[D2.1] PRELIMINARY MARKET ANALYSIS (FOCUS ON DEMAND)

Project details

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Udo Lubenau (DBI)	Brief additions to tables 6 and 7.

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List of abbreviations and definitions

Abbreviation	Definition
EC	European Commission
OITB	Open Innovation Test Bed
SEP	Single Entry Point
EU	European Union
H2020	Horizon 2020
HE	Horizon Europe
OITB	Open Innovation Test Bed
FoF	Factories of the Future
LL	Living Lab
ERDF	European Regional Development Fund
SME	Small, Medium Sized Enterprises
IP	Intellectual Property

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1 EXECUTIVE SUMMARY

This document reports the deliverable 2.1 entitled *"Market Analysis (focus on demand) - preliminary"* within the scope of INNOMEM project entitled *"Open Innovation Test Bed for nano-enabled Membranes"*.

D2.1 is the first deliverable of WP2 which final goal is the Setup of SEP for sustainability and management of the ecosystem. WP2, thus, includes all activities needed for the SEP value definition, organisation structure, appropriate legal entity, and governance rules to ensure the final SEP operation.

The main goals of WP2 are below listed:

- Strategy for the SEP set up for sustainability and business model of the ecosystem
  - Definition of a sustainable SEP as access point to upgraded and upscaled facilities and associated services
  - Intermediation platform linking the needs of customers (SMEs, start-ups, corporations, entrepreneurs, etc.) with the capacities of OITB (services, facilities, infrastructure, IP).
  - SEP operational model and key day-to-day activities will
  - Development of an innovative ecosystem across Europe.
- SEP qualification scheme and quality assurance including:
  - quality standards and fair access to services
  - Quality Management System established by experts in this field of the services provided by the PL leaders to the interested organizations
  - review of potential standards that should apply to individual PLs or services
  - definition of the type of performance indicators (KPIs)
- set up of the governance bodies responsible for transparency and equal opportunities for all service providers associated with the SEP
- financial model
- value proposition to materialise the offering of the SEP to the market

In the following paragraphs will be defined:

1- General approach to the methodology

2- EU documentation and regulations on the OITBs systems

3- Overview of already funded RD&I projects of OITB cases

4- Examples of existing OITBs scouted through desks research

5- Mapping criteria of preliminary list of OITB services provided by INNOMEM PLs owners

2 PROJECT INTRODUCTION

INNOMEM aims at developing a sustainable OITB (Open Innovation Test Bed) to foster deployment and scale-up of innovative nano-enabled membranes and their derived products.

Within the scope of INNOMEM, different types of membrane materials (polymeric, ceramic, metallic and nanocomposite), surface modification, membrane morphology and geometry and applications will be covered, providing for the first time a Single Entry Point (SEP) to provide the businesses in the sector with a one-stop-shop of the best available experts and technologies. European companies, mainly SMEs, will access through the SEP to develop, test and adopt, new high performance, multifunctional, safe and environmentally friendly nano-enabled membranes in a cost-effective and sustainable way while opening-up opportunities for demonstration of innovative nanomembranes in real life industrial problems (TRL7) and thus accelerating the market opening for these new products.

INNOMEM gathers some of the most recognised Membrane departments (>20) in Europe and acknowledged facilitators of technology transfer, corporate finance, funding and coaching, making available (i) the most promising and breakthrough manufacturing pilots and (ii) advanced characterization techniques and modelling together with (iii) non-technical services through this Test Bed: while relevant improvement metrics can be defined, the potential network of reachable stakeholders counts thousands of businesses on an international scale.

As a starting point, 14 Pilot Lines and their enabled technological services, coming from past investments at Regional (RIS3) at National and European levels, are deployed.

INNOMEM will offer its network of facilities and services through a SEP to companies from inside and outside Europe. It will take especially into account the needs of SMEs and simplify their search, with a one-stop to access and choose within an EU boutique of experts and assemble the best service portfolio for every need (single contact, external project management …).

3 OBJECTIVES OF THIS DELIVERABLE

The objective of this deliverable is to complete the first step in a demand market analysis for the services to be provided (after being defined) by the SEP. This is strictly related to the tasks 2.4 *"SEP value proposition"* and also constitutes the basis to the deliverables related to the other tasks 2.1, 2.2 and 2.3 focused on the SEP definition and business model, the SEP qualification schemes and their Governance and financial model. Overall, the main activities of task 2.4 are outlined within the INNOMEM projects and summarised below:

- An ad-hoc mini-market analyses and stakeholders mapping by exploring similar initiatives both within and beyond EU
- Assessment of possible SEP offers to the market
- Value proposition of the OITB aligned to the market needs/best stories from the market

The followed approach consists of:

1- A desktop analysis of the addressable market, assessment of the target customers types and identification of possible best use cases from existing testbeds' success stories

2- Definition of a benchmark composed of market-stage testbeds and similarly funded OITB, with different TRL classification

3- Study and initial validation procedure on the currently adopted OITB business model and identification of the provided services to serve as verification of INNOMEM potential.

The main goals related to this research consist of:

- Better acknowledgment of the customer types
- Better OITB positioning in the market
- Finding new potential clients and stakeholders to engage
- Defining the best value proposition to deploy in the demo cases

In the following, the pursued methodology will be illustrated. This is done to carry out the market analysis and highlight the main results that emerged from the analysis on the Test Beds ecosystem.

The work in this document will be followed up in D2.3, where the assumptions and the analysis will be validated by the customer type already participating to INNOMEM and suitable third parties that shall be identified.

4 METHODOLOGY

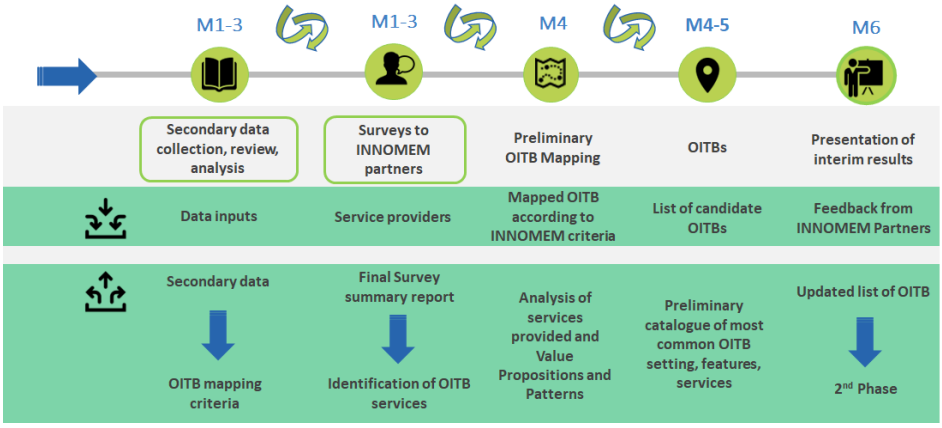
The general approach followed for the SEP catalogue definition and preliminary market analysis is based on a combination of methods and tools used for secondary data collection through desk-based research. This research focuses on better defining a market size, spotting success stories emerging among market stage testbeds and OITBS, and scouting innovative SMEs and end users. The latter play key roles in realising commercially viable OITBs and/or providing services through innovative SEP business models.

The collected information is analysed and screened to select the most relevant use-cases to INNOMEM. The final proposed catalogue aims at targeting INNOMEM partners, the service providers and users, and the external stakeholders.

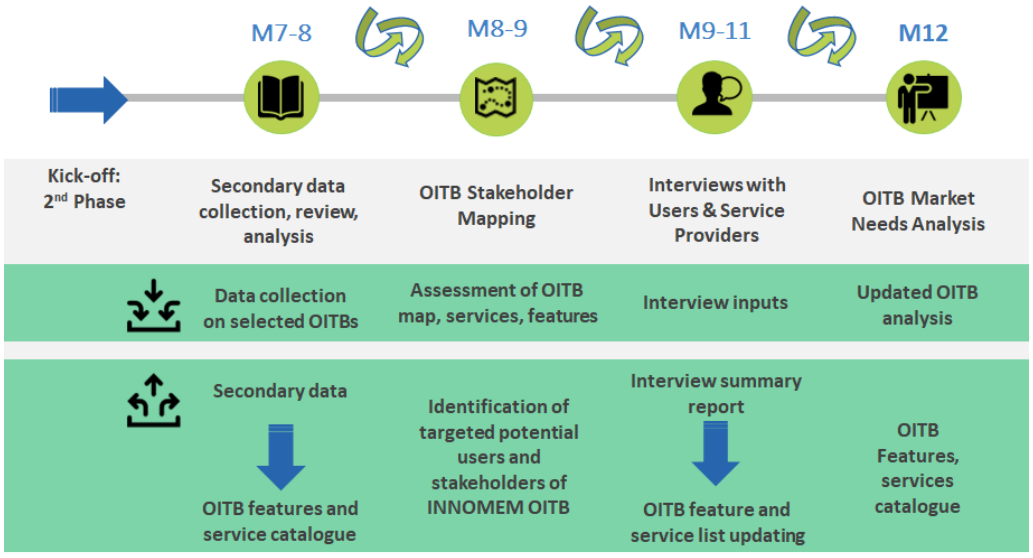
4.1 General Approach

The mapping activity is divided into two phases:

Phase 1 (M1-6): Preliminary market needs analysis → D2.1 (Scenario Assessment)



Phase 2 (M7-12): Final market needs analysis → D2.2 (Customers Validation)



4.2 Sources And Tools For The Analysis

Economic Based Analysis: Addressable Market Estimation - Our analysis focuses on defining the European market size for the membrane sector that the INNOMEM OITB aims to address. We cross-referenced the results of several market reports and relevant EU project deliverables gathered through a desk-based research. We determined the Total Addressable Market value summing the two relevant market segments of filtration and separation membranes. We focus on the filtration market segment, the largest one, conducting an analysis by fields of application. The reported potential market values were obtained calculating the different CAGR for each segment, analysing the trends of available years. Finally, we project the CAGRs to 2025 at the current values extracted from consulted reports.

Competence Based Analysis: Benchmark Building - The focus of this analysis is the European context in which the OITB concept emerged, and the system of regional and EU initiatives to which it contributes. We explored the relevance of technology infrastructures for EU competitiveness, then narrowed down the analysis to the OITBs. These are one of the EU initiatives that strengthen the EU ecosystem and network of technology infrastructures in the field of nanomaterials and advanced materials. In addition, we conducted a brief literature and bibliographical search to define and clarify **the concept** behind a **Test Bed** and differentiate it from the one behind the EU **Living Labs**. This highlights the commonalties and differences between two concepts which can often be confused.

The second step is the **identification of comparable OITBs**, highlighting the characteristics and their acquired experiences. We dedicate particular attention to the services-to-market offered by selected OITBs. Once gathered all necessary information, we identified **the main players in the sectors** that are the closest to INNOMEM technologies (development of advanced materials, inorganic and polymeric materials, nanomaterials, characterisation techniques for chemical-physical properties etc.). We scouted the **projects in similar fields of INNOMEM thematic** using PNO IT tools (e.g. www.wheesbee.com, Figure 1). Such tools enable clustering and organising relevant public and private data sets, possibly defining an innovation scoreboard, innovation networks, and strategic trends analysis.

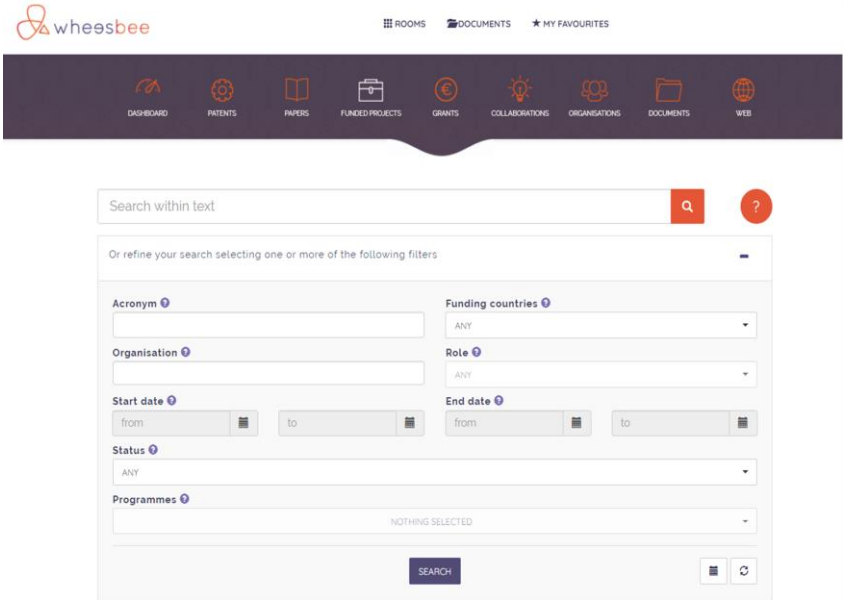


Figure 1. WheesBee innovation tool, funded project research page.

The scouted projects research allowed to:

- trace a temporal trend on OITB projects published in the last 20 years;
- list the main countries with funded OITB projects;
- identify the main sectors of application of the OITB projects at global and European level;
- extract the main OITB facilitators from European projects;
- gather the OITB EU funded projects closest to INNOMEM technology;
- Analyse the existing business models and identify the most suitable ones for the INNOMEM OITBs use case.

After deeply analysing the Test Beds linked to the scouted European projects, the attention moved to Test Beds. The goal is to identify the main **ready-to-market testbed facilitators** at European level considering some pre-determined factors: most successful cases, benefits obtained by customers, operational and economic advantages. To this end, a mapping was made through a desktop search on the websites of the several European accelerators, testbed federations, and those containing lists of ready-to-market testbeds.

Finally, the **European Test Bed market leaders** were defined as those who actively participated in the delivery of more testbeds combining the results of the analysis at a commercial and EU project level.

5 THE EUROPEAN CONTEXT FOR OITB

The EU acknowledges the crucial role of the industry in achieving long-term sustainable prosperity. Moreover, the EU identified the scarcity of scale-up and technology diffusion across Europe as a major barrier to the needed industrial transformation. To allow timely development and test for industry innovation and facilitate the launch of those on the market, the EU supports the creation, development, and accessibility of proper technology infrastructures.

The EU defined the technology infrastructures as "*facilities, equipment, capabilities and support services required to develop, test and upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public, or private status. Their users are mainly industrial players, including SMEs, which seek support to develop and integrate innovative technologies towards commercialisation of new products, processes, and services, whilst ensuring feasibility and regulatory compliance*."

To set-up and maintain state-of-the-art technology infrastructures, the investment required is high, as they can range from clean-room facilities, to high-complexity plants, industrial robotics, etc. Most of these infrastructures rely on a mixture of public and private funding. Under the 8th framework programme Horizon 2020 (H2020) alone, the EU invested about € 1.2 billion in relevant projects; to these investments, the ones under the European Regional Development Funds, and R&I support services need to be added [1]. These EU investments build on the Smart Specialisation Strategies identified by Member States both at National and Regional level, which support technology infrastructures along with European initiatives.

