

# Hydrogen



We simplify complexities through our expertise,  
making what seems impossible, possible.

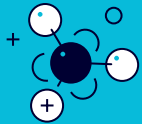
Make it sure,  
make it simple.

# Hydrogen

## Experience and Capabilities in Hydrogen

The required scope of work requires a thorough understanding of the hydrogen value chain in terms of current capability and future needs to meet decarbonization goals. RINA has deep experience developing technologies in the hydrogen sector relating to production, transportation, storage and consumption in industrial and commercial applications. Through these activities a thorough understanding of the hydrogen ecosystem has been developed including detailed knowledge of economic models, technical barriers and supply chain capability.

RINA has been involved in more than 25 initiatives in hydrogen providing a wide range of services including:



Strategic market intelligence



Technical and financial due diligence



Technology qualification



Research & Development (R&D)



Materials and components



Concept, feasibility, and design



Full scale test site for experimental validation



HSE and permitting operability



Assurance and asset integrity management



Training



Replication roadmap and business modeling



Risk assessment

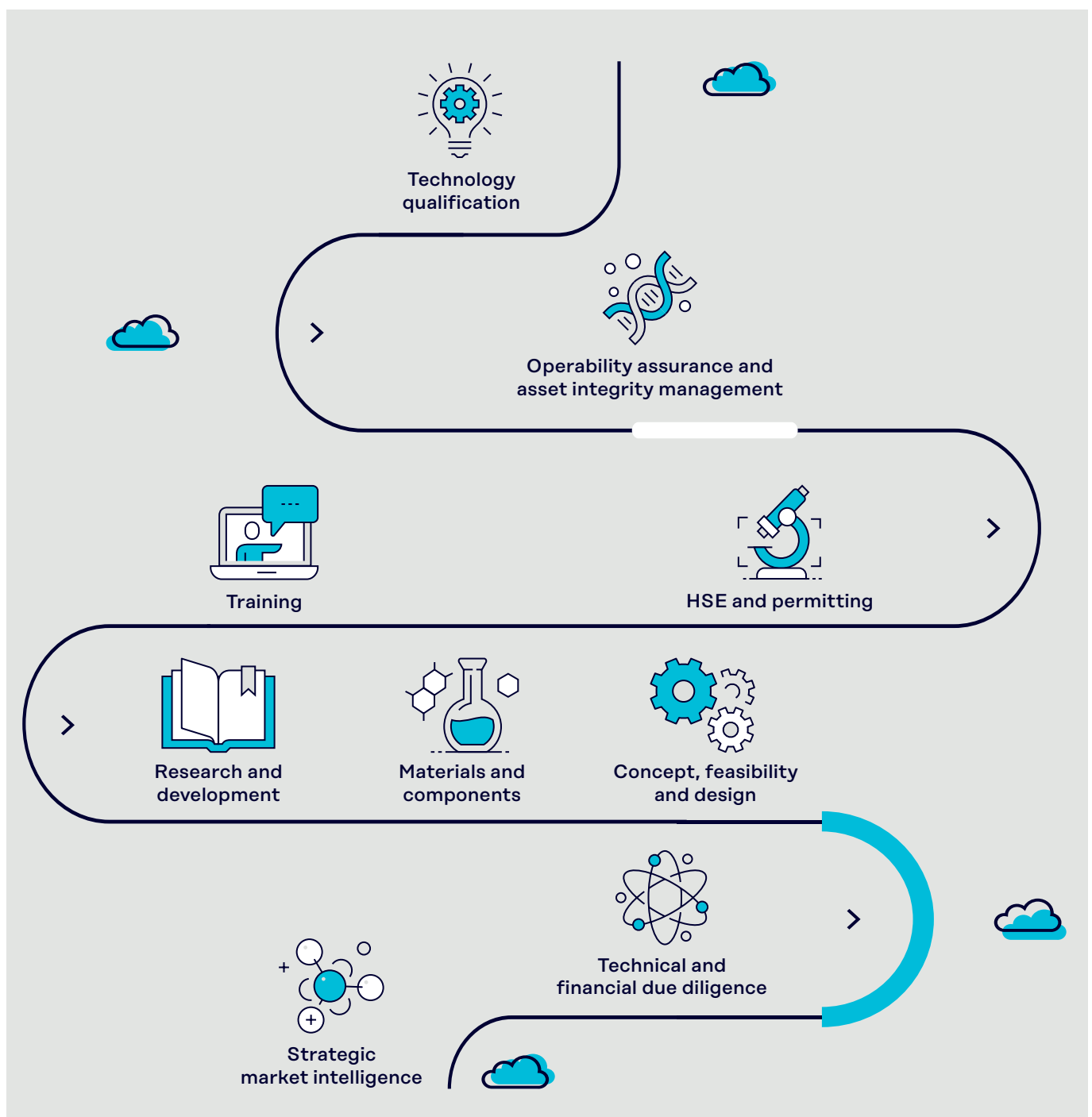
## Engineering services for H2 integration

