ² project (benefits).....	15
Figure 4a : Partners: Partners name, logo and website	17
Figure 4b: Partners: Description of one partner as example	18
Figure 5: News & Events.....	19
Figure 6: LINKS.....	21
Figure 7: CONTACTS.....	22
Figure 8a: Private area login in	23
Figure 8b: Private area: NANOMEMC ² page on Innovation Place web-platform	24

List of abbreviations and definitions

Abbreviation	Definition
EC	European Commission
EU	European Union
REA	Research Executive Agency
INEA	Innovation and Networks Executive Agency

Disclaimer

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Executive Summary

This document describes the main communication tool provided to the NANOMEMC² Consortium for the widespread diffusion of the project results, the NANOMEMC² website.

Websites allow a better communication process but also facilitates more interaction with potential stakeholders and groups of interest. These days, a website is the main communication tool for any project that wants to present its technology to a wide variety of audience.

The NANOMEMC² project is a research and innovation action of Horizon 2020 funded under the topic LCE-24-2016 “International cooperation with South Korea on new generation high-efficiency capture processes”. It aims at reducing the cost, energy and process limitations which currently make pre and post-combustion CO₂ capture processes non-viable in many industrial applications. Through the development of innovative materials, membranes and membrane processes for CO₂ capture, the project aims to make possible a substantial reduction in energy penalty, a much lower cost and a reduction of CO₂ emissions. This will allow for a radical step change in the deployment of Carbon Capture and Storage (CCS) technologies across EU industry, unleashing its potential for significant CO₂ emissions savings, which are key to reaching European targets for a more sustainable industry. In doing so, the project will seek strong collaboration with Korean counterparts on the basis of a common research path and strategy.

Developed website will comply with main requirements that any website should aim:

- Inform
- Give the possibility to get in touch with developers of the technology
- Share their opinions and give feedback
- Be dynamic so that provided information is updated regularly

Taking into account these requirements, the design was created in order to address the following topics: specific content about the technology, the innovation potential, partners, the description of the project, and the specific parts related to news of interest, how to get in touch with the coordinator, and others. Another important feature is the graphics that have been elaborated to make the website attractive and interesting for any web-surfer. After all, the website should also be a way to catch up the attention of the audience in anything related to CCS technologies and, in more detail, in anything related to membrane based carbon capture systems.

The website is part of the dissemination plan described in WP7 of the NANOMEMC² Project and this document shows its different possibilities.

1. Introduction

This deliverable describes the NANOMEMC² Web Site structure, supported by pictures of the site. The work has been developed by CIAOTECH PNO in collaboration with all partners of the project. When approaching the topic of designing a website layout the first step is to draw a sketch of the content. This was shared with all partners and according to the received feedbacks, a first design was implemented. Given that this website should show the potential of a new technology, the main features have been designed with this in mind. The result of this preliminary work was the preparation of a first draft reviewed by partners and later its publication online to share it with the audience.

The NANOMEMC² Web Site, available at the URL: www.nanomemc2.eu, is the main communication channel developed and used by the consortium. Main goals that the tool will achieve are related to the following bullet points:

- Inform the general public about the aim and objectives of the NANOMEMC² project;
- Update the stakeholders of the field (research centres and overall industries) with information about the project, news, events and downloadable communication materials.
- Ensure adequate presence of the NANOMEMC² project on the web;
- Widespread project's activities and initiatives;
- Facilitate the collaboration between potential users
- Facilitate the uptake of the project outcomes.

Nevertheless, the main aim is to serve as communication channel for the development of the project, follow up of the different phases connected to the reduction of the cost, energy and process limitations which currently make pre and post-combustion CO₂ capture processes non-viable in many industrial applications.

There is no aim for a specific number of people to be reached, so in this case the quantity is not a primary goal. It is much more interesting to have a selective audience with real replication potential than a high number of visitors without any real involvement possibilities. Any shared network with other complementary projects in the framework of the CCS Industries sectors can help to achieve this goal much easier.

The public communication website has been developed within month 3 (as planned in the DoA). The website contains current information about the project, in which project contents are accessible.