As many players are involved in the development and support of the technology infrastructure ecosystem, a wide range of cases, sizes, typologies, and practices are included under the category, mirroring the diversity of the EU. This diversity is rooted in the technological complexity of industrial competitiveness and on the need of effective testing, validation, and upscaling opportunities that can guarantee the innovation's market success. The current scenario of technology infrastructure in the EU, presents large regional differences in terms of infrastructure availability, support, fragmentation, risk of duplication of assets and activities, and accessibility. However, mechanisms to identify industry needs and infrastructure are still missing.

In several Communications [2] [3] [4], the European Commission (EC) assessed the EU's lack of scale-up and technology diffusion as a major barrier to industrial transformation. This leads to systematically missing new market and growth opportunities because of insufficient investment in infrastructures and new technologies. For these reasons, the upcoming 9th framework programme, Horizon Europe (HE), will support the co-design and co-creation of research and innovation agendas among all sectoral players in the pillar of "Global Challenges and Industry". Furthermore, HE will support an EU innovation ecosystem of technology infrastructures covering all key enabling technologies facilitating the commercialization of EU innovations. HE will work in tight synergy with the Digital Europe Programme and the European Regional Development Fund (ERDF) [5], making necessary the coordination of a more comprehensive strategic approach to technology infrastructures.

5.1 The Characteristics of Technology Infrastructures

The importance of technology infrastructures for industrial competitiveness relies on the characteristics of these entities. They play, indeed, a crucial role in the innovation process of new technology-based products and services. The use of technology infrastructures allows to de-risk innovation development through technology feasibility testing; reduce time to market by streamlined and scaled up internal operations; avoid investments in expensive equipment and facilities, and disruption in business operations.

Organizations accessing technology infrastructures, also gain access to diverse expertise and growth opportunities, while giving impulse to new standard development for testing and certification.

Reflecting the diversity and complexity in technology developments, technology infrastructures can be sector-specific and/or technology focused. As mentioned before, they are usually sustained by mixed funding sources and can be public, semi-public, or private, operating under diverse entities: non-profit research and technology organizations (RTOs), technical universities, or large industries. Furthermore, they can be operated by several organizations (i.e. shared technology infrastructures), benefiting from the more effective and shared costs of investments, expertise, and staff. Technology infrastructures can provide service and access to customers at different levels (local, national, EU and global), according to their own access regulations.

Contrary to RTOs that focus on early stage scientific discovery, technology infrastructures focus on high technology readiness levels (TRL) and industrial innovation, without excluding access to research or academic customers.

5.2 Technology Infrastructure Initiatives in the EU

In the European Union, regional and national industrial innovation strategies are playing the main role in providing investments in technology infrastructures that contribute to developing innovation, empowering cross-value chains, and cross-sectoral collaborations among different stakeholders in innovative ecosystems.

At a regional level, the ERDF supports R&I infrastructures and business delivery services with about € 16 billion invested in building or upgrading activities, and about € 21 billion funding for SME-targeted technology exploitation and development services [1]. At National level, there are several initiatives, some of which are listed in Table 1, along with initiatives at regional level.

Table 1 Examples of Regional and National Technology Infrastructures in the EU, source EC [1]

Regional			
Country	Initiative	Investment	Focus
ES	Tecnalia's Harsh Lab	Basque country's ERDF operational programme 2014-2020	Materials and components, offshore experiment & validation
IT	Mechatronics Prototyping Facility (ProM Facility)	€ 415 M	Mechatronics Prototyping
HU	Pharmapolis Pharmaceutical Science Park	€ 7.7 M	Pharmaceutical Science Park
PL	Białystok University of Technology	€ 2.8 M	Renewable energy
CZ	IT4Innovations supercomputing centre	€ 77 M	Computing and data analysis
National			
Country	Initiative	Strategy	Topic
SE	Testbed Sweden	Smart industry strategy (SIS)	Digital transformation & sustainable production methods
DE	Labs Network Industrie 4.0	Industry 4.0 initiative	Testbed network, one-stop-shop for SMEs

NL	Fieldlabs	Netherlands Smart Industry 2018-2021 Implementation Agenda	Interdisciplinary on NL most competitive sectors
FI	Finnish National Reform plan	Finnish Government programme 2015-2019	Competence platforms and growth ecosystems

5.3 EU Technology Infrastructures Initiatives

As already highlighted, the EU finances several initiatives supporting technology infrastructures in a direct or an indirect way. This is done mainly through the ERDF, under the priorities set in the Smart Specialization Strategy, the Thematic Smart Specialization Platforms whose setup is supported by the Cohesion Policy, and the framework programmes such as H2020. The latter funded trans-national R&I activities promoting industrial leadership through tailored actions for technology infrastructures that between 2014 and 2020 received € 1.2 billion of investment.

Latest EC investments in technology infrastructures funded the following initiatives:

1. Pilot lines for manufacturing: under the Public-Private Partnership (PPP) Factories of the Future (FoF), over € 100 M have been invested in H2020 for the FoF pilot lines, to which SMEs participation exceeded 35%.
2. **Technological infrastructures in the transport sector** supported and advanced transport technology infrastructures in several fields. They also followed the technological evolution of digitalization and electrification of the transport system. This led to the development of digital twin infrastructures, energy storage testing, alternative fuels validation, combination of advanced multi-disciplinary optimization design tools with High Performance Computing, etc. Technology infrastructures in the field generally serve as research infrastructures, adding value not only to industry, but also to research and education.
3. **Digital Innovation Hubs (DIH)** [6] are non-profit, one-stop-shops that support the EU business, particularly SMEs and the public sector in the ongoing digital transformation efforts. They allow industry of any dimension to access knowledge and testing facilities in the more advanced digital technologies. The DIHs provide access to testing facilities, support in the development of skills and training, finding investments, opportunities of networking, and access to relevant innovation ecosystems.
4. **SMEs' access to Key Enabling Technologies – KETs Technology Centres (KETs TCs)**: The KETs TCs support industry, especially SMEs [7], in the development and production of new KETs-based products. This helps innovation going from research results to commercialization and reducing the time to market. To do so, TCs offer services such as access to technology expertise and validation facilities, proof of concept, prototype development, piloting, demonstration, testing product validation, and certification.
5. **European Institute of Technology (EIT)** [8]: The EIT supports the development of Knowledge and Innovation Communities (KICs), collaborative partnerships across EU universities, RTOs, and industry. KICs currently cover the sectors of Climate, Digital, Food, Health, InnoEnergy Innovation, Raw Materials, and Advanced manufacturing. KIC RawMaterial [9], for example, offers supports in the development of innovative technologies and business creation, funding innovation Upscaling projects with high TRLs
6. **Open Access to Joint Research Centre (JRC) facilities** [10]: in deploying the JRC Strategy 2030 'Infrastructures Fir for Purpose', the JRC opened 38 facilities in the nuclear and radiological fields,

chemistry, bioscience/life sciences, physical sciences, and ICT, to external users. This guarantees access to EU researchers and industry and raising JRC's facilities value and visibility. The JRC facilities are accessible through relevance-driven and market driven modes.

7. **Pilot lines and Open Innovation Test beds (OITBs) for Materials**: Between 2014 and 2017, the EC invested € 225 M to support 24 nanotechnology and advanced material pilot line projects. This includes 80 pilot lines across Europe, ranging TRLs between 4 and 7, aiming at developing cost effective and sustainable industrial scale facilities for SME-based testing and validation before pilot production. € 240 M have been invested between 2018 and 2020 to create Open Innovation Test Beds (OITBs). OITBs broaden the pilot lines concepts and provide access to technology and legal support services in the field of advanced materials and nano-enabled technologies.

5.4 OITB Definition and characteristics

The OITBs mentioned in the last bullet points represent a EU initiative which aims to provide support to users, particularly SMEs, in minimising costs and lowering technological risks, accessing relevant competences and services such as risk-benefit assessments, ensuring regulatory compliance, implementing standardization efforts, and accessing business services (e.g. mentoring, coaching, market analysis, etc.).

The EC defines the **Open Innovation Test Bed** (OITB) as a **set of entities, established in at least three Member States or Associated Countries, providing common access to physical facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments**.

The objective of the OITB is to bring nanotechnologies and advanced materials within the reach of companies and users to advance from validation in a laboratory (TRL 4) to prototypes in industrial environments (TRL 7). In doing so, the OITBs cover all the activities from the prototyping to industrial production, validation of material characteristics and control of the respect of legal and regulatory constraints. They also enable to run demonstration cases and dissemination activities, allowing the showcase of capabilities and services ensuring OITB's sustainability.

As per EC requirement, the OITBs need to guarantee **Open Access**: any interested user, from Europe and beyond, should be able to access the test beds' facilities, capabilities, and services, independently of whether or not the user is part of an OITB H2020 consortium. The access must be granted at fair conditions and pricing and with transparent and mutual obligations (e.g. for security, safety and IPR).

OITBs address the need of **users** identified as individual innovators, teams and institutions from academia, RTO, SMEs, large industry, start-ups, public/private sector. OITBs should set a framework for the **definition of the access conditions** to their facilities and services, compliant with transparency and fair access requirements.

OITBs represent the evolution of similar initiatives already included under the FP7 focused on the establishment of pilot lines for characterization, modelling, and safety. In the early stages of H2020, these initiatives started focusing on the materials industry, to accelerate innovation in the KETs of Nanotechnologies and Advanced Materials, then evolving towards the current model of the OITB.

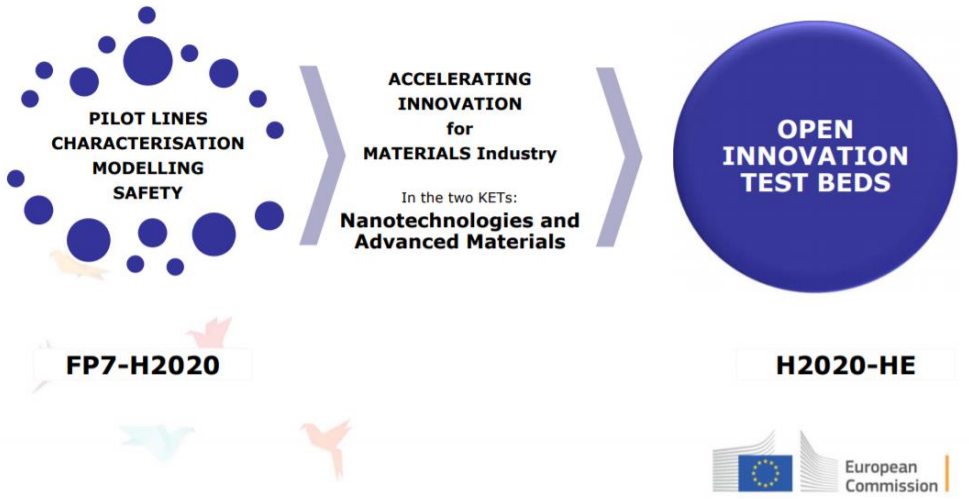


Figure 2. From FP7, to H2020 and HE OITBs (Source: DG R&I)

The OITB concept represent a tool for pursuing EC President Junker's priorities [11] of boosting competitiveness, creating jobs, and supporting growth. It is also a tool for the deployment of the EU Strategy for Key Enabling Technologies (KETs) [12] [13] supporting EU's industrial innovation capacities and the exploitation of EU's potential in competitive markets. Furthermore, OITBs recall the EU Industrial Policy [14] focuses on stimulating investments in innovation and new technologies, along with supporting EU SMEs and entrepreneurship. Finally, the concept falls into the priorities highlighted by Commissioner Moedas at the beginning of its mandate, on the Open Science, Open Innovation, Open to the World vision [15].

5.4.1 THE OITB V. THE LIVING LABS

The concept of OITB seems to be close to the one of Living Labs (LLs), when considering the existing commonalities of the approach of these two types of entities to the innovation systems. Nonetheless, despite those common traits, OITB and LLs differ on many crucial points.

The LL concept can support the definition and characterization of the OITB when the "testbed" concepts arises. Indeed, the LLs have had a multitude of definitions themselves, which changed over time leading to a new definition. The latter also embeds testbeds within the LLs identified as independent open innovation ecosystem, such as the OITBs.

According to the European Network of Living Labs (ENoLL) [16], the LLs are user-centred, open innovation ecosystems based on systematic user co-creation approaches, integrating research and innovation processes in real life communities and settings. According to this definition, the element of the testbed in the LL only represents a resource to be applied in the development of experiments and innovation activities. The goal of the LL is to produce positive output on collaboration, social and user impact, business, economic, testbed and framework development. Applying this view, the latest definition of a LL is the following:

> A living lab is a sociotechnical platform with shared resources, collaboration framework and real-life context, which organizes its stakeholders into an innovation ecosystem that relies on representative governance, open-standards, and diverse activities and methods to gather, create, communicate, and deliver new knowledge, validated solutions, professional development, and social impact. (Westerlund et al. 2018) [17].

This definition approaches the concept of testbeds, however presenting differences that need to be stressed from the definition of testbed provided by **Vinnova**, **Wentland** (2016) and the same **European Commission**:

Vinnova defines a Testbed as a "physical or virtual environment in which companies, academia and other organisations can collaborate in the development, testing and introduction of new products, services, processes or organisational solutions in selected areas"- It distinguishes three levels: laboratory environment, simulated environment, and real environment. The first two are used primarily in academia, research institutes, and industry, while the third mainly concerns the public sector.

Wentland (2016) defines Testbeds as "instruments which reconfigure societies" and "vehicles of innovation governance, rather than as a mean to test technologies in a real-world environment or as a tentative, locally confined release".

Finally, the EC talks about "Open Innovation Testbed" (OITB). It defines it as a "set of entities, established in at least three Member States or Associated Countries, providing common access to physical facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments", aiming to bring nanotechnologies and advanced materials within reach of companies and users to advance from validation in a laboratory (TRL 4) to prototypes in industrial environments (TRL 7).

The last definition is the relevant one for the scope of this research in the INNOMEM project. What is clear is that the testbed can be understood both as an innovation tool within a LL, and as an open innovation ecosystem. However, some differences can be identified. Compared to a classic LL, a test bed also includes virtual and simulated environments, is often not limited to a geographical area, and can be offered as a stand-alone service in which innovation is mainly oriented to the market and not only to individual communities or networks of organizations.

5.4.1.1 OITB SCOPE AND EXPECTED IMPACT

OITBs are primary target are the SMEs, in particular those operating in the manufacturing sector. These can highly benefit from accessing technology infrastructures to increase their sales and employment, generating more innovative products. This is due to the possibility of accessing shared facilities based on reduced costs, which enable higher return on spending [1].

The EU OITBs open the access to facilities and services supporting the design, development, prototyping, testing, and upscaling of materials and nanotechnologies for new products. They allow to run demonstration activities in relevant industrial environments and showcase technologies with potential users in the industry in cross-border applications. Furthermore, they facilitate the access of SMEs along product value chains and identify and assess potential regulatory, economic and technical barriers, engaging (cross)sectoral stakeholders across the EU and Associated Countries.

In achieving this scope, the OITBs would enable opening and upgrading technology infrastructures and facilities across Europe, reducing the costs of accessing relevant services for companies that need to use test beds for the successful development of their products. At the same time, the OITBs can improve industrial productivity and accelerate innovation in the specific domains of nanotechnologies and advanced materials. Finally, OITBs would generate impact increasing access to finance for SMEs that suffer

from limited availability of financial resources [18] needed to invest in those materials and their applications, while also increasing SMEs access to test bed services up to 20%.