Our engineering services for H2 integration include compatibility studies of H2 assets with the power grid and electrical integration (e.g. harmonic studies), analysis of ancillary (energy services) markets, compatibility studies for direct connection of electrolyzers with renewable plants and analysis of regulatory and fiscal frameworks, technical and economic feasibility studies for the implementation of H2 technologies in industrial environments (including selection and sizing of the most appropriate technologies) and application of H2 and component (e.g. fuel cells) selection in niche sectors (datacentres, emergency kits, remote and off-grid facilities etc.).

# Building capability

We have carried out a number of different activities in order to increase our experience in the utilisation of hydrogen, allowing us to offer a roadmap of services as shown below:

- Green steel scenario evaluation to direct reduction with green hydrogen, CO<sub>2</sub> tax evaluation
- Hydrogen scenario analysis for reheating furnaces, CO<sub>2</sub> emission reduction
- Metallurgical know-how on the effect of hydrogen in steel
- Standard and Fit-for-Purpose laboratory testing to assess the material resistance to hydrogen embrittlement
- Unique testing capability (lab and full scale) using hydrogen at high pressures (up to 1000 bar)
- Burner fed by fuel and hydrogen up to 60%: Efficiency, low emission, safety requirements, product side effects
- Participation in international research organisations such as EPRG (European Pipeline Research Group)