2. Web site structure

The website of the project has been developed in English, understanding that this is not only the official language of the project but also the main communication language if the technology wants to reach a wide audience. The NANOMEMC² Web Site will be constantly updated with information and news, to keep people interested and updated about the project progress. The website will also host the NANOMEMC² dissemination material elaborated during the project. Regarding the layout, eight main areas or sections have been considered for the website:

- HOME
- ABOUT NANOMEMC² PROJECT: The Project – Objectives - Benefits
- PARTNERS
- NEWS & EVENTS
- PUBLIC DOCUMENTS
- LINKS
- CONTACT
- PRIVATE AREA

All sections belong to a “**Public area**” and all the contents and the functionalities are accessible to all visitors. However, the “**Private Area**”, is also present, dedicated to project partners, user group and EC officer, where they can share documents and information in dedicated folders. The “Private area” links with the Virtual Collaboration Platform of the project that will be used for internal purposes only.

For a more intuitive usage, the public sections are accessible directly from the main menu; while the private area is accessible from the specific tag at the top of each page.

In the footer and header of each page there are links to access to the other project sections. Additionally, the header includes highly evocative images, based on the concept of the impact of NANOMEMC² on the **environment**, considering that the whole project is focused on CO₂ capture technology. The primary goal is indeed the development of highly efficient and effective processes for the reduction of CO₂ emissions in the atmosphere, to reduce the greenhouse effect and the issues related to climate change. Therefore, the images chosen for the website have the aim of recalling the technologies under development, in terms of novel materials and innovative processes, as well as the scientific progresses, since they all are expected to contribute significantly to the reduction of the carbon footprint of industries and power plants and, in the longer time scale, and also to be capable of mitigating the greenhouse effect and the consequent issues related to climate change.

This strategy will help with the communication part and will attract a higher number of potential representatives from industries connected to the project aims.



Figure 1a: Header of the website

All logos from partners are shown in the footer (Figure 1b). This is an easy way to locate who is involved in the development of the project. Moreover, in the footer the flag of EU and the text stating the funding of the project as Horizon 2020 project appears.



Figure 1b: Footer

2.1 Home Page

The Home Page clearly communicates the site's purpose, and shows all major contents available on the Web Site. The text in the page describes the aims and the potentiality of the project, to provide a clear statement to visitors about the contents of the project. The figure below (Figure 2) shows the home page of NANOMEMC² Web Portal with: the header, the footer, Newsletter and anticipation of the news that make up the body of the page.