Investing in the OITBs will highly contribute to address the challenges identified by the EC in achieving successful innovation by easing the transfer of research results on the market. OITBs, provide more visibility to technology infrastructures and enable them to prioritise strategic oversight on a European level by providing mechanisms to upgrade technology infrastructures and identify missing ones. OITBs also guarantee quick and easy access to technology infrastructures, especially to SMEs. The connection among OITBs, and between them and other existing networks of technology infrastructures, offers visibility to small testing facilities addressing over-capacity issues with which larger centres are dealing [1].

5.4.1.2 EU REQUIREMENTS FOR OITBS

The EC requires the OITB to establish a Single-Entry Point (SEP) as a legal entity, under the status chosen at OITB's discretion. The SEP provides access to the OITB services and should have the power of signing contracts on behalf of the OITB for which it can be held accountable. In addition, the SEP should define its internal arrangements to manage the interaction with the OITB members. Indeed, specific contractual arrangements should determine the interaction between the SEP and the OITB, and these arrangements should be reflected in the OITB's H2020 project consortium agreement. The agreements should consider the following issues:

- Governance, organisation, responsibilities, monitoring of the test bed (KPIs and impact) and internal procedures.
- IP measures and ownership rules on respective rights and obligations, including liability and confidentiality arrangements.
- SEP transparency and neutrality measures agreed between OITB members and their SEP to execute incoming client requests.
- Other general provisions (duration, termination, communication, applicable law, settlement of internal disputes etc.).

The OITB needs to provide complete and transparent information on the accessible facilities, capabilities, and services. This information needs to be on the SEP including details on available facilities, technical capabilities, nature of the services provided, pricing structures and legal conditions. The SEP also needs to run active promotional and dissemination efforts to maximise user reach and lower the access barriers in regional, national, and European networks.

The OITB/SEP needs to guarantee a dedicated customer support service and offer user case examples to attract potential users while promoting international quality controls and standards (ISO/CEN), fostering trust among OITB, its members and users.

General access terms and conditions must be defined, reflecting the nature of the technologies and services provided by OITB members in relation to the user. These terms and conditions need to include regulation of: Contractual relationships; Final price, service level, delivery time; Access rights and conditions; User/task selection criteria; Intellectual property rights and obligations, and data protection; Confidentiality; Health, safety and environment rules; Guarantee and Liability; Standardisation guidance; Dispute settlements.

Finally, the OITB and SEP regulations need to take into consideration the **potential heterogeneity of the users** in terms of region, sector, legal background, and language, pursuing the equal treatment and access to the services and facilities to any user.

OITB access costs and fees should be negotiable and reflecting the type of user (i.e. academia, RTOs, SMEs, large enterprise, etc.), its needs and requests complexity. In terms of **prices**, they should reflect market conditions and present a clear structure, specifying each facility's access units (e.g. cost per session/duration/equipment, data usage/transmission), and the resources and services entitled to the user as part of their contractual agreement with the OITB.

6 MARKET ANALYSIS – VALUE ASSESSMENT

In this service market-oriented analysis, the criteria of the analysis were based on relating the potential services offered by INNOMEM partners with the potential demand of the membrane sector's main actors. In this regard, an analysis to quantify the value of the membrane market was carried out to determine the business potential of the INNOMEM OITB. Subsequently, we identified the customers segment who could benefit more from the services that can be offered by the INNOMEM OITBs. Finally, the SEP catalogue containing the initial list of the services that can be provided by INNOMEM OITBs is presented.

6.1 Market size definition

As anticipated in paragraph 4.2, the definition of the market size for the membrane sector was determined cross-referencing several sources including sectoral market reports and relevant EU project deliverables, gathered through a desk-based research [19] [20] [21] [22] [23].

The **European membrane market** represents **25% of the global market** [21] [22]. To identify it, the values of the **Chemical Separation Membrane Market** and **Membrane Filtration Market** were considered and summed together.

The **Chemical Separation Membrane Market** is segmented as membrane distillation, membrane liquid extraction, gas/liquid separation, gas/liquid contacting, gas/gas separation, pervaporation, zero liquid discharge and based on membrane type (PTFE Membranes, EPTFE Membranes, PEEK Membranes, Polypropylene Membranes, PVDF Membranes, Silica Membranes, Zeolite Membranes and Others) [19].

The **Membrane Filtration Market** is segmented as Municipal Water, Municipal Wastewater, Industrial Water, Industrial Wastewater, Other Applications (Food & Beverage, Industrial and Manufacturing, Pharmaceutical industry) and based on membrane type (Ultrafiltration, Microfiltration, Nanofiltration, Reverse Osmosis) [20].

Based on these two market segments, the value of the **total EU membrane market** is estimated of **€ 4.943,42 M in 2025**, growing at a **CAGR of 6,61%** from 2018.

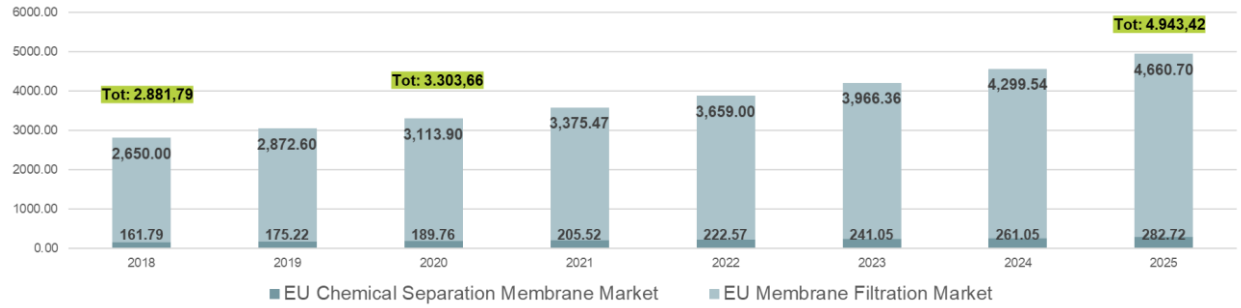


Figure 3. European Membrane Market in Million € (Source: PNO elaboration)

Figure 3 shows that the **membrane filtration market** is the segment with the highest value, counting for **over 90% of the total** [23]. This market can be further segmented by type of application, in which the **Water and Wastewater processing** segment accounts for **€ 1.092,24 M** in **2018**. On the one hand, this segment is expected to grow at a **CAGR of 1,32% until 2025**, reaching a value of **€ 1.178,57 M**. On the other hand, the **other applications** (Food & Beverages, Pharmaceuticals and Industrial/manufacturing) will have greater growth in the following years, as shown in Figure 4 and Figure 5 below.

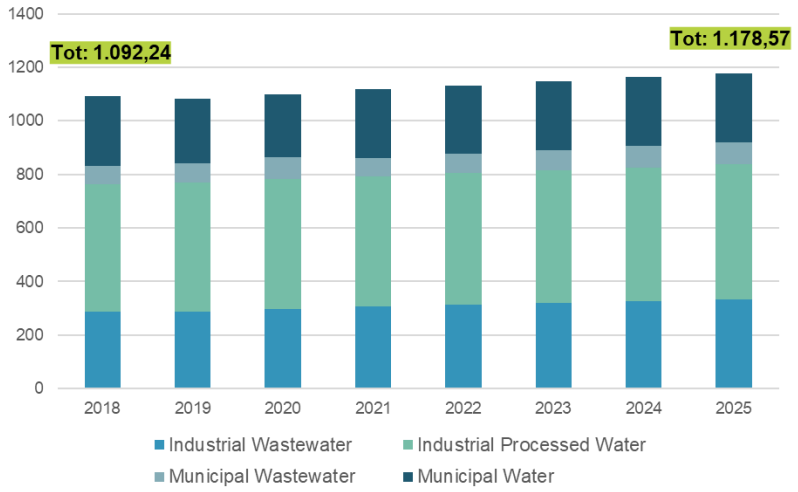


Figure 4. European Membrane Filtration Market per Water and Wastewater Treatment Applications in M € (Source: PNO elaboration)

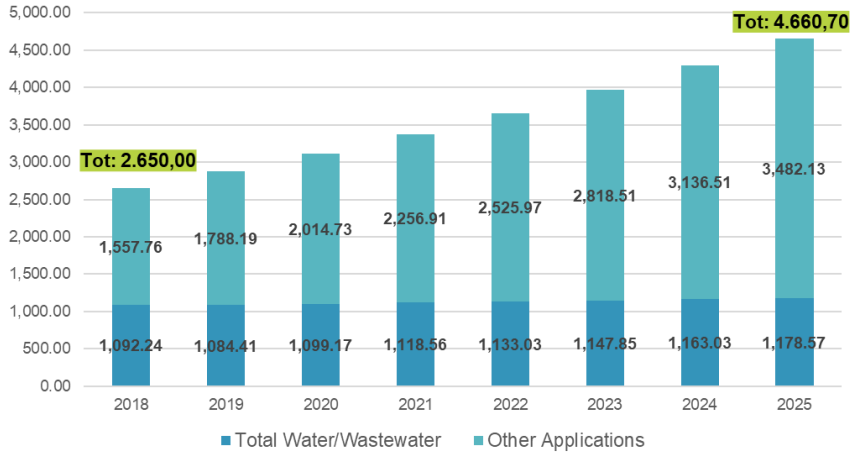


Figure 5. European Membrane Filtration Market per Applications in M € (Source: PNO elaboration)

6.2 Membrane sector customer segment

The methodology for identifying the customer segment for the INNOMEM OITB applied the following steps carried out through desktop research:

- Identification of case studies of some European Test Beds ready-to-market.
- Analysis of the customers types which have benefited from these testbed services.
- Mapping and classification of European companies operating in the membrane sector.

The analysis of the customer segment started from the sample of 13 testbeds included in Table 2,

Table 2. List of EU testbeds used as source for customer segment research

Test Bed Name	Organisation	Country	Cases Study Analysed
Anwendungszentrum Logistik	Fraunhofer	DE	10
Censis Test bed	University of Glasgow	UK	23

Digital and eHealth TestBed	Kernow Health CIC	UK	4
KTH Living Lab	KTH Royal Institute of Technology	SE	2
MMI Transferlab	Fraunhofer	DE	3
Nordic Proof Test Bed	Norway Health Tech	NO	3
OuluHealth Labs	Oulu Health	FI	6
Platform-art	GNV	ES	2
Smart Automation Lab/WZL	RWTH Aachen	DE	22
Smart Factory OWL	Fraunhofer	DE	4
Testa Center Test Bed	Cytiva (General Electric)	SE	8
Testbed for elderly and disabled – Örebro	Angen Research & Innovation	SE	7
Virtual Engineering Centre (VEC Test Bed)	University of Liverpool	UK	12
		Total	106

From the 13 testbeds included in the sample, **106 client organisations** emerged and were analysed per type of collaboration to identify the most appropriate client segment for the OITBs.

Out of the 106 identified OITB clients, **77%** are **SMEs** (**82 companies** with less than 250 employees at the time of collaboration), while only **17%** are **large companies** (**18 companies** with more than 250 employees at the time of collaboration). The remaining **6%** are **universities** (**4**) and **other types of organisations** (**2**).

The total of SMEs was then further stratified into three subcategories to better identify the testbed client typology. Out of the 82 SMEs, the category includes **37 Micro** companies (0-9 employees), **23 Small** (10-50 employees) and **22 Medium** companies (50-250 employees). Micro companies represent almost half of the SMEs accessing the OITBs: we found they are very young enterprises, which accessed testbeds within 2 years since their establishment; indeed, a vast majority of them (**22** out of 37) results to be still in the **pre-revenue phase**.

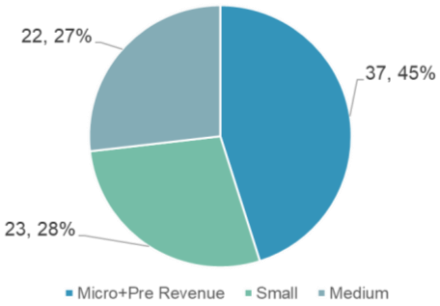


Figure 6. SMEs categories (Source: PNO elaboration)

6.2.1 MAPPING POTENTIAL INNOMEM CLIENTS

The procedure followed to identify potential clients for INNOMEM OITB started from an analysis of the clients that accessed OITB services. Out of this sample, we narrowed down the focus to define the characteristics of the most common clients, which resulted to be ***young, pre-revenues micro-enterprises***. Once this general target was identified, we proceeded narrowing the focus on companies operating in the domain of material science for membranes. This shed light on what could be the potential customer segment of the INNOMEM OITB.

To map and classify the EU companies in the membrane sector, we considered two database: Environment Xprt and Venture Radar. The analysis identified **583 companies**. The analysis revealed that relevant companies are mainly established in the UK (122) and Germany (114), followed by the western and

Mediterranean Europe (NL – 44, IT – 42, ES – 37, FR – 33) as Figure 7 shows. Considered alone, these countries host 67% of the total of European based companies operating in the membrane sector.

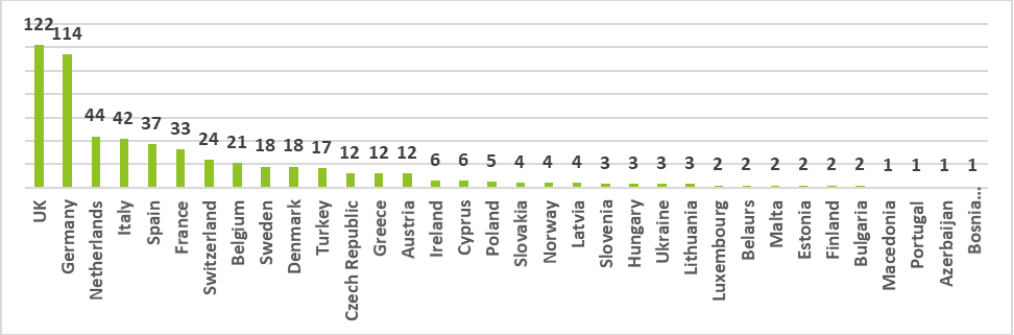


Figure 7. Companies in Membrane Sector per Organisation Country (Source: PNO elaboration)

This sample of companies was also classified according to their size (Figure 8). The result is that 68.8% of the European companies that operate in the membrane sectors are SMEs (401). Out of these, 40% qualifies as a micro enterprise (161) and they represent the potential customer segment for the INNOMEM OITB.

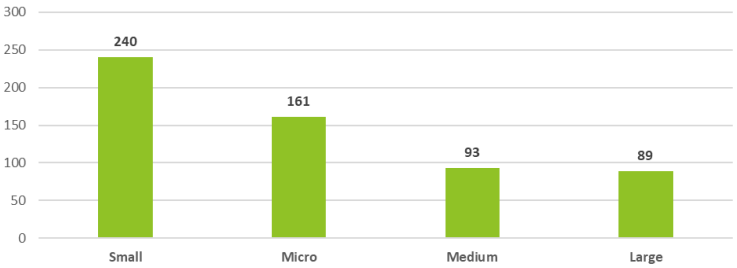


Figure 8. Companies in Membrane Sector per size (Source: PNO elaboration)

7 MARKET ANALYSIS – BENCHMARK INITIATIVES

7.1 PUBLICLY FUNDED OITB project initiatives

Between 2018 and 2020, H2020 funded OITBs in **6 NMBP domains** along with Characterisation and Modelling to upscale nanotechnology and materials (Figure 9), investing about **€ 260 M**.