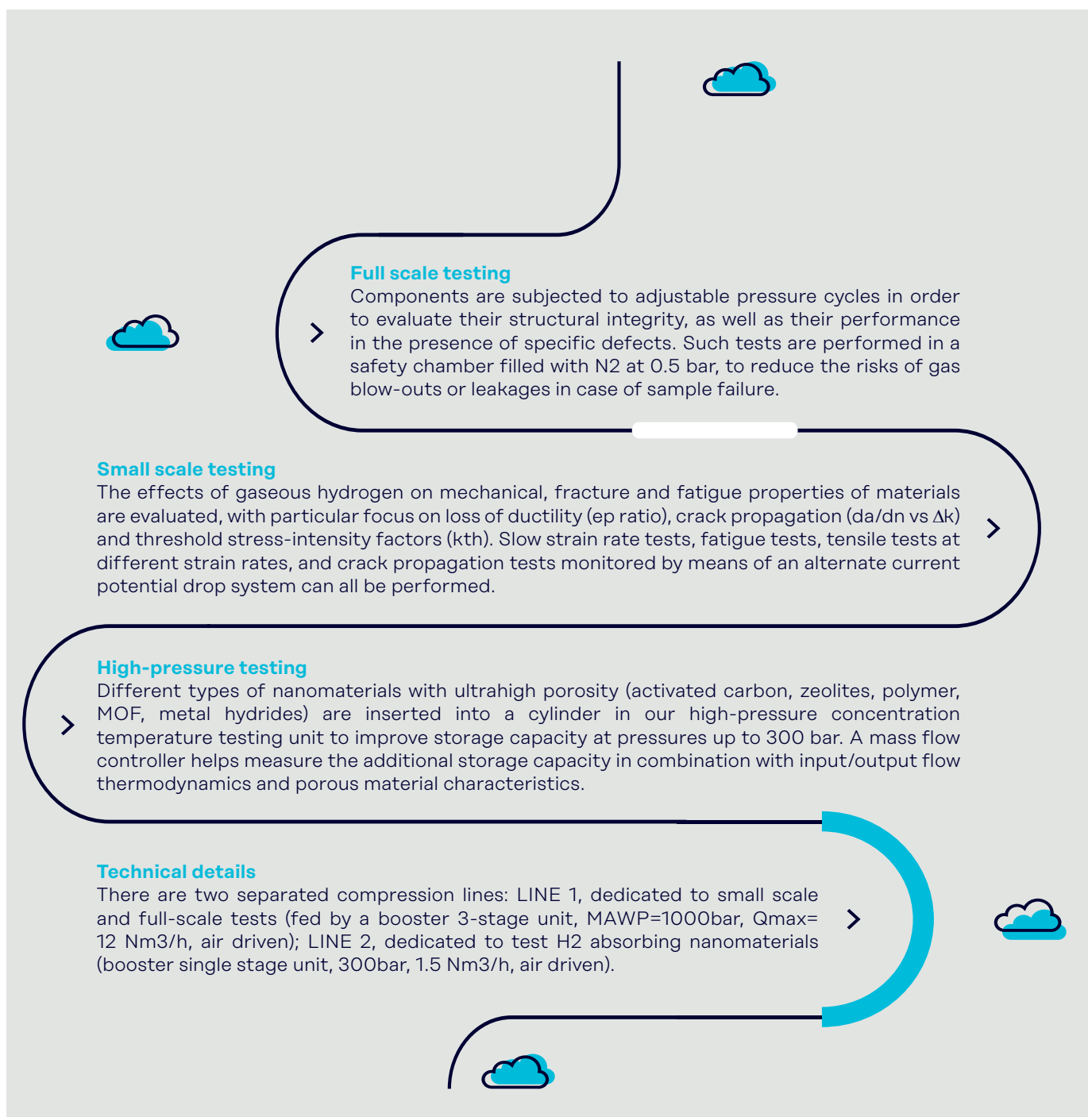


# $\Delta$ H Laboratory

We have invested heavily in advanced research and development capabilities to test products in hydrogen environments, including facilities capable of evaluating material and component performance in the presence of gaseous hydrogen at pressures up to 1000 bar / 14500 psi.

Facilities can accommodate ultrapure hydrogen supply from cylinders or directly from internal production by an H<sub>2</sub> generator, together with the possibility of studying gas mixtures with pollutants or other gases and we are also able to determine the improvement of storage capacity by nano-porous materials, and make use of Ultrapure H<sub>2</sub>, H<sub>2</sub> with contaminants, or mixtures of H<sub>2</sub> with other gases, including methane.

Our  $\Delta$ H Laboratory allows us to carry out the full scale, small scale and high-pressure testing, as illustrated below:



# Key projects

## MELITA PIPELINE

**Client:** Malta Ministry for Energy & Water

**Location:** Malta

RINA is engaged in the role of project management consultant for the Melita TransGas Pipeline FEED project, consisting of a 22" pipeline that allows for the bidirectional transportation of natural gas. The scope of works included examining the documentation developed by the engineering contractor regarding the possible injection of renewable gases into the interconnection pipeline consisting of a blend of dry natural gas and hydrogen with a maximum hydrogen concentration up to 10% and between 10% and 100% and covered the transportation of 100% pure bio-methane and of raw biogas.

## HYWIND TAMPEN

**Client:** Confidential

**Location:** Norway

RINA performed a technical assessment concerning a proposed 88 MW floating offshore wind generation scheme located close to the Gullfaks oil facility, including feasibility and power system study reports covering power export to the existing oil facility, an assessment of the potential impact on reliability, stability and availability of the Gullfaks Power System, analysis of the potential impact on power system harmonics, power flows, fault levels and protection systems, comment on the potential impact on overall greenhouse gas emissions and recommendations for improvements and further studies before financial close.

## HYWIND TAMPEN

**Client:** Kvaerner

**Location:** Norway

RINA is providing quality control and assurance services related to the floating wind mooring system including brackets, bridles, shackles, tri-plates, H & Y links, studless mooring chains, connectors, tensioners, mooring wires and anchor shackles. Inspections were carried out to cover the monitoring of all manufacturing operations, witness heat treatment operations, mechanical test witnessing, dimensional and NDT tests, proper implementation of QA/QC, traceability, final inspections, material storage and overseeing shipments.