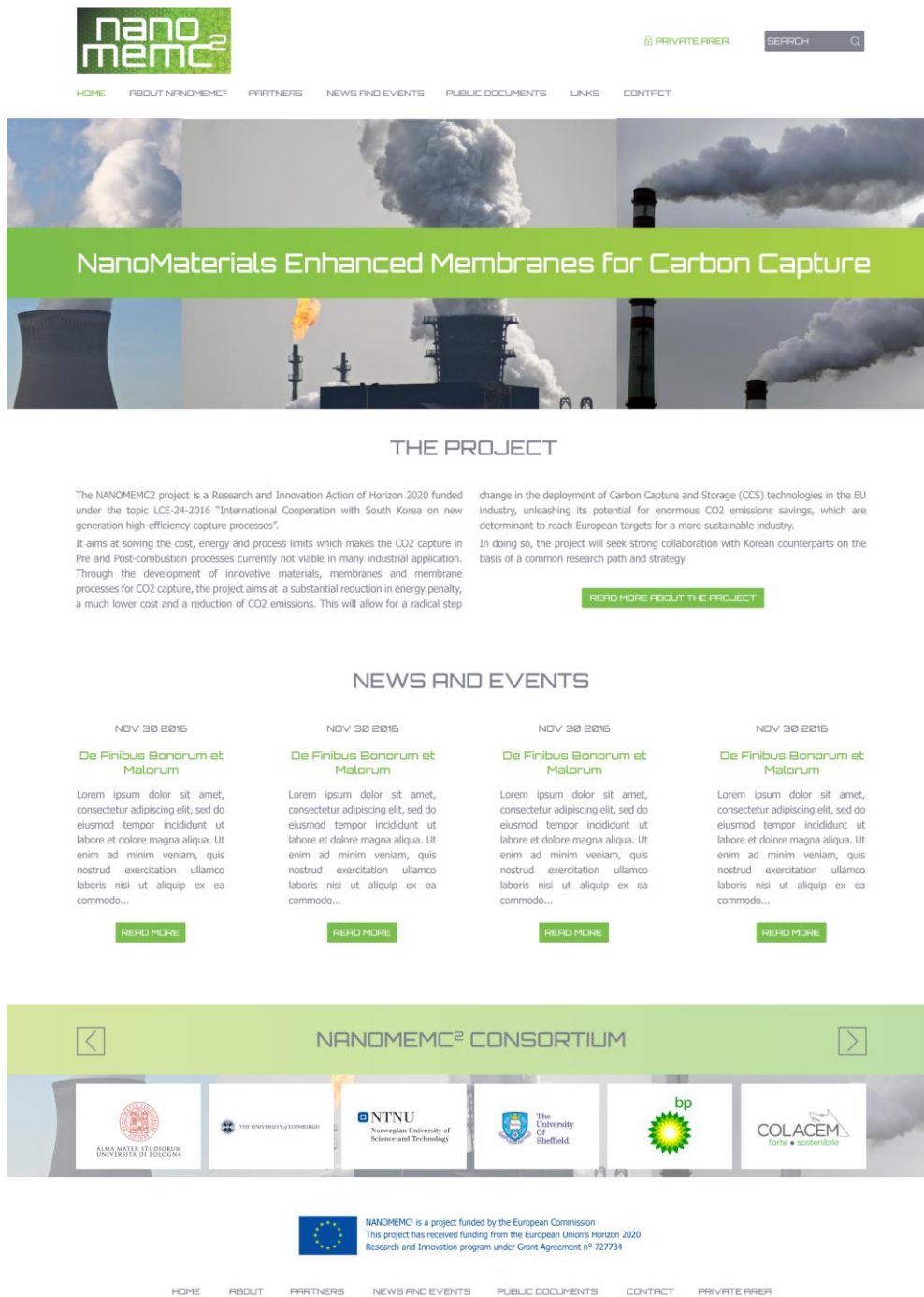


Figure 2: Home page

2.2 ABOUT NANOMEMC² PROJECT

This section includes:

- The **context** of the project, explaining that membrane separation processes can be applied to many CO₂ capture processes from pre-combustion (CO₂-H₂ / CO₂- CH₄ separation) to post-combustion (CO₂-N₂) and oxyfuel (O₂-N₂) and are generally endowed with high flexibility and potentially low operating costs when compared to other capture methods. However the current materials lack the separation performance and durability needed for an efficient and economically feasible exploitation of such technology. The NANOMEMC² project aims to overcome the current limitation by focusing on the development of innovative CO₂ selective

membranes with high flux and selectivity suitable for application to both pre and post-combustion capture processes. To address this objective nano-composite or mixed matrix membranes will be developed with particular focus on facilitated transport mechanisms promoted by carrier attached to the polymer. Graphene based nanoplatelets and cellulose nano-fibres will be studied in detail along with possible modification to improve polymer compatibility and affinity with CO₂. New generations of Facilitated Transport Mixed Matrix (FTMM) and Continuous Phase Mixed Matrix membranes for CCS applications will be developed with increased performance for both pre-combustion and post-combustion capture. Both hydrogen selective (for pre-combustion) and CO₂ selective membranes (for both pre and post combustion) will be developed targeting flux and selectivity beyond the current performance for industrial deployment of carbon capture membrane technologies.

■ A **description** of the project's specific **objectives**:

The general objective of the NANOMEMC² project is to contribute to a real and effective deployment of CCS technologies by reducing the cost and energy penalty of CO₂ capture through the development and optimal integration of innovative membranes for CO₂ separation within different energy intensive industrial processes.

It will be implemented through the attainment of the **scientific NANOMEMC² main goal**: to fully develop the potential of membranes in the selective capture of CO₂ from gaseous emissions, increasing the efficiency of the capture step, and reducing the overall CCS cost below the value of 40€/tonne of CO₂ avoided.

NANOMEMC² will focus on both pre-Combustion and post-combustion strategies thus applying new membranes for separation of CO₂ on both fuels and flue gases. To that aim, both CO₂ selective and hydrogen selective membranes will be considered in the project to increase flexibility thus maximizing the chance of success of the proposed technologies. A novel generation of highly functionalized nano-fillers as well as of novel preparation technologies, able to simultaneously increase permeance and selectivity of the final membranes will be used for the synthesis of advanced hybrid materials. The tunable structure of the nano-particles and a proper functionalization design will allow this new class of nano-material-enhanced hybrid membranes to meet the industrial criteria for a wide deployment of capture process in existing and future energy intensive industrial plants.