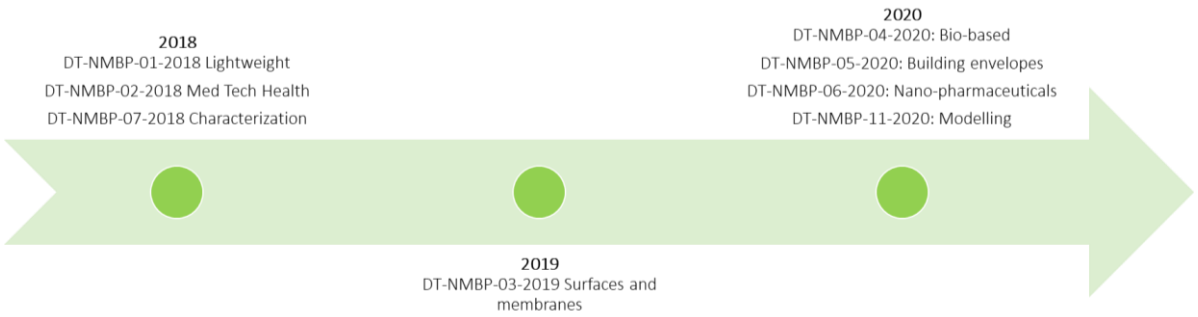


Figure 9. H2020 call topics funding OITBs

A project analysis was carried out to identify the OITB projects publicly funded at global level, analyzing the temporal evolution of this funding. Testbeds, considered as instruments of open innovation, have been an object of interest by the funding bodies for several years. However, in the **last decade** there has been a growing trend: as shown in Figure 10, there has been an exponential growth since 2010, with peaks in 2012, 2014, 2017 and 2019, in which at least 8 OITB projects per year have been funded globally.

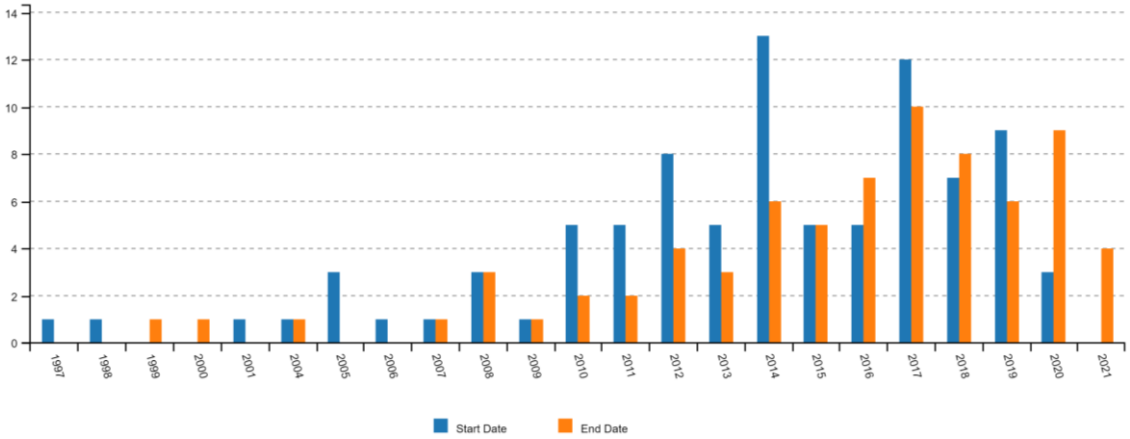


Figure 10. OITB project funded over time (Source: PNO Elaboration)

Indeed, the research found a total of 96 projects identified at a global level, which were subsequently classified considering the funding countries and application sectors (Figure 11). The UK ranks the first place among Country providing public funding to the establishment of testbeds, with 45 projects funded, the European Union, ranks second with 25: together, they have funded the 73% of the total projects.

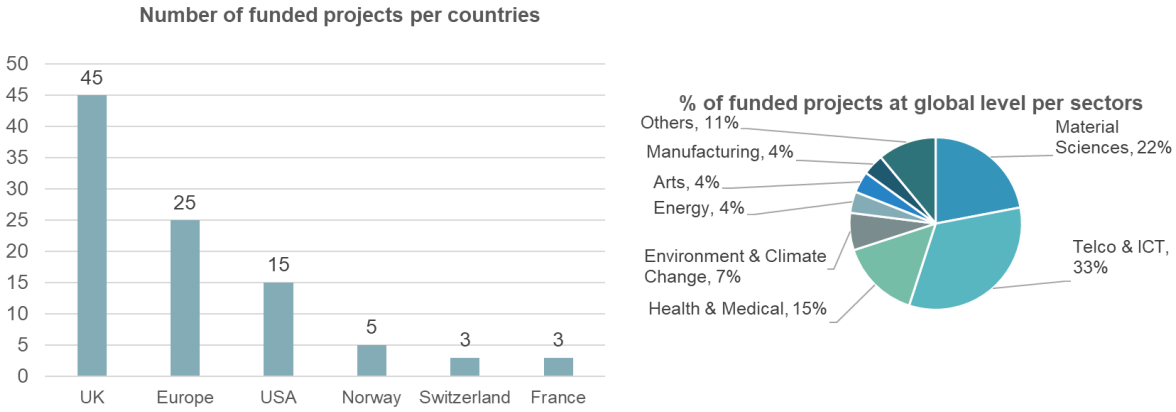


Figure 11. OITB funded projects per countries and sectors at global level (Source: PNO elaboration)

The main sectors of application of the OITBs emerging from the projects are Telco & ICT, Material Sciences and Health & Medical. Our analysis narrowed down the focus on the EU funded projects, and classified them according to the applied sector in which those 25 projects were funded (Figure 12). While on a global level the main sector of investment for OITB is Telco & ICT, the EU mostly invested on the development of advanced materials: 40% of the European OITB projects financed.

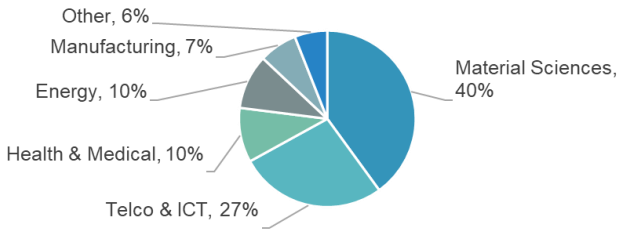


Figure 12. Percentage of EU funded projects per sectors

As for the organizations that participated in the selected projects (Figure 13), Fraunhofer is the absolute leader with 14 participations, followed by the CEA with 5, Tecnalia, TU Eindhoven and Thales with 4.

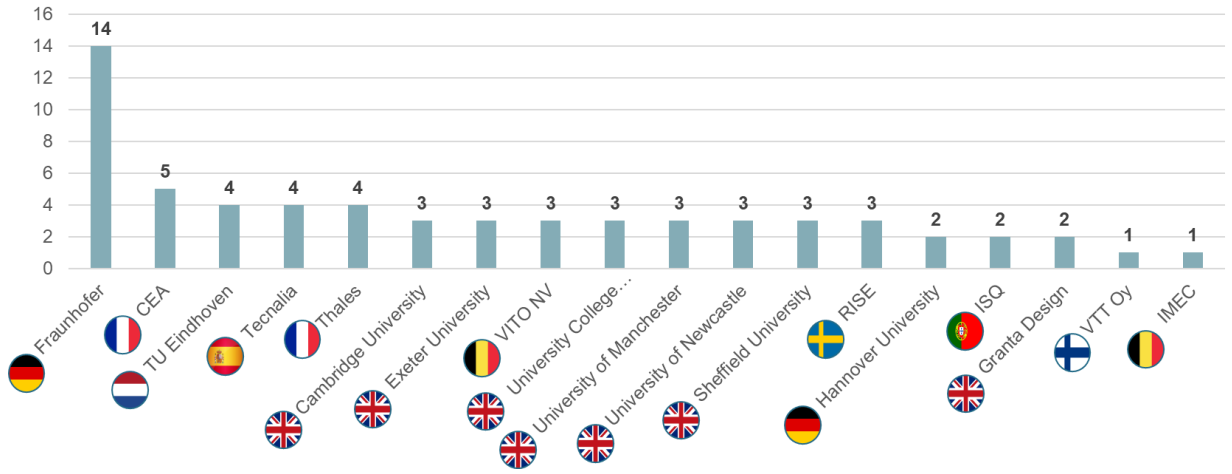


Figure 13. Top facilitators in EU funded OITB projects

7.1.1 10 EU PROJECTS IN THE FIELD OF ADVANCED MATERIALS

The final goal of this deliverable is to compile a market analysis to support the development of the INNOMEM OITB, define the characteristics of its domain and users demands, and a catalogue of services that could make the OITB succeed on the market. To achieve this goal, our research further focused on the 40% of EU funded projects in the field of material science, equivalent to the 10 projects selected for the in-depth analysis, summarized in Table 3.

Out of these 10 projects we selected the testbed for their thematic proximity to INNOMEM, in the field of the development of materials for industrial applications projects, **NewSkin** is the most similar to INNOMEM as it also aims to **develop new advanced membranes and materials** to be applied to several sectors.

The analysis of these projects revealed that OITBs can have different business models, often hybrid ones incorporating a variety of features from different models. These hybrid business models converge characteristics of both value co-creation and revenue generation ones. Typically, test beds business models are oriented to the generation of revenues (e.g. Add On, Performance-based Contracting, Rent Instead of Buy, Solution Provider, Pay per Use). Nonetheless, the hybrid models showed characteristics of business models focused on the co-creation of value, such as the Open Business Model, Integrator and Two-side Market models. Additional details on the OITBs Business Model are out of the scope of this deliverable and are more in-depth analysed in D.2.3.

Table 3. List of EU funded OITB Projects in the material science domain (SOURCE: PNO elaboration)

Title	Coordinator	Start Date	Funding	OITB Scope
INNOMEM Open Innovation Testbed for nano-enabled Membranes	FUNDACION TECNALIA RESEARCH & INNOVATION (SPAIN)	May 2020	14,716,872 €	Different types of membrane materials (polymeric, ceramic, metallic and nanocomposite), surface modification, membrane morphology, geometry and applications will be covered, providing a single entry point for industrial partners, mainly SMEs, while opening-up opportunities for demonstration of innovative nanomembranes in real life industrial problems (TRL7) and thus faster opening the market for these new products.
NEWSKIN Innovation Eco-system to Accelerate the Industrial Uptake of Advanced Surface Nano-Technologies	CONVENTION EUROPEENNE DE LA CONSTRUCTION METALLIQUE ASBL (BELGIUM)	April 2020	14,998,893 €	The NewSkin project aims to create an OITB which will provide technologies, resources and services to uptake efficient and cost- effective innovative processes to manufacture and test nano-enabled industrial and consumer products. Nano-enabled portfolio includes a complete set of processes for the large-scale manufacturing of graphene nano-enabled membranes (characterization and testing facilities).
OASIS Open Access Single entry point for scale-up of Innovative Smart lightweight composite materials and components	FUNDACION TECNALIA RESEARCH & INNOVATION (SPAIN)	January 2019	11,757,065 €	OITB for innovative scale-up of smart lightweight aluminium and polymer-based composite compounds and products to which companies – and more precisely SMEs – can gain access to develop, test and adopt, new lightweight, high performance, multifunctional, safe and environmentally friendly high value materials, components and structures in a cost-effective and sustainable way.
LIGHTME An Open Innovation Ecosystem for upscaling production processes of lightweight metal alloys composites	POLITECNICO DI MILANO (ITALY)	January 2019	11,057,990 €	The LightMe project aspires to be a point of reference for boosting innovation in the field of lightweight metal matrix nanocomposites (MMnC) setting up an Open Innovation Ecosystem (testbed) that will boost the introduction of new functionalities, features and capabilities to lightweight metals.
LIGHTCOce Building an Ecosystem for the up-scaling of lightweight multi-	NATIONAL TECHNICAL UNIVERSITY OF	January 2019	11,096,720 €	Upscaling and testing of multifunctional lightweight concrete and ceramic materials by providing open access to SMEs and Industry to Pilot Lines (PLs) through a one stop shop ecosystem consisting of upgraded Pilot Lines, characterisation & testing facilities,

functional concrete and ceramic materials and structures	ATHENS – NTUA (GREECE)			process modelling, quality assurance and monitoring, and standardisation, safety and innovation management services that will be accessible to the interested stakeholders (clients). The ecosystem will be reached from customers through a single-entry point (SEP).
FORMPLANET Sheet metal forming testing hub	EURECAT (SPAIN)	January 2019	6,907,432 €	FormPlanet project aims to develop, demonstrate and integrate ecosystem (open innovation testbed) offering novel testing methodologies to characterise sheet metal properties, predict part performance and prevent production loses to the sheet metal forming industries, tackling the upcoming challenges in formability and part quality assessment.
I-TRIBOMAT Intelligent Open Testbed for Materials Tribological Characterisation Services	AC2T RESEARCH GMBH (AUSTRIA)	January 2019	7,113,313 €	i-TRIBOMAT will provide the world's first Open Innovation Testbed dedicated to validating and up-scaling new materials, thereby enabling intelligent Tribological Materials Characterisation and fostering industrial innovation in the European manufacturing industry.
LEE-BED Innovation testbed for development and production of nanomaterials for lightweight embedded electronics	TEKNOLOGISK INSTITUT (DENMARK)	January 2019	10,696,766 €	Open Innovation Testbed to de-risk and accelerate the development and manufacturing of nanomaterials and lightweight embedded electronics for the benefit of European industry. rapid development and pilot production of nanomaterial, inks, adhesives and composites as well as digital based pilot production lines.
TEESMAT OPEN INNOVATION TEST BED FOR ELECTROCHEMICAL ENERGY STORAGE MATERIALS	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (FRANCE)	January 2019	8,900,252 €	OITB dedicated to material characterisation for Li-ion batteries, Na-ion batteries, Li all-solid batteries, Printed Zn/Li batteries, Lead-acid batteries, Metal-air batteries, redox flow batteries, supercapacitors and any kind of other electrochemical energy storage device. Qualified private/public Service Providers (SPs) to develop and demonstrate novel materials characterization techniques, data analytics & services and apply them to 25 industrial User Access Cases (UACs).
SIMDOME Digital Ontology-based Modelling Environment for Simulation of materials	ALMA MATER STUDIORUM - UNIVERSITA DI BOLOGNA (ITALY)	January 2019	3,941,630 €	SimDOME aims to develop an industry-ready software framework for materials modelling interoperability, based on EU/EMMC standards on materials modelling, by combining, further developing and adapting existing software developed within previous EU FP7-NMP projects. SimDOME will integrate and provide the upscaled software and services for maintenance and support via the existing and future European Materials Modelling Marketplace (EMMM), the network of modelling translation environments and the Open Innovation modelling testbeds.