## HYWIND TAMPEN

**Client:** Equinor

**Location:** Norway

RINA was contracted to provide geotechnical laboratory and reporting services for the investigation relating to the anchor/foundation system. The scope of work included integration of the shallow and deep-water geophysical data and sub-bottom profile interpretation with data from geotechnical locations across the site. Results from in-situ testing (PCPT) and laboratory testing (thermal conductivity) were superimposed with the sub-bottom profiles and schematic geological cross sections were developed for the turbine park.

## H2OCEAN PROJECT

**Client:** European Commission

**Location:** Europe

The project led to the development of an innovative, harmonised design for an economically and environmentally sustainable multi-use open-sea platform, with the concept including offshore structures and floaters to harvest wind and wave power, using part of the energy onsite for offshore hydrogen production to be used for storage and shipping. RINA acted as designer and systems integrator through the development of a full system conceptual design, harmonisation of the various unit operation concepts provided and development of the required HAZOP analyses for the whole concept design, including the offshore hydrogen production unit.

### NESOI PROJECT

**Client:** The EU Islands Facility H2020 GA

**Location:** EU islands

RINA leads the technology scouting activities and the selection of island projects to be supported by the NESOI European Island Facility, which has three key objectives: promote investments for energy transition in the islands; facilitate the decentralization of energy systems; contribute to EU policies and the achievement of 2030 targets. To achieve this, NESOI is in the process of building a platform able not only to provide first-step funding for islands energy transitions plans, but also a one-stop-shop for islands to find ideas and effective organisational, technical and financial instruments for the whole value chain of a project.

### FLOATING PV

**Client:** Equinor

**Location:** South East Asia

Equinor is in the process of expanding its business in the floating solar PV industry and is looking to understand risks, opportunities and costs associated with the use of the technology. To this aim, RINA completed an assessment which included assisting in establishing a cost estimate for development, construction and operations, identifying suppliers that could deliver the project under an EPC contract on location, and providing an overview of floating, mooring and anchoring, and inverter requirements including a comparison between the main suppliers of floating structures.

### OFFSHORE LNG RECEIVING PROJECT

**Client:** KOGAS

**Location:** Korea

RINA was appointed by the Korea Gas Corporation for the development of a project model analysis study concerning offshore LNG receiving facilities. The scope of work included analysis of LNG markets (FSRUs, FSUs, LNGC) for a general overview on solutions currently available, an overview of the main potential constraints to affect/impede project development based on main international standards and design best practices (site independent), analysis of 10 site locations and of the most suitable solution to guarantee small scale LNG distribution/regasification.

### SMILE - SMART ISLANDS ENERGY SYSTEM H2020

**Client:** European Commission

**Location:** Europe

SMILE project which will demonstrate different innovative technological and non-technological solutions in large-scale smart grid demonstration projects in the Orkneys, Samsø and Madeira islands, paving the way for their introduction onto the energy market. RINA is acting as project coordinator, ensuring the effective implementation of new controlling algorithms and predictive measures in order to avoid grid unbalancing and carrying out overcharging and frequency mismatching as well as checking the status of the smart grid resilience and of cyber security measures adopted.

### MULTI UTILITIES SMART ENERGY GRIDS H2020

**Client:** European Commission

**Location:** Europe

Europe 2018 - ongoing MUSE GRIDS - Multi Utilities Smart Energy GRIDS H2020. MUSE grids aims to demonstrate, in two weakly connected areas (a town on a top of a hill and a rural neighborhood), a set of both technological and non-technological solutions targeting the interaction of local energy grids to maximise local energy independency. As project coordinator, RINA is providing analysis to verify the replicability and exploitation of MUSE grids technologies in order to leverage the monitored results of demonstration activities towards guideline redactions for future applications on the market. In addition, RINA will provide guidelines for replication and virtual simulations via the MUSE grids planning tool.

## Key projects

### INSULAE H2020

**Client:** European Commission

**Location:** EU islands

The EU-funded INSULAE project aims to help islands find locally produced, sustainable and low-cost sources of energy. They will develop interventions linked to seven replicable use cases at three lighthouse and, to assist Europe's policymakers, the project will design an investment planning tool to be displayed at four Follower Islands in Germany, Greece, Spain and the Netherlands Antilles for the improvement of related action plans. RINA is in charge of energy regulatory aspects as well as analysis of the gender, socioeconomic and environmental aspects of the islands and delivery of business models and exploitation strategies.