NANOMEMC² will also address the development of new, high efficiency capture processes by actively coupling the research for novel membranes with the simulation and techno-economic analysis of different possible schemes for the efficient implementation of the capture step in the industrial plants of interest. This specific objectives will be complemented by the **NANOMEMC² cooperation goal**: to establish a strong cooperation between Europe and the Republic of Korea in the field of CCS in order to exploit complementary expertise and accelerate the progression towards industrial development of CO₂ capture solutions. The project will develop a constant flow of knowledge and information with the Korean partners that is at the forefront of research in terms of membrane technology for CO₂ capture. In line with the strategic approach adopted by the EU in the international cooperation for R&I and as reinforced at the 5th EU-Korea Joint S&T Cooperation Committee in June 2015, the EU and Korea face similar challenges and share many values and concerns. CCS is one of these challenges and thus focusing the collaboration among European and Korean scientists and innovators will provide mutual beneficial.

■ The **benefits** expected from the project:

The NANOMEMC² approach is to address, through process intensification and technological innovation, three of the highest priorities in the EU energy-intensive industry, namely:

- i) **CO₂ emissions reduction (- 35% for basic set up);**
- ii) **Energy penalty (from current 30% of amine absorption down to potential 20% expected)**

iii) Cost competitiveness (at least -20% for both CAPEX and OPEX).

The NANOMEMC² project will have relevant impacts in the EU industry and global markets, by:

- **Contributing to advance the knowledge** on new materials, technologies and processes for cost-efficient and high-performance CO₂ capture. The NANOMEMC² project aims at the development of **next generation** capture processes based on **membrane** gas separation processes and the use of innovative solution for hybrid membranes exploiting **facilitated transport** or **sieving** mechanisms;
- **Build a strong and concrete case for rapid industrial application**, by demonstrating and pre-validating the above innovations for two crucial EU industrial sectors during the project (oil refineries and cement production). Several options will be investigated in term of process flow sheet and the combination of synthesis and characterisation with the modelling at the molecular and process scale.
- Substantially **improving the competitiveness of EU industry**, by lowering the cost of CO₂ capture and increasing the overall efficiency, thus promoting a sustainable and competitive European industry at the same time. Moreover, a series of concrete assets (hybrid materials, new membranes and products, new or re-designed CO₂ capture processes, etc) will be available at the end of the project, to be exploited by project partners, following a well-designed exploitation plan. Finally, relevant project results will be disseminated to the industrial community via dedicated channels and actions (i.e. industrial workshop), thus enhancing the replicability of the NANOMEMC² solutions.
- Contributing to the full unleashing of the economic potential of CCS and in particular the **CO₂ capture markets** for EU materials and technology providers, process modelling and simulation experts, through the set up of a **strong business model and related business plan** for the NANOMEMC² innovations.

The impact of NANOMEMC² on the **environment**, and by reflection on society, is also well defined, as the whole project is focused on CO₂ capture technology. The primary goal is indeed the development of highly efficient and effective processes for the reduction of CO₂ emissions in the atmosphere, to reduce the greenhouse effect and the issues related to climate change.

Therefore, the technologies under development, in terms of novel materials and innovative processes, as well as the scientific progresses, are expected to contribute significantly to the reduction of the carbon footprint of industries and power plants and, in the longer time scale, to be capable of mitigating the greenhouse effect and the consequent issues related to climate change.

Further figures (Figures 3a-c) about the specific pages described are reported below.

The screenshot shows the website's header with the logo, navigation menu (HOME, ABOUT NANOMEMC², PARTNERS, NEWS AND EVENTS, PUBLIC DOCUMENTS, LINKS, CONTACT), and a search bar. Below the header is a large green banner with the text 'THE PROJECT'. Underneath the banner is a horizontal strip of four images: a cooling tower, an industrial plant with smokestacks, a tall chimney, and a smokestack emitting a large plume of white smoke.

THE PROJECT Membrane separation processes can be applied to many CO₂ capture processes from pre-combustion (CO₂-H₂ / CO₂-CH₄ separation) to post-combustion (CO₂-N₂) and oxyfuel (O₂-N₂) and are generally endowed with high flexibility and potentially low operating costs when compared to other capture methods. However the current materials lack the separation performance and durability needed for an efficient and economically feasible exploitation of such technology.