7.2 EU ready to market test bed analysis

Following the analysis of the OITB projects funded by the EC, the research focused on the European testbeds already active and whose services are already available on the market. The goal was to identify the main 'ready-to-market' testbed facilitators at the European level to show successful cases of users. Therefore, a non-exhaustive map of EU testbed was created based on a web-based research of the following:

1. Open innovation accelerators: Catapult, Zenzic, NHS England, (UK); Vinnova (Sweden); Business Finland (Finland); I4KMU (Germany);
2. Testbed federation: FED4FIRE+ (EU); FED4SAE (EU); HELNET (Greece); SoftFIRE (EU);

- lists of Testbeds present in different websites: Real-World Testbeds, Testbed Sweden, Nordic Innovation, Produktion2030, World Metereological Organization, Testa Center, TSSG Testbeds, 8th Transport Research Arena TRA 2020, Fraunhofer IEM, DKE, ROLE Project, Fraunhofer IPA, Diario Vasco, Platform Industrie 4.0.

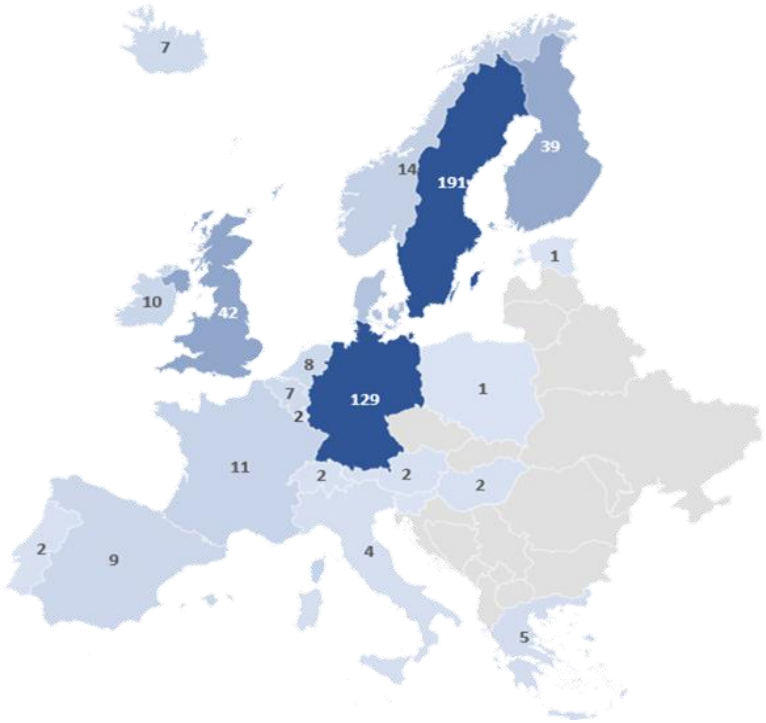


Figure 14 Identified European ready-to-market testbeds (Source: PNO elaboration)

This methodology allowed to identify **511 testbeds** across Europe (Figure 14, most of which based in Sweden (191), Germany (129), UK (42), Finland (39), and Denmark (22). In this scenario, RISE is the organization managing more ready-to-market testbeds (157), followed by Fraunhofer (27).

7.3 OITB and users success stories

This mapping activity supported the identification of success stories of OITBs and users, which guided the profiling of potential users for the INNOMEM OITBs.

These stories are synthetized in the following boxes.

Box 1: Testa Center

Testa Center, based in Sweden, offers a pilot-scale testbed for projects and education in the production of biological products, e.g. monoclonal antibodies, peptides, protein, vaccine, and viral vectors. It is operated as a non-profit company, owned by Cytiva (formerly GE Life Sciences) and spinning out from the collaboration with the Swedish government (supported by Vinnova). The main objective for Testa Center is to bridge the gap from discovery to industrialization.

Below, two examples of successful collaborations with Testa Center: BioLamina AB and Toleranzia AB (Sweden).

BioLamina

Organisation Type: SME (about 20 employees)

Collaboration Period: 2018-2019

Performed Activity: Protein production to support the transformation of cells in any organ of the human body

Operational Benefits: Bioprocessing improvements from a 10-litre to 40-litre scale process to produce MX / CTG Laminin 521 with the opportunity also to achieve a 200-litre scale process in the future.

Economic Benefits: BioLamina AB recorded an increase in turnover from €2.5 million (2018) to €4.6 million (2019).

Toleranzia

Organisation Type: SME (about ten employees)

Collaboration Period: 2019

Performed Activity: At Testa Center, the company has scaled up the process for TOL2, medicines for the autoimmune nerve and muscle disease myasthenia gravis.

Operational Benefits: The process at Testa Center ran very smoothly, and the team was able to scale up the process 40 times, also reducing working time with respect to their own laboratory time.

Economic Benefits: In 2019 Toleranzia AB received 400 000 SEK from SWElife earlier this year for the project in Testa Center.

Box 2: Nordic Proof

Nordic Proof, based in Norway, offers professional and efficient public health care Testbeds that actively contributes to business development in the Nordic healthcare sector. It is a network of partners from renowned health institutions and testing hubs in healthcare in the Nordic countries. It is operated as a non-profit company, administered by Norway Health Tech, and financed by Nordic Innovation.

Below, an example of successful collaboration with Nordic Proof: RabMed AS (Norway).

RabMed

Organisation Type: Start-up (2 employees)

Collaboration Period: 2019-2020

Performed Activity: early-phase studies and testing of the product AmpuSeal (needle-free quick-connector between break-neck glass ampoules and the syringe) through roundtable sessions with three testbeds: Danderyds Hospital in Stockholm, Oslo University Hospital Intervention Center and Oulu University Hospital in Finland.

Operational Benefits: Reduction of production costs for AmpuSeal by 32%.

Economic Benefits: The collaboration has made the product more competitive on the market, opening to business growth thanks to comfortable discussion on production and pricing with the sizeable B2B Medtech device companies.

The Operating Profit has grown from NOK 194.000 in 2018 to NOK 262.000 in 2019, which considering the same revenues flow attests the reduction of operating costs.

Box 3: GMV

GMV, based in Spain, is the owner of Platform-art Testbed. Platform-art is a dynamic testbed for supporting and enhancing the validation of space GNC technologies and related metrology equipment, with real air-to-air metrology dynamic stimulation. Platform-art allows the use of sensors measurements in an open and closed loop, through the recreation of relative (full or scaled) trajectory and attitude profile by using robotic arms.

Below, an example of successful collaboration with GMV: Effective Space Ltd (UK company, now part of Astroscale U.S).

Effective Space

Organisation Type: SME (18 employees)

Collaboration Period: 2017-2019

Performed Activity: Three platform-art© test campaigns performed to allow the launch of the SPACE DRONE™ spacecraft in 2020. These activities include verification of the Rendezvous and Docking (RvD) system, testing of the sensor engineering models, checking of the onboard computers that run the GNC (guidance, navigation, and control) software, and the docking arms system.

Operational Benefits: The collaboration has allowed the highest possible space GNC technologies and equipment maturity to be achieved pre-launch on the ground.

Economic Benefits: The two launches of the SPACE DRONE derive from a multi-year contract which has a total value of more than $100 million.

Box 4: KTH Live-In Lab

KTH Live-In Lab, based in Sweden, offers a full-scale test environment ranging from buildings and installations to housing and management organizations. Research and testing can be carried out in real buildings, which means that not only the product or service itself is evaluated, but also how each component contributes to the performance of the whole building. KTH Live-In Lab can match customer projects with researchers from relevant interest areas and create individual offers within the framework of each project, often financially supported by agencies and accelerators (e.g. Vinnova).

Below, an example of successful collaboration with KTH (Royal Institute of Technology): Labtrino AB (Sweden)

Labtrino

Organisation Type: Start-up (6 employees)

Collaboration Period: 2019 (6 months)

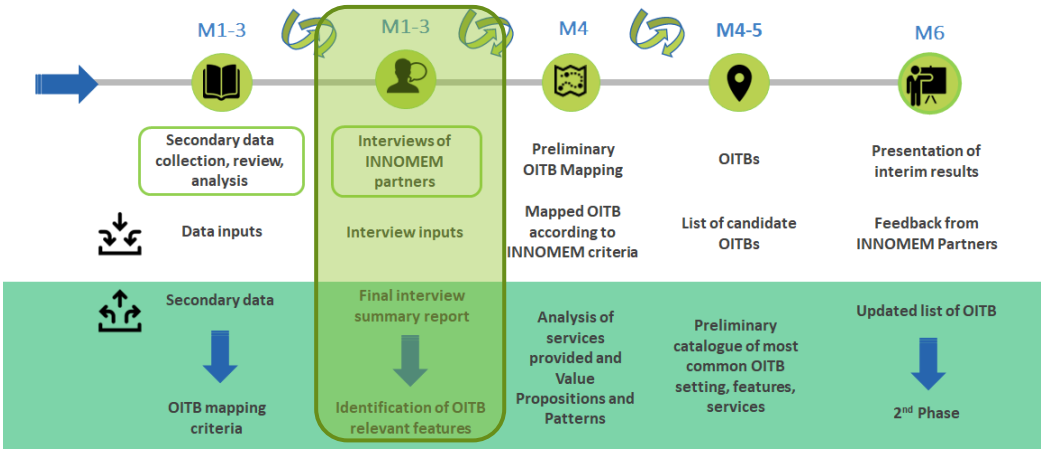
Performed Activity: The project aims to investigate the possibility of reducing water and energy consumption in multi-family homes with the help of Labtrino's innovative non-invasive ultrasonic water measurement technology.

Operational Benefits: The collaboration has allowed the start-up to obtain a solid knowledge of ultrasound technologies and to develop a prototype with an accuracy of 98% in the laboratory. Labtrino claims that it will now be able to reduce the water consumption of Swedish citizens by 40-50%.

Economic Benefits: The collaboration has created new business opportunities. The turnover had grown from 0 SEK in 2018 to 597.000 SEK in 2019.

8 SERVICE PACKAGE ANALYSIS

To give the first preliminary list of the services that will be provided by the OITBs, partners were asked for input on the most relevant features for the OITB mapping. The services divided into technical and non-technical where then organised in different categories to simplify the access to the needed services. Firstly, a mapping of the existing OITBs was created to understand what kind of services can be found on the market. Then the expertise and facilities owned by the INNOMEM partners were identified and analysed to select the most appealing services to be included in the final SEP catalogue, as explained in the following two paragraphs.



8.1 Surveys Analysis

At the beginning of the WP2 a survey was prepared and circulated among INNOMEM partners. They were asked to provide information needed to draw the value proposition and addressed market of the organisations involved in the OITB service provision. Each partner indicated the type of services their universities, research centres, industries and SMEs group provided under the following categories:

- Ownership of one or more pilot lines
- Remarkable Lab infrastructures and technological services
- IP / Technology / Patents
- Business-oriented services
- Technological expertise & capabilities
- Addressed market intended to be reached

The complete list of these services is reported in the Annexes.

The collected information was deeply analysed and the expertise of each organisation, together with the existing pilot lines, were selected with the vision of the OITBs final services intended to be promoted by the INNOMEM SEP with reference to the currently running OITBs.

8.2 OITB characteristic services

In order to identify the kind of services to include in the catalogue of INNOMEM SEP, the different services offered by the scouted existing OITBs closest to INNOMEM technology field (development of advanced materials) were identified, analysed and selected.

Through a desk research, we initially found the catalogues of the existing OITBs. The services provided by each of them were then collected and reported in two classes: technical and non-technical services.

The technical services include those related to characterization, testing, development, modelling, simulation of materials as well as those related to process monitoring and engineering, whilst the non-technical services include the side services such as LCA, business support, regulatory, etc.

For each category, the services and technical or non-technical expertise collected from the various catalogues of OITBs identified in paragraph 7 are reported. The respective OITBs reference related to those services is also reported. The two tables below gather both technical and non-technical services list.

Table 4. OITBs technical services from the analysed projects.

Technical Service	Provided services and expertise	OITB Reference
Membranes Manufacturing	Set of processes for the large-scale manufacturing of graphene nano-enabled membranes, from continuous graphene production to nano-pore creation and functionalization as well as testing facilities.	NEWSKIN
Material Development and Processing	Nano-materials and Nano-intermediates development (**all**); Continuous laser texturing, roll-to-roll (R2R) and Texturing During Molding (TDM) nano-textures mass production processes; Continuous PVD and CVD processes (**Newskin Project**); User Specific Benchmarking of New Materials and Material & Surface Analysis (**i-Tribomat**)	NEWSKIN, OASIS, LightCoce, i-Tribomat, Lee-Bed
Process Monitoring and Control	Pilot plant semi-industrial facilities for the definition of efficient automated controlled and nano-safe nano-coating processes for large components (**Newskin**); Process control systems customized for each Pilot Line; Quality control and monitoring processes (**LightCoce**); Process Monitoring: Scanning electron microscopy, Atomic force microscopy, White light Interferometry, Scatterometry, Diffractometry, Confocal microscopy (**Lightme**); Process control: machine learning (**Lightme**).	NEWSKIN, LightCoce, Lightme, Teesmat
Product Process Engineering	Process and technology development - definition of new technology requirements and processing parameters; Piloting service for novel ceramic and polymer-based products & technologies; Composite Parts Prototyping; High resistance die coatings	OASIS, LightCoce, i-Tribomat, Lee-Bed
Modelling and Simulation	Product design and material selection based on customer's specifications; Thermal, mechanical and multi-physics, predictive and mutli-scale modelling; Process simulation	OASIS, LightCoce, Lightme, Formplanet, i-Tribomat, Teesmat
Testing and Characterisation	Testing and characterization (Fire engineering; Corrosion resistance assessment; Material characterization (mechanical, thermal and chemical); Durability test); NDT inspection	OASIS, LightCoce, Lightme, Formplanet, i-Tribomat, Teesmat

Table 5. OITBs non-technical services from the analysed projects.

Non-Technical Service	Provided services and expertise	OITB Reference
Customers Support	Business Plan and support to help customers to successfully accomplish TRL7 to TRl9 transition; Coaching and Training; Dissemination and marketing. Technical and economic feasibility.	NEWSKIN, OASIS, Lightme, Formplanet, Lee-Bed
Business Linking	Supply chain management and end-users networking. Ensuring a smooth connection of different stakeholders within an ecosystem with the ultimate goal to foster innovation	NEWSKIN, LightCoce, Lightme, Teesmat
Corporate Funding	Access to private and public funding, loans and others to get the necessary resources to industrialize and commercialize products.	NEWSKIN, OASIS, LightCoce, Lee-Bed, Teesmat
Data Management	collection, storage, exploitation, analysis and evaluation of the data	LightCoce, i-Tribomat, Teesmat
Technology Protection	IPR and patent services to protect and take ownership of the work performed.	Lee-Bed
LCA	LCA to translate results into end user markets environmental and cost benefits.	NEWSKIN, Lightme, Lee-Bed
Regulatory	Nano-Safety and Regulatory aspects (standardization).	NEWSKIN, OASIS, LightCoce, Lightme, Formplanet, Lee-Bed, Teesmat

8.3 Preliminary List of INNOMEM OITB Services

The preliminary catalogue of services provided by the OITB reports the ensemble of the technical and non-technical expertise of the INNOMEM partners, owners of different expertise, advanced technologies for materials synthesis and/or PLs and laboratory facilities for the manufacturing of membrane materials. These services were selected from the list provided by the partners during the interview phase by taking in consideration the technical expertise of the value proposition of each INNOMEM organisations and by grouping similar services of different partners in categories, separated into technical and non-technical services.