### TALENT H2020

**Client:** European Commission

**Location:** Europe

TALENT aims to develop new modular, scalable and safe technological solutions for a cost-effective integration of electric batteries in the grid in order to enhance the flexibility in the energy system. RINA is responsible for the analysis of the environmental impacts of the TALENT assignment as well as developing an exploitation strategy. Moreover, RINA will check regulatory aspects by assuring the compatibility with EU standards in the energy sector as well as with the standards and risks analysis of the decentralised hybridised energy management system software and hardware. RINA will assist in the evaluation of the different technologies developed at multi-home, district and utility level and will set the specifications for the battery digital twin.

### E-LOBSTER

**Client:** European Commission

**Location:** Europe

European distribution networks and light-railway are looking at integrated solutions to enhance distribution grid stability by providing ancillary services inter-exchanging electricity, and E-LOBSTER intends to capture such potential through the development of an innovative, economically viable and easily replicable electric transport-grid inter-connection system. RINA is acting as project coordinator and will provide guidelines for the cyber-security of smart transport grids in order to increase their reliability and resilience as well as developing a platform for the optimised control of the interexchange of electricity between railway electricity and distribution networks.

### RESILIENT

**Client:** European Commission

**Location:** Europe

The concept behind RESILIENT is the design, development and instantiation of a new system of interconnectivity between buildings, distributed energy resources and grids, assessing the associated energy and environmental benefits. The integrated concept, has been validated in three pilot projects in Belgium, Italy and the United Kingdom, used to assess the energy and environmental benefits and to validate models and technologies to apply them afterwards throughout Europe. RINA's role is that of project coordinator, responsible for the definition of an exploitation strategy, monitoring district pilots and managing the resulting data for further validation.

### EVERYWH2ERE

**Client:** European Commission

**Location:** Europe

The EVERYWH2ERE project will integrate already demonstrated robust PEMFC stacks and low weight intrinsically safe pressurised hydrogen technologies into easy to install, easy to transport FC based transportable gensets. 8 'plug and play' gensets will be realised and tested through a pan-European demonstration campaign at construction sites, music festivals and urban public events all around Europe, demonstrating their flexibility and extended lifespan. A detailed logistic and environmental analysis will be performed in order to study the complete techno-economic viability of the gensets and a decision support tool will be created to support end-users in future replicability.



### FLEXNCONFU

**Client:** European Commission

**Location:** Europe

The use of alternative carbon-free fuels in existing power plants and a high penetration of renewable energy sources into the grid are required to meet EU 2030 and 2050 climate and energy goals. The FLEXnCONFU project will develop innovative, economical, viable and replicable power-to-X-to-power solutions to be integrated to existing and new power plants to level the load, and to unleash their flexibility, converting electricity into hydrogen or ammonia to, in turn, be reused locally in the same power plant to respond to varying demand, thus reducing time their environmental impact.