OBJECTIVES The NANOMEMC² project aims to overcome the current limitation by focusing on the development of innovative CO₂ selective membranes with high flux and selectivity suitable for application to both pre and post-combustion capture processes.

BENEFITS To address this objective nano-composite or mixed matrix membranes will be developed with particular focus on facilitated transport mechanisms promoted by carrier attached to the polymer or the filler. Graphene based nanoplatelets and cellulose nano-fibres will be studied in detail along with possible modification to improve polymer compatibility and affinity with CO₂. New generations of Facilitated Transport Mixed Matrix (FTMM) and Continuous Phase Mixed Matrix membranes for CCS applications will be developed with increased performance for both pre-combustion and post-combustion capture. Both hydrogen selective (for pre-combustion) and CO₂ selective membranes (for both pre and post combustion) will be developed targeting flux and selectivity beyond the current performance for industrial deployment of carbon capture membrane technologies.



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HOME ABOUT PARTNERS NEWS AND EVENTS PUBLIC DOCUMENTS LINKS CONTACT PRIVATE AREA

Figure 3a: about NANOMEMC² project

OBJECTIVES

THE PROJECT

OBJECTIVES

BENEFITS

The general objective of the NANOMEMC² project is to contribute to a real and effective deployment of CCS technologies by reducing the cost and energy penalty of CO₂ capture through the development and optimal integration of innovative membranes for CO₂ separation within different energy intensive industrial processes. It will be implemented through the attainment of the scientific NANOMEMC² main goal: to fully develop the potential of membranes in the selective capture of CO₂ from gaseous emissions, increasing the efficiency of the capture step, and reducing the overall CCS cost below the value of 40€/tonne of CO₂ avoided.

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Figure 3b: about NANOMEMC² project (objectives)



Figure 3c: about NANOMEMC² project (benefits)

2.3 PARTNERS

The section “PARTNERS”, hosts the information of each partner of NANOMEMC² project.

For each organisation, it is included:

- the logo of the organisation, the full name and the website (figure 4a)
- A brief description of the organisation, highlighting their main competences related to the project (figure 4b)

Clicking on the symbol “+” it will possible to see the full description of the organization.