The technical services group the upscaling facilities and/or expertise offered by each partner and are divided over four categories: i) type of testing and characterisation techniques provided for the evaluation of membranes properties and performances evaluation, ii) upscaling facilities for membrane modules fabrication, characterization and testing, iii) different type of membranes (i.e. polymeric, HF, nanostructured, ceramics, Pd-based) and their applications, iv) process design. Per each service are reported the facilities and pilot lines made available by the partners. The addressed market segment is also indicated in the table collecting the technical services (Table 6). For the non-technical services, the expertise was grouped in the following categories: Data management, Software development, Venturing activities, Techno-economic analysis, Consultancy, Innovation services. The specific services are detailed in the following tables.

Table 6. PLs and associated services accessible in INNOMEM OITB

TECHNICAL SERVICES		UPSCALING FACILITIES/EXPERTISES & CAPABILITIES	Related PLs/expertise owner	Addressed Market
Membranes properties characterisation techniques	Properties evaluation of gas and/or liquid separation	Testing and characterization of membranes for gas separation applications such as hydrogen production/purification/upgrade, pre- and post- combustion carbon dioxide capture, biogas upgrading, natural gas purification, air separation and olefin/paraffin separation (**CNR**)(**TUE**)(**DBI**)/ High pressure permeation testing setup: Up to 60 bar **(TUE)(DBI)** up to 100 bar (under construction) (**TEC**). pilot installations are available for gas and liquid separation testing: - Ultrafiltration - Nanofiltration - Reverse Osmosis - Organic Solvent Nanofiltration - Electrodialysis – Pervaporation, High pressure and temperature mixed gas permeation setups (**UT**); gas sorption, porosimetry (**FORTH**). Pressure increase facility for the assessment single gas permeation performance (**HZG**); Pore size distribution for supports and intermediate layers; helium-leakage test; nitrogen diffusion test; water and solvent fluxes; retention measurement of different molecules like PEG, Dextrane (**RKV**)	CNR/TEC/UT/FORTH/HZG/TUE/RKV/DBI	membrane manufacturers or end-users interested in the performance of a certain membrane or membrane process for a defined application.
	Long term performances evaluation	Lab scale facilities for the verification of the separation performance and long-term stability of membranes up to 55 bar (**HZG**) and 50 bar (**TUE**)(**DBI**) in mixed and single gas environments.	HZG/TUE/DBI	
	Liquid filtration pilot systems	Extensive, flexible lab-scale equipment for aqueous as well as organic solvent filtration fit for down-stream purifications, but also for reaction-separation coupling. Unique, mobile pilots for liquid filtration, both water and organic solvent filtration (Atex). Some of them are also fit for GMP applications or high temperature applications (**VITO**); Test equipment for membrane-dewatering of solvents (**DBI**)	VITO/DBI	ceramic membrane manufacturers, end users (e.g. engineering companies for solutions implementation) researchers (e.g. for PtG-processes)
	Physico-chemical characterization techniques	SEM, FE-SEM, EDX, SAXS, TEM, AFM, XRD, XPS, Raman spectroscopy, AFM, FTIR, MALDI-TOF, STED, Confocal, TGA, DSC, FLIM, Ellipsometry, QCMD, EIS, HPLC, GC, ion chromatography, Zeta-potential (**CNR**, **RWTH, TUE**, **UT**);	CNR/ RWTH/ TEC/ VITO/UT/FORTH/UDE/ICL/AU/ TUE	Value chain sectors of the membrane production; end-users interested in the

		Automatic time lag permeation apparatus (**TEC**); Physico-chemical and performance characterization of membranes in a wide variety of liquid membrane processes (**VITO**); Permporometry, Custom-build lab equipment for membrane manufacturing and testing (**UT)**; analytics and surface analytics of materials (**UDE)**; Laboratory rigs for membrane performance assessment (**ICL**, **AU**, **TUE**).		performance of a certain membrane or membrane process for a defined application; Medical sector, wastewater treatment technology developers; ceramic membrane manufacturers
Membranes scale up	Membranes scale-up	Development and scale-up of membranes *for gas separation applications* such as hydrogen production/purification, pre- and post- combustion CO2 capture, biogas upgrading, natural gas purification, air separation and olefin/paraffin separation (**TEC, UT**). Development and scale-up of membranes for *aqueous applications* such as removal of organic micropollutants, pesticides etc. Membrane module design, construction, and manufacture for membrane areas up to 75 m2 (**HZG**). Development and scale-up of membranes by different phase separation processes. Lab-scale and pilot-scale equipment for membrane preparation/fabrication (**UDE**)	TEC/UT/HZG/UDE	membrane manufacturers; polymers and inorganic materials manufacturer, OEMs, end users
	Membrane modules characterization	reverse osmosis, nanofiltration, ultrafiltration, microfiltration, membrane condensers, membrane contactors, membrane distillation (**CNR**); Construction of module manufacturing equipment (**MESEP**) Pervaporation (**TUE**); testing facilities for membrane module sizes ranging from single fiber modules to 4”-modules (**RWTH**)	CNR/ MESEP/TUE/ RWTH	membrane manufacturers or end-users interested in the performance of a certain membrane or membrane process for a defined application i.e. medical sector, wastewater treatment
Type of membranes	Polymeric membranes and HF membrane applications	development of polymeric and HF membranes: - Membrane geometries, Additives, Materials and solvents, Chemistry in a spinneret – simultaneous membrane formation and functionalization, Module and spacer design and flow MRI analytics, Simulation from pore-size to process level,	RWTH/TEC	Medical sector, wastewater treatment technology developer, entire value chain of

		Application of additive manufacturing techniques for prototyping and device manufacturing (**RWTH**)/ Polymeric, inorganic (metallic and carbon) membranes (i.e. Pd-based thin film membranes by electroless plating and/or PVD, pore fill Pd membranes, Carbon Molecular Sieve membranes) and mixed matrix membranes (**TEC**)		membrane products actors
Type of membranes	Micro- and nanostructured or nanocomposite membranes	Development and scale-up of membranes by different phase separation processes; Development of separation membranes for ultrafiltration, nanofiltration, osmotic separations, membrane distillation and other processes, including micro- and nanostructured or nanocomposite membranes; Advanced surface functionalization of commercially available membranes; Development of porous adsorbers and membranes for contaminant removal from water (**UDE**)/ Fabrication of Thin film composite membranes, Fabrication of Thin film nanocomposite membranes (**UNIZAR**)	UDE/UNIZAR	novel membrane manufacturers
	Ceramic membranes for solvents filtration	Development of new methods for efficient functionalization of ceramic membranes, aimed at increased performance in liquid filtrations; extensive feasibility and proof of concept testing from lab to pilot scale in a broad range of separation problems. Unique expertise in Organic Solvent Nanofiltration (**VITO**). Production of ceramic membranes for micro-, ultra- and nanofiltration. Large multi-channel-tube-structures for filtration like honeycombs production (**RKV**). Manufacturing expertise for Ceramic membranes for water and wastewater treatment; Catalytic membranes for emission control; Ceramic membranes for gas separation, such as CO2 capture; Ceramic membranes for energy conversion, such as solid oxide fuel cell and electrolysis (**ICL/AU**)	VITO/RKV/ICL/AU	ceramic membrane manufacturers, end users (e.g. engineering companies for solutions implementation)

Design	Process Design modelling and simulation	Design and development of membrane modules for the various membrane operations, such as gas separation, membrane distillation, membrane contactors, etc; Modelling and simulation of mass transport in membranes (polymeric, zeolites, metal, etc.) (**CNR**)/ Design and development of membrane modules and membrane reactors (**TEC/TUE**)/ Design and development of efficient membrane-based processes solving industrial purification and/or process intensification problems (**VITO/DBI**); HF module design and prototyping for particular application, design of the production lines with process optimization (**MESEP**). Module level design and prediction of topological, transport, separation and/or barrier properties, geometry characterization and 3D reconstruction from SEM images (**FORTH**); Development and scale-up of membranes for gas separation applications. Design of membrane modules and membrane processes as well as hybrid and integrated processes. Modelling of membrane and membrane module performance as well as process simulation. (**HZG**). Computer modelling of fluid dynamic processes in COMSOL Multiphysics (**UNIZAR**).	CNR/TEC/VITO/MESEP/FORTH/HZG/UNIZAR/TUE/DBI	innovative membrane manufacturers or end-users interested in the performance of a certain membrane or membrane process for a defined application.
Pilot lines for membrane technologies	Mixed Matrix Hollow fibers for gas separation	Dual Layer Mixed Matrix HF spinning system for gas separation membrane manufacturing mewith increase selectivity and permeability. Development of separation membranes for ultrafiltration, nanofiltration, osmotic separations, membrane distillation and other processes, including micro- and nanostructured or nanocomposite membranes. Advanced surface functionalization of commercially available membranes; Development of porous adsorbers and membranes for contaminant removal from water;	PL1. Dual Layer Mixed Matrix HF spinning system for gas separation membrane manufacturing. (TEC)	Raw material provider (e.g. polymers) ; Membrane manufacturer; Engineering in prod. Plant; Final user (in various sectors)
	Pd-based membranes for high performance and selectivity	Electroless plating system for Pd-based membranes onto porous tubular supports for Thinner Pd-based layers, higher permeance (**TEC**). Manufacturing of the supports with intermediate layers for the Pd-based membranes (**RKV**)	PL2. Electroless plating system for Pd-based membranes onto porous	Raw material provider (e.g. polymers); Membrane manufacturer;

			tubular supports. (TEC)/ RKV	Engineering in prod. Plant; Final user (in various sectors)
Pilot lines for membrane technologies	Tubular ceramic membranes	System for chemical functionalization of commercial size, tubular ceramic membranes. Fit for Grignard method (VITO IP) or other grafting techniques. Functionalities: increased performance and/or fouling resistance of membranes in liquid filtration (both water-based and solvent-based liquids) (**VITO**)/Inorganic micro-tubular-membranes with unique bi-modal pore structures, and of various macro-structures (single-layer, multi-layer and multi-channel etc.) for advanced separation and catalysis (**ICL/AU**) High T ceramic membranes (**TUE**)	PL3. Grafting of tubular ceramic membranes. (VITO) PL4, micro-tubular ceramic membranes (ICL/AU) - TUE	ceramic membrane manufacturers, end users (e.g. engineering companies for solutions implementation)
	Polymeric flat sheet membranes	phase inversion on non-woven support and optional subsequent dip or roller coating, including mixed matrix membranes: Membrane casting machine for support membranes onto non-woven material on rolls up; Membrane coating machine for the fabrication of thin film composite membranes	PL5: Flexible flat sheet polymeric membranes (HZG)	research and development chain form polymers synthesis to membrane production, membrane module design and membrane process development, including modelling and simulation
	Nano-phase Ion-Exchange Polymer Membranes	Coating and phase separation technology. Functionalities: Scale-up of polymer-based membranes with optimal ion conductivity and selectivity as well as mechanical and chemical stability.	PL7. Roll-to-Roll Coating of Advanced Nanophase-Segregated Ion-Exchange Polymer Membranes (UDE).	Raw material provider (e.g. polymers); Membrane manufacturer; Final user (in various sectors)
	CO2 separation and water purification	Development and scale-up of membranes for CO2 separation and water purification	PL11. GO/CNTs mixed-matrix membrane system (DEMOK)	CO2 capture and conversion to high added value chemicals technology
Pilot lines for membrane	ceramic molecular sieving and template grown carbon nanotube membranes	Development and scale-up of CVD modified membranes for shifting the equilibrium of Glycerine Carbonate production and other processes.	PL12. Molecular sieving nanoporous ceramic and CNT membranes system (DEMOK)	low energy demand desalination and wastewater treatment technology developers

	Hollow fiber (HF) with enhanced geometry features, decrease concentration polarization and fouling tendency. HF modules at industrial scale. HFs with additional surface modification/crosslinking	Increased efficiency for more demanding membrane applications such as nanofiltration (polyamide) and gas separation (MOFs). Set ups: Microfluidic system, Nanofiltration system, Gas separation plant (**UNIZAR**). In-line nanoscale surface modification technology; spinline facilities including benchtop for dope recipe development and fast screening of various dope recipes, lab scale for parameter screening and process development, pilotline to fabricate larger batches of hollow fiber membranes with consistent quality. Potting centrifuge, (**UT**). Spinning line for novel HF : Testing pilot lines for all membrane applications; Micro CT for 3D imaging; Flow MRI to study hydrodynamic behaviour in membrane modules; Central chemical analytic laboratories (**RWTH**); Centrifugal potting of hollow fiber modules in an industrial scale. (**MESEP**)	PL9. Modification of HFs by microfluidics (UNIZAR) PL10. In-line modification of nano-coatings on hollow fiber membranes (UT); PL13. HF with 3D-printed rotating spinnerets (RWTH Aachen University); PL14 Centrifugal potting of hollow fiber membranes. (MESEP)	HF producers and end users, Medical sector, wastewater treatment technology developer, entire value chain of membrane products actors (polymers and inorganic materials manufacturer, OEMs)

Table 7. Non-technical services provided by INNOMEM partners to OITB system.

NON-TECHNICAL SERVICES	EXPERTISES & CAPABILITIES	INNOMEM expertise owner	Addressed Market
Data management	Software FURTHRmind for research data management; Consultancy on data management; Training on FAIR research data management; Rental of server capacity	FURTH/ TUE	academic and industrial research and development departments
Software development	software FURTHRmind: Customized software development, programming as a service; Programming expertise: Python, Qt	FURTH	academic and industrial research and development departments
Venturing activities	Support in corporate venturing activities to accelerate innovation in companies (B2B “deep tech” breakthrough innovation), addressing the business opportunity maturation process from challenge identification, scouting, acceleration, IP transfer, market validation.	VNTRS	Start-ups, investors, Raw material provider; Membrane manufacturer; Engineering in prod. Plant; Final user (in various sectors)
Techno-economic analysis	Techno-economic evaluations of membrane-based processes.	VITO /TUE/DBI	Membranes manufactures at industrial level

Consultancy	module design, R&D activities in module development, Set up of the production process (**MESEP**). desktop or consultancy work, feasibility studies, characterization of membrane samples, membrane development up to first prototype, application studies, small scale piloting, benchmarking, troubleshooting and building of customized equipment (**UT**).	MESEP/UT	Membranes manufactures at industrial level; polymers and inorganic materials manufacturer, OEMs, end users
Innovation services	Market analysis, business plans, grants & funding scouting,	PNO	Membrane manufacturing value chain sectors

The list of non-technical services gathers a lower amount of expertise at this stage, as it will be fully completed in the following deliverable, D2.4 "Final SEP Definition and business model". The next 6 months will also focus on increasing and better addressing the non-technical services intended to be provided by the SEP, i.e. business support and coaching, acceleration and innovation services, dissemination, marketing, and technology transfer.

9 CONCLUSIONS

9.1 Conclusions and Next Steps

The main goals related of the D.2.1 was to define the market of the membranes in Europe to identify the market segment that the INNOMEM OITB should address to engage potential clients and stakeholders. The research deployed a methodology that mixed desk-based research with the analysis of quantitative secondary data, collected through web-based exploration of available data and database, and qualitative data gathered from INNOMEM solution provider partners. These data were used to carry out the market analysis, highlighting the main results that emerged from the analysis on the testbed ecosystem, and identify potential services to be included in INNOMEM SEP catalogue.