### BEST4HY

**Client:** European Commission

**Location:** Europe

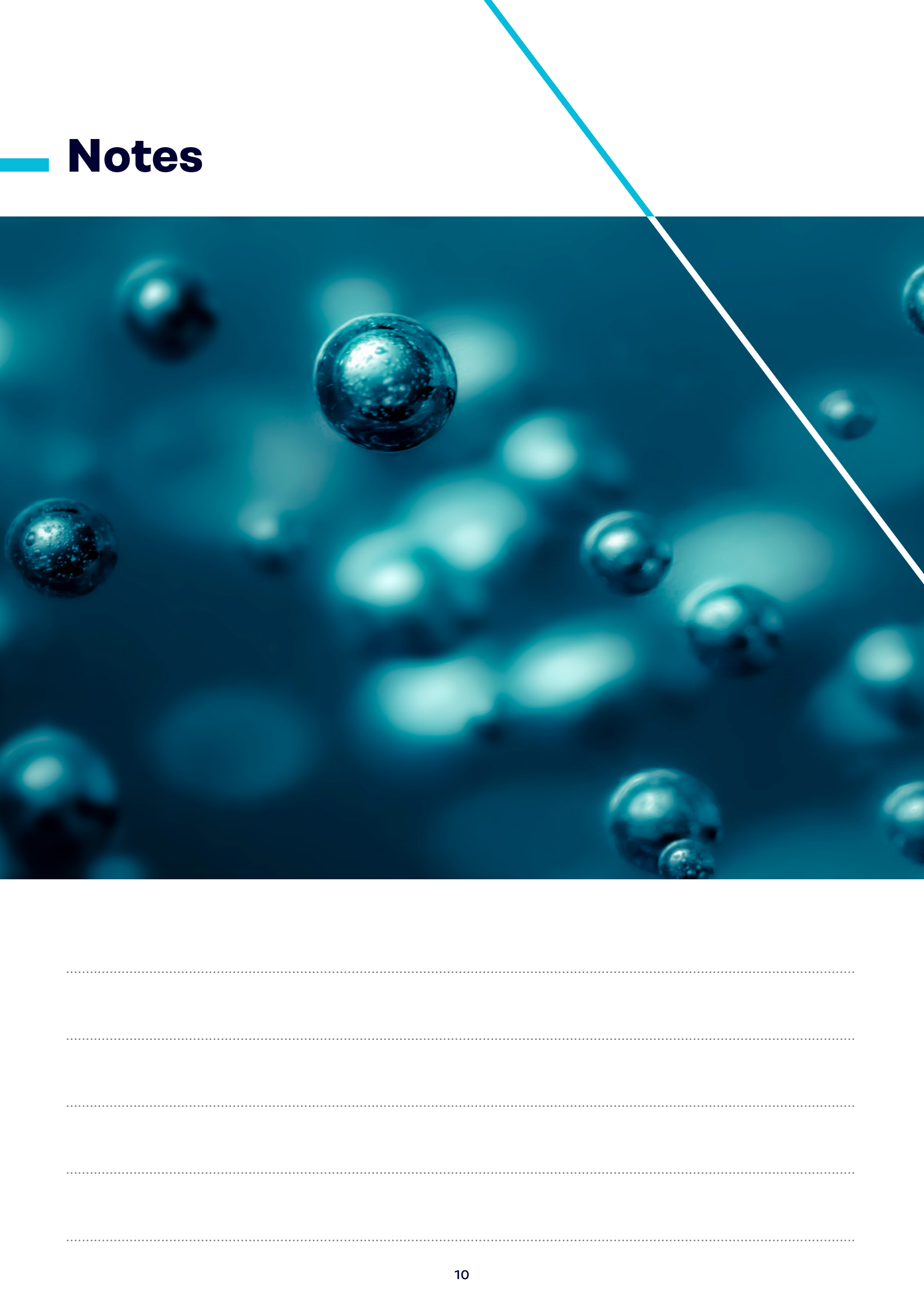
The objective of the project is to increase the maturity of recycling technologies adapted or developed specifically for proton-exchange membrane and solid oxide fuel cells which would ensure the maximisation of recycling of critical raw materials including PGMs, rare earth elements, cobalt and nickel. The technologies are evaluated for cost efficiency and environmental impact to ensure the materials bring value to the European economy without harmful emissions or high energy costs. Pt and membrane materials are delivered back for manufacturing MEAS to be tested in full stacks, while both anode and cathode materials from EoL solid oxide fuel cells are treated for direct recycling into cells.

### ENGIMMONIA

**Client:** European Commission

**Location:** Europe

ENGIMMONIA will study the benefits of using a carbon-free fuel in vessel engines, coupling its benefits/performances with other clean energy technologies such as waste-heat recovery solutions, on board renewable energy integration and on board fuel/energy/heat management optimisation via real time energy management system geared towards the creation of the ENGIMMONIA poly-generation energy hub. Targeting the long term full decarbonisation of the shipping sector, ENGIMMONIA will capitalise on previous R&D initiatives that tested some of these technologies for terrestrial application, moving them to marine sector coordinated by RINA as a naval classification body.