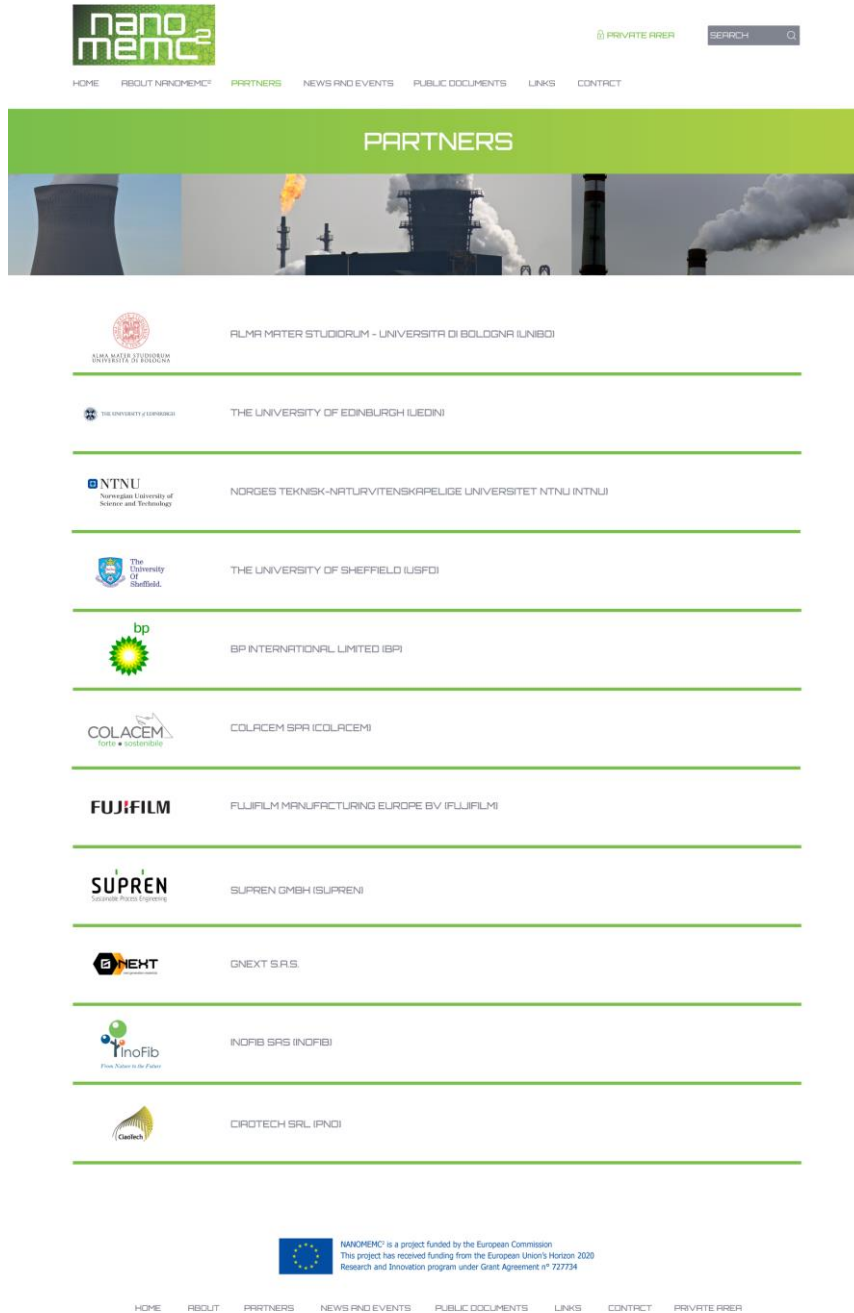


Figure 4a : Partners: Partners name, logo and website



ALMA MATER STUDIOURUM - UNIVERSITÀ DI BOLOGNA (UNIBO)

Founded in 1088, the Alma Mater Studiorum – Università di Bologna (UNIBO) is known as the oldest University of the western world. Nowadays, UNIBO still remains one of the most important institutions of higher education across Europe and the second largest university in Italy with 11 Schools, 33 Departments, about 3000 professors and researchers, and more than 84.000 students. With regard to the international reputation, UNIBO has been awarded the use of the logo "HR Excellence in Research" and is among the top 5 Italian universities in the main International rankings, e.g., 1st Italian university (182nd position) in the international QS – World University Rankings of the world best universities since 2010. UNIBO is one of the most important institutions of higher education across EU and the second Italian University in access to EU funding. UNIBO has gained a considerable experience in International and European research projects, successfully participated in FP7 with more than 275 funded projects in different specific programmes (acting as coordinator in 58 of these, total budget 87.5 m€). On the European side, Unibo is member of the major European Networks and stakeholders thematic groups, such as: the European Climate Research Alliance (ECRA); the European Technology Platforms (ETP) SuSchem, WSSTP, BioFules; the Joint Programming Initiatives (JPI) Water challenges, FACCE, Oceans; the Public Private Partnership (PPP) Spire; the KIC Climate; the EIP Water Challenges. In addition Unibo is candidate of the consortium for the KIC RawMatters. In the first year of Horizon 2020, UNIBO won 63 projects for a total budget up to now higher than 14 m€.

NANOMEMC2 project in particular will take place in the Department of Civil, Chemical, Environmental and Material Engineering (DICAM) which is part of the school of engineering and architecture and is composed of more than 100 full time professors and researchers and about 150 PhD, Post Docs and graduate students. The research topics of the department cover very different areas and many different research group. Among the others the research group of Diffusion in Polymer focuses on the experimental analysis and modelling of mass transport in polymeric films and membranes in view of the optimization of materials properties for the applications of interest. This group will be involved in NANOMEMC2 where it will use the described expertise for the development and testing of membrane materials suitable for high efficiency carbon capture applications.

ROLE IN THE PROJECT

The UNIBO research unit will be the coordinator of the NANOMEMC2 project and the leader of WP1 "Coordination and management". Apart from that UNIBO will also lead WP2, related to the materials development where it will focus on the development of Facilitated Transport and Continuous Phase hybrid membranes for CO₂ Capture. UNIBO will be also involved in:

WP3, where it will test the membranes developed in WP2 in a wide range of operative conditions and with particular reference to pre-combustion capture applications for both CPHM and FCHM.