In analysing the European market, which represents the 25% of the global market, we focused on its larger segments, the membrane filtration and separation markets. The EU membrane filtration market is the one with the highest value, accounting for **over 90% of the total** and expected to achieve about €4.660 M of value by 2025, with a CAGR of 8,4%.

Based on a selected sample of 106 organisations, this study found that most relevant OITB clients are **micro-companies in their pre-revenue phase**. When focusing on the European membrane sector, we found that INNOMEM OITB could serve a segment of 401 SMEs, out of which 40% classifies as micro-enterprise, representing the INNOMEM targeted customer segment.

The study identified both technical and non-technical services to be included in the INNOMEM SEP catalogue according not only to the most relevant and commonly offered services to support companies operating in the membrane sector, but also the specific ones that the INNOMEM partners are able to provide, based on their skills, expertise, and assets.

9.1.1 NEXT STEPS

The D2.1 represents the starting point for the D2.2, including the complete market analysis on the demand side. D2.1 provides the analysis and results that will guide the definition of the INNOMEM OITB services. On the catalogue of these services, feedback of the potential customer segment identified in this deliverable will be collected. The goal will be to establish the drivers for potential clients to access INNOMEM OITB.

9.2 Limitations

This analysis presents some limitations concerning, above all, the availability of data. We summarized them as follows:

1. The first difficulties emerged in the exploration of the OITB general concept, which seems to be limited to the European experience of publicly funded testbed, usually under H2020. The concept is, indeed, embedded in the more general category of technology infrastructures enhancing industrial growth and competitiveness through the support of testing, experimenting, and piloting activities.
2. Another barrier was faced during the mapping phase of the ready-to-market testbeds, due to a lack of a single database that would collect information on the various testbed distributed in Europe: this barrier was overcome by referring to the various national accelerators and to some testbed federations, from which it was possible to obtain a fair mapping.
3. Identifying the customer organizations of the ready-to-market test beds for the definition of the customer segment also implicated some challenges. The mapping of the European testbeds already conducted during the research, allowed to identify more quickly some testbeds that disclose information and use cases.
4. Finally, quantifying the market value of membrane sector in Europe was challenging, as this still represents a very niche market and no reports on the whole sectors are available, to the best of our knowledge. Through the analysis of typologies of membranes on which INNOMEM focuses, the barrier was overcome by identifying the two largest market segments that together can be considered as INNOMEM relevant market.

10 BIBLIOGRAPHY / REFERENCES

[1] European Commission, 2019. "Technology Infrastructures – Commission Staff Working Document". Directorate-General for Research and Innovation. Brussels, March 2019. doi:10.2777/316112

[2] COM/2017/0479 final Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0479

[3] COM(2017) 376 final, Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52017DC0376

[4] COM(2018) 306 final, A renewed European Agenda for Research and Innovation - Europe's chance to shape its future: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0306

[5] Proposals for the Common Provisions Regulation, and other Cohesion Policy regulations: https://ec.europa.eu/commission/publications/regional-development-and-cohesion_en

[6] Digital Innovation Hub Catalogue: http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool

[7] SMEs' Access to Key Enabling Technologies: https://ec.europa.eu/growth/tools-databases/kets-tools/kets-tc/map

[8] European Institute of Innovation and Technology: https://eit.europa.eu/

[9] Developing raw materials into a major strength for Europe: https://eitrawmaterials.eu/innovation/

[10] Open access to JRC Research Infrastructures: https://ec.europa.eu/jrc/en/research-facility/open-access

[11] http://juncker.epp.eu/sites/default/files/attachments/nodes/en_01_main.pdf

[12] COM(2012) 341 final, A European Strategy for Key Enabling Technologies – A Bridge to growth and jobs: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0341:FIN:EN:PDF

[13] COM(2012) 582 final, A Stronger European Industry for Growth and Economic Recovery: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0582:FIN:EN:PDF

[14] https://ec.europa.eu/growth/industry/policy_en

[15] Moedas, C. (2015), Open Innovation, Open Science, Open to the World – A Vision for Europe. Luxemburg. doi:10.2777/552370.

[16] https://enoll.org/about-us/

[17] https://openlivinglabsdays15.files.wordpress.com/2015/09/living-labs-as-innovation-platforms-the-key-constructs-habib-westerlund-leminen_final.pdf

[18] De Marco, C. E., Martelli, I., & Di Minin, A. (2020). European SMEs' engagement in open innovation When the important thing is to win and not just to participate, what should innovation policy do? *Technological Forecasting and Social Change*, 152, 119843.

[19] Global Market Study on Chemical Separation Membranes: Development of Membranes for Efficient CO2 Capture Driving Revenue Growth. https://www.persistencemarketresearch.com/market-research/chemical-separation-membranes-market.asp

[20] Membrane Filtration - Global Market Outlook (2017-2026). https://www.openpr.com/news/1878994/membrane-filtration-market-worth-23-74-billion-with-cagr

[21] Global Chemical Separation Membranes Market Analysis, 2013-2023. https://www.giiresearch.com/report/kry725247-global-chemical-separation-membranes-market.html

[22] Membrane Filtration Market by Type (RO, MF, UF, NF), Application (Water & Wastewater, Dairy Products, Drinks & Concentrates), Membrane Material (Polymeric, Ceramic), Module Design (Spiral, Tubular), and Region - Global Forecast to 2023. https://www.marketresearch.com/MarketsandMarkets-v3719/Membrane-Filtration-Type-RO-MF-11603227/

[23] Replicability study of REMEB MBR in urban WWTPs-Deliverable 5.3-Remeb Project. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bd4d113d&appId=PPGMS

11 ANNEXES

11.1 Interviews List

Organisation

Organisation name	National Research Council of Italy – Institute on Membrane Technology (CNR-ITM)
Organisation type	RTO

Value proposition

Pilot lines	
Remarkable Lab infrastructures and tech. services	• Plants for **mass transport properties evaluation of gas separation** membranes/membrane modules, also in presence of water vapour and contaminants (sulphur compounds, acids, VOCs, etc) • Plants for membranes and **membrane modules characterization** for operation such as, for instance, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, membrane reactors, membrane contactors, membrane distillation, etc. • In-house **physico-chemical characterization techniques** for membranes, such as, SEM, XRD, XPS, Raman spectroscopy, AFM, etc.
IP / Technology / Patents	Patents on various membranes and membrane technologies
Business-oriented services	No
Technological expertise & capabilities	• Testing and characterization of membranes for gas separation applications such as hydrogen production/purification/upgrade, pre- and post- combustion carbon dioxide capture, biogas upgrading, natural gas purification, air separation and olefin/paraffin separation. • Testing and characterization of membranes and membrane modules for reverse osmosis, nanofiltration, ultrafiltration, microfiltration, membrane condensers, membrane contactors, membrane distillation • **Design and development of membrane modules** for the various membrane operations, such as **gas separation**, membrane distillation, membrane contactors, etc. • **Modelling and simulation of mass transport in membranes** (polymeric, zeolites, metal, etc.)

Addressed market

The characterization and testing of membranes address both membrane manufacturers or end-users interested in the performance of a certain membrane or membrane process for a defined application.

Organisation

Organisation name	National Centre for Scientific Research "Demokritos"
Organisation type	RTO

Value proposition

Pilot lines	PL11-DEMOKRITOS. Thin-film oriented GO/CNT HF membranes prepared by layer-by-layer deposition. Functionalities: High permeance membranes (>1200 GPU) with CO2/N2 selectivities > 50. PL12-DEMOKRITOS. Chemical Vapour Deposition (CVD) modified membranes prepared by a novel CVD methodology. Functionalities: High permeance CVD membranes with tailored nanopore size, accuracy of the order of 0.02 nm.
Remarkable Lab infrastructures and tech. services	Novel in-line system combine gas relative permeability and differential permeability measurements with ex-situ measurements, (SANS, nitrogen and mercury porosimetry, TEM and SEM etc).
IP / Technology / Patents	Patents on thin film GO/CNT HF membranes and CVD modified membranes in preparation in cooperation with HTF.
Business-oriented services	No
Technological expertise & capabilities	• Development and scale-up of membranes for CO2 separation and water purification • Development and scale-up of CVD modified membranes for shifting the equilibrium of Glycerine Carbonate production and other processes.

Addressed market

Mainly the following markets are addressed on the membrane development and their combinations in addressing market needs in (a) the CO2 capture and conversion to high added value chemicals technology and (b) the low energy demand desalination and waste water treatment technology.

Organisation

Organisation name	FURTHRresearch GmbH & Co. KG
Organisation type	SME

Value proposition

Pilot lines	
Remarkable Lab infrastructures and tech. services	
IP / Technology / Patents	
Business-oriented services	• Software FURTHRmind for research data management • Customized software development, programming as a service • Consultancy on data management • Training on FAIR research data management • Rental of server capacity
Technological expertise & capabilities	• Programming expertise: Python, Qt

Addressed market

Our focus lies on the provision of our software FURTHRmind for research data management and on the customized development of applications for the software. Furthermore, we train our users in general FAIR research data management and in the usage of our software. We address academic and industrial research and development departments. One of our focus areas is the field of membrane research, in which we also have topic-related expertise. Therefore, we are aware of the challenges regarding FAIR research data management that research groups in this area face.

Organisation

Organisation name	RWTH Aachen University
Organisation type	PB

Value proposition

Pilot lines	PL13. **HF with 3D-printed rotating spinnerets.** Functionalities: Novel HF membrane geometries decrease concentration polarization and fouling tendency.
Remarkable Lab infrastructures and tech. services	• Testing pilot lines for all membrane applications • Micro CT for 3D imaging • Flow MRI to study hydrodynamic behavior in membrane modules • Central chemical analytic laboratories
IP / Technology / Patents	Patent on a microstructured hollow fiber membrane system for enhanced mass transfer
Business-oriented services	• Provision of material analysis • Membrane development for industry
Technological expertise & capabilities	• Development of polymeric membranes and membrane applications with a strong focus on hollow fibers: - Membrane geometries - Additives - Materials and solvents - Chemistry in a spinneret – simultaneous membrane formation and functionalization - Module and spacer design and flow MRI analytics - Simulation from pore-size to process level - Application of additive manufacturing techniques for prototyping and device manufacturing • Testing facilities for membrane module sizes ranging from single fiber modules to 4”-modules • Various chemical and analytical surface characterization: XPS, MALDI-TOF, STED, Confocal, FTIR, XRD, SAXS, TEM, SEM, TGA, DSC, FLIM, AFM, Ellipsometry, QCMD, EIS, HPLC, GC, ion chromatography, Zeta-potential, etc.

Addressed market

Our focus lies on the development of new hollow fiber geometries for medical applications, wastewater treatment, and other fields. We also put a focus on the exploration of novel applications for our work. Within this field, we work together with the entire value chain of membrane products. Our cooperation starts with companies providing materials, membrane and membrane product producers to companies applying membranes in their separation processes. As an example, the fabrication of spinnerets with more durable materials (from polymeric spinneret materials to metal) is addressed, which is needed for a scale-up of the membrane fabrication. Screening for new membrane materials is conducted in cooperation with polymer providers. Furthermore, we are also involved in product development in close cooperation with the client. An example of this is the design/development of disposable, single-use membrane modules for

bio-medical protein fractionation. We also offer an array of material and membrane characterization techniques.

Organisation

Organisation name	TECNALIA Research & Innovation
Organisation type	RTO

Value proposition

Pilot lines	PL1. **Mixed Matrix Hollow fibers**. Dual Layer Mixed Matrix HF spinning system for gas separation membrane manufacturing. Functionalities: membrane performance increase (selectivity and permeability). PL2. **Pd-based membranes**. Electroless plating system for Pd-based membranes onto porous tubular supports. Functionalities: Thinner Pd-based layers, higher permeance.
Remarkable Lab infrastructures and tech. services	• Automatic time lag permeation apparatus • High pressure permeation testing setup: up to 100 bar (under construction)
IP / Technology / Patents	Patents on advanced Pd based and carbon based membranes
Business-oriented services	No
Technological expertise & capabilities	• Development and scale-up of membranes for gas separation applications such as hydrogen production/purification, pre- and post- combustion carbon dioxide capture, biogas upgrading, natural gas purification, air separation and olefin/paraffin separation. • Polymeric, inorganic (metallic and carbon) membranes (i.e. Pd-based thin film membranes by electroless plating and/or PVD, pore fill Pd membranes, Carbon Molecular Sieve membranes) and mixed matrix membranes. • Design and development of membrane modules and membrane reactors, together with TUE •

Addressed market

Membrane value chain (proposition that may be adapted, if required):

Raw material provider → Membrane manufacturer → Engineering in prod. plant → Final user (in various sectors)
The development and testing of membranes address mainly membrane manufacturers. However, the projects require to work in partnership with raw material providers (e.g. polymer providers) to develop and validate business cases for application in multiple sectors involving engineering and end-user companies.

Organisation

Organisation name	TECNALIA Ventures
Organisation type	SME

Value proposition

Pilot lines	
Remarkable Lab infrastructures and tech. services	
IP / Technology / Patents	
Business-oriented services	Support in corporate venturing activities to accelerate innovation in companies. Specialized in B2B "deep tech" breakthrough innovation. Access to OITB infrastructure as part of new ventures maturation process to reduce risk and make them more attractive for investment. Venture builder, addressing the business opportunity maturation process from challenge identification, scouting, acceleration, IP transfer, market validation, prototyping, test-bed validation, piloting and commercialization as spin-out or new business line.
Technological expertise & capabilities	TECNALIA Ventures currently manages a portfolio of over a dozen participated companies. Every year more than 100 business opportunities are analyzed and accelerated. Around 50% of them are funded through a "proof-of concept" fund and followed until they are ready to be invested by smart capital. In TECNALIA Ventures, we team up with the entrepreneurial ecosystem to achieve IMPACT bringing together: • Smart Minds: Talent and technologies to realize a competitive advantage • Smart Management Well-rounded entrepreneurial teams • Smart Money: Investors that bring value to ventures

Addressed market

We work with industrial companies willing to activate and accelerate innovation in the whole chain: Raw material provider → Membrane manufacturer → Engineering in prod. plant → Final user (in various sectors).

We also address investors and start-ups

Organisation

Organisation name	VITO
Organisation type	RTO

Value proposition

Pilot lines	PL3. **Grafting of tubular ceramic membranes**. System for chemical functionalization of commercial size, tubular ceramic membranes. Fit for Grignard method (VITO IP) or other grafting techniques. Functionalities: increased performance and/or fouling resistance of membranes in liquid filtration (both water-based and solvent-based liquids).
Remarkable Lab infrastructures and tech. services	• Extensive, flexible lab-scale equipment for aqueous as well as organic solvent filtration fit for down-stream purifications, but also for reaction-separation coupling. • Unique, mobile pilots for liquid filtration, both water and organic solvent filtration (Atex). Some of them are also fit for GMP applications or high temperature applications
IP / Technology / Patents	IP on functionalisation of ceramic membranes by grafting techniques, and beneficial use the grafted membranes: e.g. EP 09155686, EP 14 156 401,3, EP 18 184 449.9
Business-oriented services	
Technological expertise & capabilities	• Development of new methods for efficient functionalization of ceramic membranes, aimed at increased performance in liquid filtrations. • Physico-chemical and performance characterization of membranes in a wide variety of liquid membrane processes. • Extensive feasibility and proof of concept testing from lab to pilot scale in a broad range of separation problems. Unique expertise in Organic Solvent Nanofiltration. • Design and development of efficient membrane-based processes solving industrial purification and/or process intensification problems • Techno-economic evaluations of membrane-based processes.