# Notes

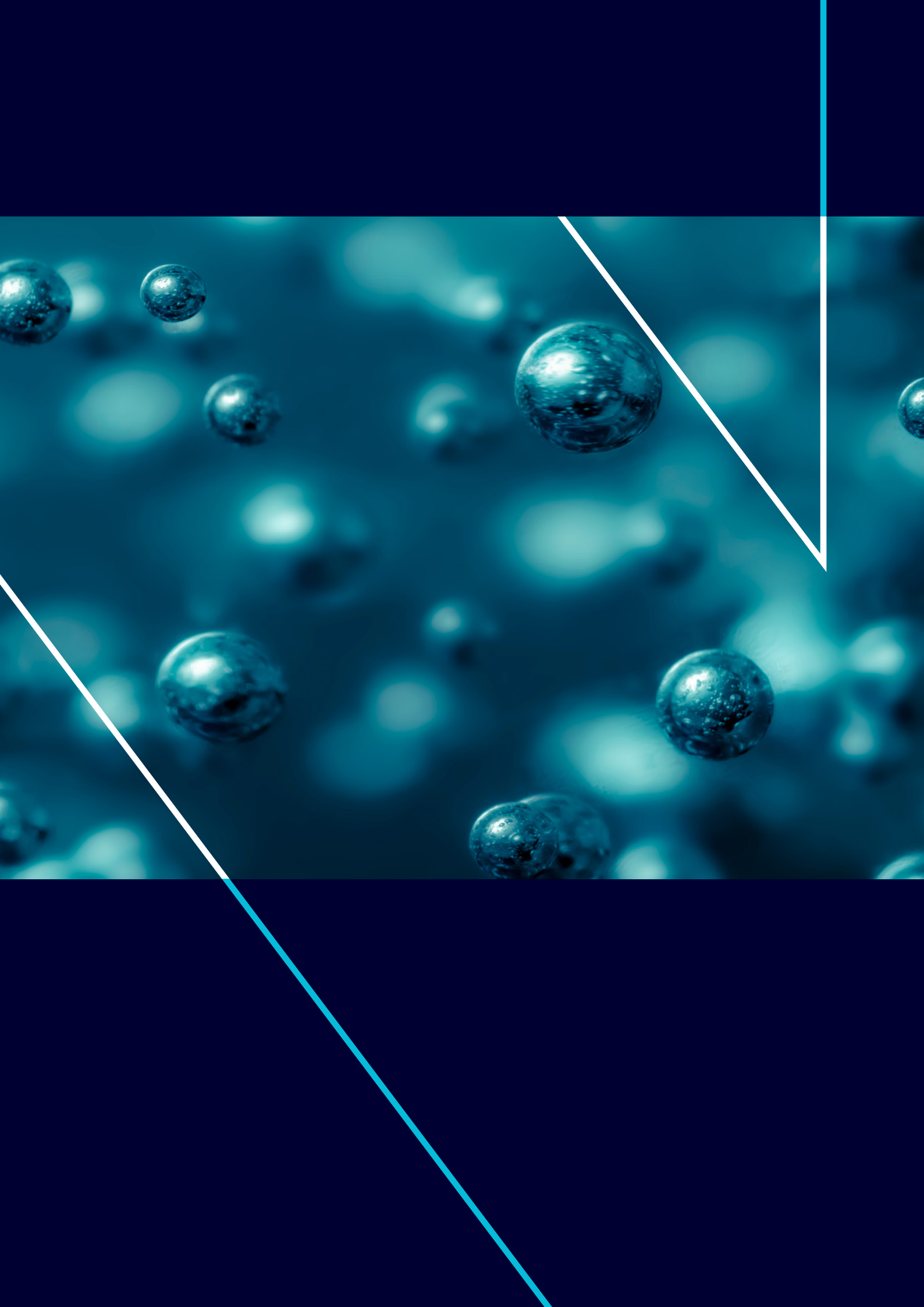
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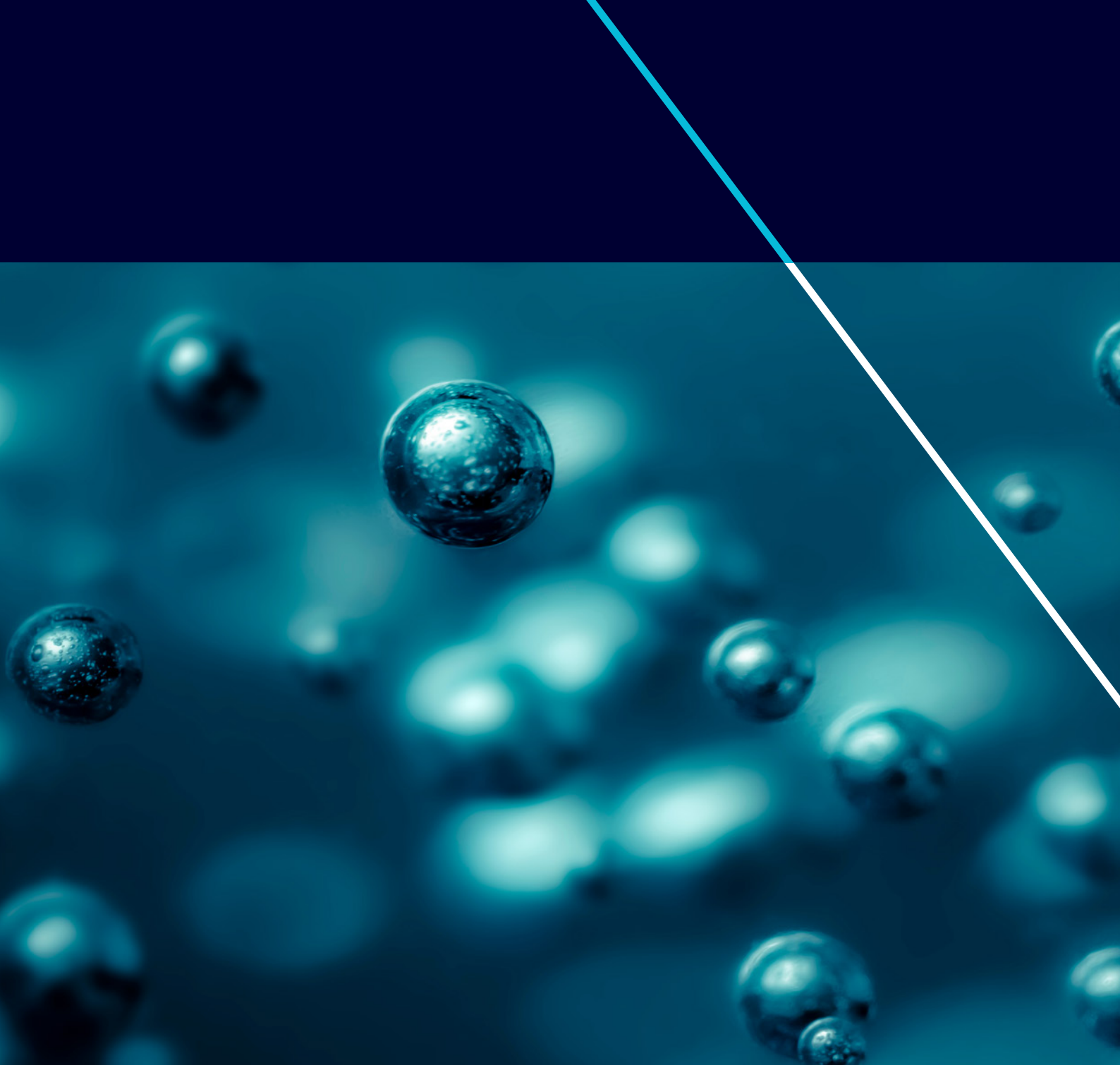
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info@rina.org  
**rina.org**

RINA consists of the parent company RINA S.p.A., the holding which controls the main sub-holdings RINA Services S.p.A. and RINA Consulting S.p.A. In order to ensure compliance with the applicable recognition, authorization, notification and accreditation rules, including those relevant to the management of impartiality, RINA has adopted a governance and organizational model. According to this model, the sub-holdings are subject to direction and co-ordination by the holding in the finance, administration, strategic, organizational, managerial and business continuity fields, while technical and operational decisions remain under the exclusive responsibility of the sub-holdings and their controlled companies. The strict separation of duties in the governing bodies and the impartiality risk assessment, which identifies and manages the impartiality and conflict of interest threats coming from the company relations, ensure compliance with the applicable impartiality rules.