WP4 where it will focus on the development of structure properties relationship able to guide the material development and on the construction of macroscopic models for the description and prediction of membrane behavior in different operative conditions. These model will serve as a base for process simulation analysis (WP5) and system scale up (WP6).

WP7 and WP8 where, as Coordinator, it will have a significant role both in the dissemination and in keeping contact end ensure twinning activity with Korean Partner.

Figure 4b: Partners: Description of one partner as example

2.4 NEWS & EVENTS

The section "News & Events" (Figure 5) contains an archive of news related to NANOMEMC² as well as interesting events dealing with the deployment of CCS technologies, CO₂ capture, integration of innovative membranes for CO₂ separation within different energy intensive industrial processes, events and news of the stakeholders and platforms mentioned in the LINKS page, at a national and even European level.

The goal is to create a linkage with other projects and become an information hub for membranes and CSS.



Figure 5: News & Events

2.5 Section “LINKS”

The “LINKS” section (Figure 6) indicates several URL websites which represents very important links for the NANOMEMC2 project. It comprises coherent web references strongly connected to the project aims, such as: EERA (Coordinating energy research for a low carbon Europe); European Technology Platforms - Innovation Union; Joint Technology Initiatives; the Public-Private Partnerships in research, the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP), European Technology Platform for Advanced Engineering Materials and Technologies (EUMAT); Sustainable Process Industry through Resource and Energy Efficiency (SPIRE); CCP - CO2 Capture Project; Carbon Capture and Storage Association (CCSA) ; European Membrane Society (EMS); as well as the South Korean Ministry of Science, ICT and Future Planning (MSIP).



Figure 6: Links

2.6 Section “Contacts”

The “CONTACTS” section (Figure 7) includes a simple form where basic information is required. The data inserted in the form will arrive as an email to the project coordinator. It is avoided to show direct e-mail addresses to preserve privacy and robot search. This page will allow stakeholders to ask for more information directly to the project partners, in order to create a networking possibility with other projects and initiatives.