Addressed market

VITO's developments on chemical functionalisation of ceramic membranes mainly addresses ceramic membrane manufacturers. However, in this stage, the projects require to work in partnership with the separation problem owners i.e. the end-user companies. The end-users can be in a wide variety of sectors. In some cases, engineering companies will be involved in the implementation of the solutions.

Organisation

Organisation name	Me-Sep
Organisation type	SME

Value proposition

Pilot lines	PL14 **Centrifugal potting of hollow fiber membranes.** Centrifugal potting of hollow fiber modules in an industrial scale.
Lab infrastructures and tech. services	Lab centrifuge for HF potting adjustable for module size
IP / Technology / Patents	
Business-oriented services	• Consultancy on module design • R&D activities in module development • Set up of the production process
Technological expertise & capabilities	• HF module design for particular application • HF module prototyping • Construction of module manufacturing equipment • Design of the production lines with process optimization

Addressed market

The development of the hollow fiber modules addresses mainly membrane manufacturers and final users of the membrane that seek opportunities to develop new type of membrane modules or would like to modify existing products. Typically, the projects would require cooperation between HF membrane manufacturer, Me-Sep and end-user of the hollow fiber module to validate business cases and attractiveness of the prototyped product to the market.

Organisation

Organisation name	University of Twente / EMI Twente
Organisation type	Knowledge Institute

Value proposition

Pilot lines	At the University of Twente the following hollow fiber spinning facilities are available: A benchtop spinline for hollow fibers. Goal: dope recipe development and fast screening of various dope recipes. The fiber can be spun in well-controlled conditions. It is equipped with high-pressure syringe pumps to process small quantities of polymer solution and has co-extrusion capability. It fits a walk-in fumehood and is designed such to allow the use of both non-hazardous (e.g. water) and hazardous (e.g. alcohols) coagulants. Lab scale spinline: for parameter screening and process development Pilot spinline: to fabricate larger batches of hollow fiber membranes with consistent quality. Functionalities: The spinline can fabricate single and dual-layer hollow fiber membranes from polymer solutions in any relevant dimension. These membranes may then be used in various applications such as micro- and ultra-filtration, gas separation and dialysis. Ability to co-extrude two polymer solutions or spin with a shell liquid sing a triple orifice spinneret at rates of up to 50 m/min. The dope, bore and shell liquid temperatures may be up to 70 °C. Option to extrude solutions which include particles, e.g. metal organic frameworks, ceramics or carbon using high-pressure syringe pumps. Polymer mixing, filtration and degassing before spinning are integrated within the set-up. Filter pressure measurement is included to monitor the quality of filtration and for protection of the filter and spinneret. Potting centrifuge: for potting hollow fiber membrane modules up to a length of about 1 meter and 4 inch in diameter. Various pilot installations are available for gas and liquid separation testing: - Ultrafiltration - Nanofiltration - Reverse Osmosis - Organic Solvent Nanofiltration - Electrodialysis - Pervaporation
Lab infrastructures and tech. services	Scanning Electron Microscopy (SEM), Field Emission SEM (FE-SEM) and Energy Dispersive X-ray (EDX) Spectroscopy, Permporometry, Custom-build lab equipment for membrane manufacturing and testing, High pressure and temperature mixed gas permeation setups
IP / Technology / Patents	

Business-oriented services	Services like desktop or consultancy work, feasibility studies, characterization of membrane samples, membrane development up to first prototype, application studies, small scale piloting, benchmarking, troubleshooting and building of customized equipment.
Technological expertise & capabilities	Development and scale-up of membranes for gas separation applications such as air separation, CO2-removal from bio- or natural gas, hydrogen production/purification, CO2 capture, olefin/paraffin separation. Development and scale-up of membranes for aqueous applications such as removal of organic micropollutants, pesticides etc.

Addressed market

The services of EMI Twente serve any organization within the value chain:

- Manufacturers of polymers and/or inorganic materials who wish to determine whether they can be used to produce membranes which are likely to perform better than existing options and in turn create added value for their products.
- Membrane producers who wish to develop innovative products but have insufficient or limited in-house research capacity or want to have access to the newest developments at the University.
- Technology providers (OEMs) wishing to investigate the potential of new or existing membranes in specific fields of application or understanding their separation performance.
- End users of membrane technology who want to understand how a certain membrane technology performs in their processes (e.g. process development, benchmarking).

Organisation

Organisation name	FORTH/ICE-HT
Organisation type	RTO

Value proposition

Pilot lines	No
Lab infrastructures and tech. services	Porosimetry, Gas sorption, Geometry characterization and reconstruction from SEM images
IP / Technology / Patents	
Business-oriented services	No
Technological expertise & capabilities	3D reconstruction from SEM images, characterization, membrane and module level design and prediction of topological, transport, separation and/or barrier properties

Addressed market

The design, development and optimization of membranes address mainly membrane manufacturers. However, the projects require to work in partnership with raw material providers (e.g. polymer providers) to develop and validate business cases for application in multiple sectors involving engineering and end-user companies.

Organisation

Organisation name	Helmholtz-Zentrum Geesthacht (HZG)
Organisation type	Research centre

Value proposition

Pilot lines	PL5: Flexible flat sheet polymeric membranes
Lab infrastructures and tech. services	The lab and pilot scales infrastructures involved in INNOMEM are: • Membrane casting machine for support membranes onto non-woven material on rolls up to 70 cm width, 250 m length, casting speed up to 10 m/min, precipitation bath 5-50°C. • Membrane coating machine for the fabrication of thin film composite membranes, very small layer thicknesses are produced down to 50 nm, breadth 0,6m, role length up to 250m, coating speed up to 5 m/min, oven temperature up to 120 °C. • Pressure increase facility for the assessment single gas permeation performance. • Lab scale facilities for the verification of the separation performance and long-term stability of membranes up to 55 bar in mixed and single gas environments. Facilities not directly involved in INNOMEM (but could be used) • Membrane module design, construction and manufacture for membrane areas up to 75 m^2. • Different pilot scale units for investing gas permeation application in the range of up 100 $m^3_{(STP)}$/h, up to 65 bar and temperature ranges from -20 to 110°C. • Model describing operating performance of gas separation membrane modules implemented in different software environments as e.g. Aspen Custom Modeler or MS Excel.
IP / Technology / Patents	There are various patents and confidential, documented know-how relating to flat sheet membrane production.
Business-oriented services	The pilot scale membrane facilities as well as lab and pilot scale facilities for membrane and membrane module resting of HZG can be used by businesses in the scope of contract research.
Technological expertise & capabilities	Development and scale-up of membranes for gas separation applications. Design of membrane modules and membrane processes as well as hybrid and integrated processes. Modelling of membrane and membrane module performance as well as process simulation.

Addressed market

Since HZG is a German government funded research institution, it does not address a market as such. In the field of membrane technology HZG covers the research and development chain form polymers synthesis to membrane production, membrane module design and membrane process development, including modelling and simulation. Along this pathway, cooperation with SME and industry, both from Germany and internationally is an essential part of the activities. These co-operations are either conducted in the scope of collaborative research projects or in the form of contract research. Within membrane technology, pressure driven liquid phase membranes and membrane processes are addressed as well as gas phase separations. The latter are part of INNOMEM. Examples of contract research are (names cannot be provided due to confidentiality restrictions):

- Production of porous membranes by phase inversion using customer supplied polymers.
- Licensing of simulation tools for designing gas separation processes
- Investigation of the operating performance of customer supplied membrane modules, e.g. in vapour permeation and gas separation.
- Production of HZG developed CO_2 selective TFCM for pilot plant applications, including installation into membrane modules (0.2 to 20 m^2 of membrane area).
- Conducting test series of HZG developed as well as customer supplied membrane materials in order to assess permeation performance for single gases and gas mixtures as function of temperature and pressure.
- Investigation of coating performance of company supplied polymers for the production of composite membranes.

Licensing:

- Licensing of HZG membrane production to GMT Membrantechnik GmbH.
- Licensing of HZG gas- and vapour separation membrane technology to Flowserve SIHI, ARID Technologies, Dalian Puricle and Borsig Membrane Technology.
- In excess of 750 plants (ranging from gasoline station organic vapour recovery to large chemical installation with some 1000 $m^3_{(STD)}$/h feed flow) have been installed.

Organisation

Organisation name	Rauschert Kloster Veilsdorf GmbH
Organisation type	company

Value proposition

Pilot lines	**Pd-based membranes**. Manufacturing of the supports with intermediate layers for the Pd-based membranes.
Lab infrastructures and tech. services	- Measurement of pore size distribution for supports and intermediate layers - helium-leakage test - nitrogen diffusion test - water and solvent fluxes - retention measurement of different molecules like PEG, Dextrane

IP / Technology / Patents	Patents on ceramic technologies
Business-oriented services	Yes (see above)
Technological expertise & capabilities	Rauschert is experienced in the extrusion processes of ceramics of all kinds. The production of tubular ceramic membranes is one of our main businesses. We are producing ceramic membranes for micro-, ultra- and nanofiltration. Recently we have started the development of large multi-channel-tube-structures for filtration applying our knowledge of honeycombs production. Rauschert was involved in the development and prototyping of supports and intermediate membrane layers in the projects DEMCAMER and BIONICO. The developments started in those projects will be improved during the current project INNOMEM.

Addressed market

Rauschert produces either the support or coated elements (membrane), which are delivered to other specialized membrane manufacturers (like TECNALIA). Those manufactures do apply special membranes and coating onto our supports or membranes. Afterwards those final special elements can be used to design and build filtration plants for the end customer.

Currently, our biggest customers are in food and beverages industries (like wine, beer, juices filtration). Furthermore, wastewater and process water applications do complete our main markets. We are always increasing our membrane portfolio, in terms of geometries and ways to apply membranes (tailor-made for the application). These developments do intend to increase our knowledge about special applications and do open new markets for us, like in this project. In this project the Pd membranes will be used in hydrogen applications.

Organisation

Organisation name	Universität Duisburg-Essen (UDE)
Organisation type	University

Value proposition

Pilot lines	PL7. Roll-to-Roll Coating of Advanced Nanophase-Segregated Ion-Exchange Polymer Membranes (UDE). Coating and phase separation technology. Functionalities: Scale-up of polymer-based membranes with optimal ion conductivity and selectivity as well as mechanical and chemical stability.
Lab infrastructures and tech. services	• Lab-scale and pilot-scale equipment for membrane preparation/fabrication; • Equipment for general analytics and surface analytics of materials; • Various membrane characterization set-ups in lab- and small pilot scale.
IP / Technology / Patents	Patents and patent applications on membrane preparation, biocompatible materials or template-imprinted materials

Business-oriented services	No
Technological expertise & capabilities	• Development and scale-up of membranes by different phase separation processes; • Development of separation membranes for ultrafiltration, nanofiltration, osmotic separations, membrane distillation and other processes, including micro- and nanostructured or nanocomposite membranes • Advanced surface functionalization of commercially available membranes; • Development of porous adsorbers and membranes for contaminant removal from water;

Addressed market

In the value chain, the membrane manufacturers are mainly addressed by the research done in our UDE team because we can offer our expertise in developing and testing advanced or novel membranes. Additionally, a collaboration with raw material providers may also be envisaged for the development of custom-made functional polymers as precursors for the preparation of advanced or novel membranes.

Organisation

Organisation name	University of Zaragoza (UNIZAR)
Organisation type	RTO

Value proposition

Pilot lines	PL9. **Modification of HFs by microfluidics**. Functionalities: Increased efficiency for more demanding membrane applications such as nanofiltration (polyamide) and gas separation (MOFs)
Lab infrastructures and tech. services	- Microfluidic system - Nanofiltration system - Gas separation plant
IP / Technology / Patents	Co-authored and/or co-shared patents with companies, in the field of the synthesis of porous materials (e.g. ES2574332B1, ES2682056B1, ES2672113B2)
Business-oriented services	No
Technological expertise & capabilities	-Simultaneous modification of HFs with MOF by interfacial polymerization up to 25 fibers at the same time -Fabrication of Thin film composite membranes -Fabrication of Thin film nanocomposite membranes - Computer modelling of fluid dynamic processes in COMSOL Multiphysics

Addressed market

The development and membrane testing is addressed mainly to membrane manufacturers.

Organisation

Organisation name	Imperial College London (IC) / Aston University (AU)
Organisation type	University

Value proposition

Pilot lines	PL4, micro-tubular ceramic membranes
Lab infrastructures and tech. services	Membrane fabrication system; membrane characterization equipment; laboratory rigs for membrane performance assessment.
IP / Technology / Patents	Related patents: 1. KINGSBURY, Benjamin Francis Knatchbull; WU, Zhentao; LI, Kang. CATALYTIC CONVERTER SUBSTRATE WO2013/175239 2. KINGSBURY, Benjamin Francis Knatchbull; WU, Zhentao; LI, Kang. CERAMIC MATERIAL, WO/2014/057260 3. KINGSBURY, Benjamin Francis Knatchbull; WU, Zhentao; LI, Kang. A SUBSTRATE AND A METHOD OF MANUFACTURING A SUBSTRATE WO2015/033157 4. WU, Zhentao; LI, Kang. MONOLITH WO/2015/177517
Business-oriented services	N/A
Technological expertise & capabilities	• Ceramic membranes for water and wastewater treatment • Catalytic membranes for emission control • Ceramic membranes for gas separation, such as CO2 capture. • Ceramic membranes for energy conversion, such as solid oxide fuel cell and electrolysis

Addressed market

Innovate designs of membrane (geometry and microstructure), membrane unit and process to improve efficiency and reduce cost of different processes, which locates at Membrane manufacturer → Engineering in prod. Plant by understanding key requests or expectations from Final users. An example of this is Microtech Ceramics Ltd, a spin-off company from IC in 2014. By understanding the limitation of current catalytic converter technology, innovations in ceramic substrate designs were achieved via our membrane technology, which is subject for commercialization in partnership with catalyst provider, engine test organization and even car producers etc.. This also echoes with Showcase in WP3 to address demands from Liqtech.

Organisation

Organisation name	CiaoTech (PNO Group)
Organisation type	Large Industry

Value proposition

Pilot lines	
Lab infrastructures and tech. services	
IP / Technology / Patents	IP and R&D technology trends analysis, Finding relevant sector networks, Categorizing stakeholders according to affinity or investing capacity
Business-oriented services	Market Analysis, Business Planning, Grants & Funding, Tax Incentives support, Coaching and Open Innovation
Technological expertise & capabilities	Notably, PNO consultants are not technicians, but most of them are ex researchers and have a scientific degree or PhD.

Addressed market

Membrane value chain (proposition that may be adapted, if required):

Raw material provider → Membrane manufacturer → Engineering in prod. plant → Final user (in various sectors)

We provide horizontal services to support each one of the above parts of the value-chain. We can support their decision-making with an ad-hoc analysis. Support their funding and also connect them through our network and improve investor-client match in the loop.