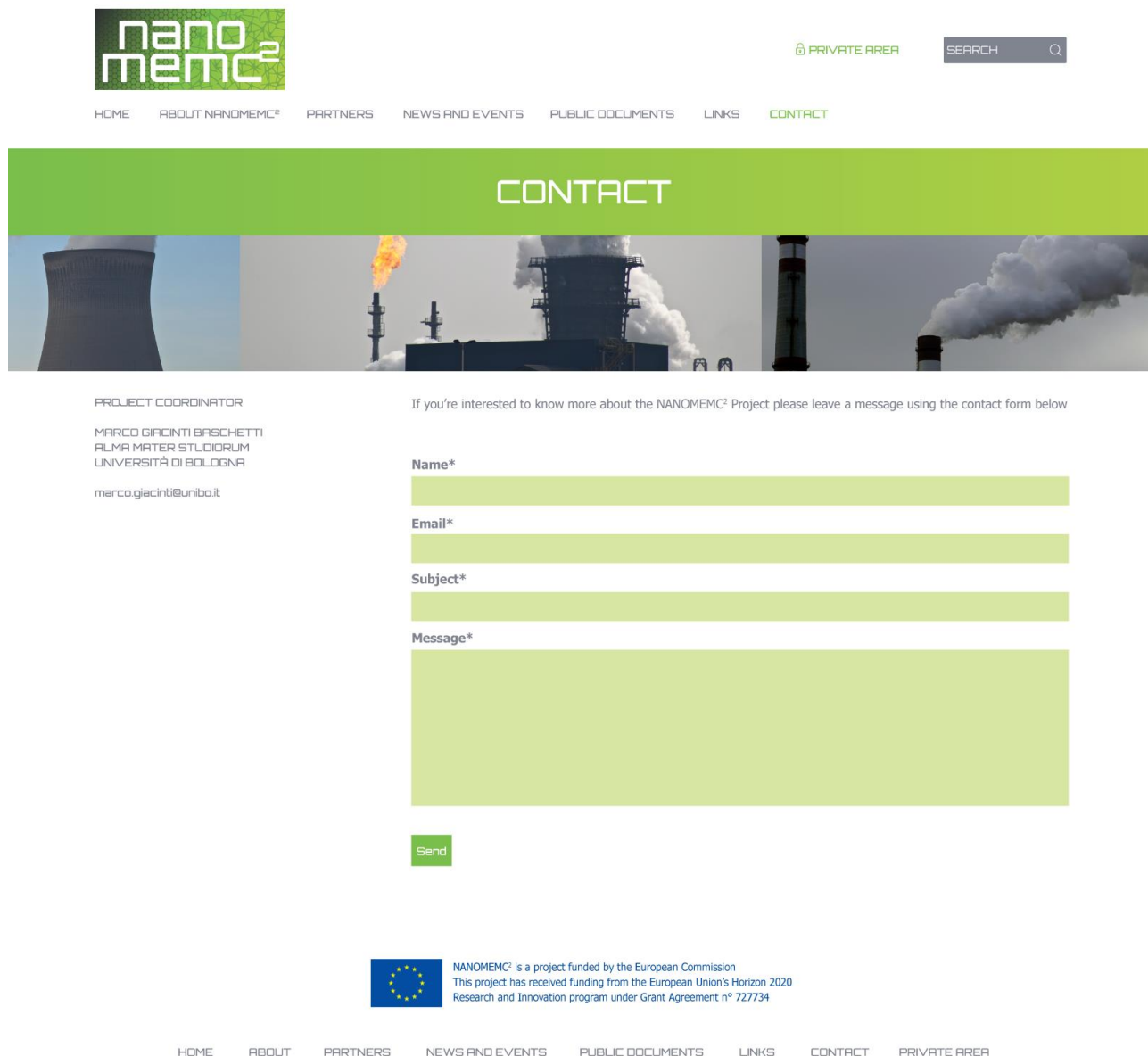


Figure 7: Contacts

2.7 Section “Private Area”

PRIVATE AREA is accessible only to NANOMEMC² partners, User Group and EC Officer to share documents and information. It can be accessed through the login area (Figure 8a) at the top of the page. After the log-in the page is automatically redirected to NANOMEMC² page on Innovation Place web-platform (Figure 8b). Thus, any partner can access the private area from the website and upload-download any dissemination material that is required.

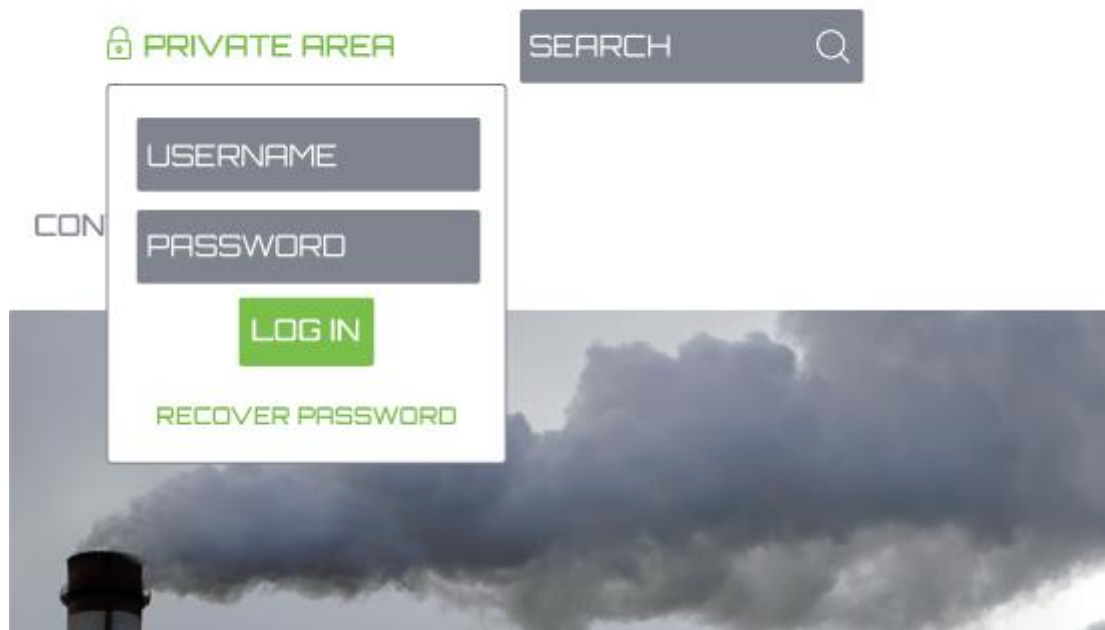


Figure 8a: Private area login in



Figure 8b: Private area: NANOMEMC² page on Innovation Place web-platform