

FINAL PUBLISHABLE REPORT

Grant Agreement number 18NET01
 Project short name Energy Gases
 Project full title Support for a European Metrology Network for energy gases

Project start date and duration:		01 May 2019, 48 months
Coordinator: Annarita Baldan, VSL		Tel: +31 15 2691500
Project website address: www.euramet.org/energy-gases/		E-mail: a.baldan@vsl.nl
Internal Funded Partners:	External Funded Partners:	Unfunded Partners:
1. VSL, Netherlands		
2. IMBiH, Bosnia and Herzegovina		
3. NEL, United Kingdom		
4. NPL, United Kingdom		
5. RISE, Sweden		

TABLE OF CONTENTS

1	Overview	3
2	Need	3
3	Objectives	3
4	Results	4
4.1	Publication of the EMN for Energy Gases Strategic Research Agenda	4
4.2	The EMN for Energy Gases brand and the Platform of Measurement Services	6
4.3	Creation of tools to enhance synergies between the EMN for Energy Gases members, stakeholders and other parties	9
4.4	Dissemination of outputs derived from EU metrology research projects under the portfolio of the EMN for Energy Gases for the benefit of policy, regulation and standardisation	11
5	Impact	12
6	List of publications	13
7	Contact details	13

1 Overview

Driven by EU legislation on renewable energy (2009/28/EC) and by the ratification of the Paris agreement, which aims at a zero-carbon economy, and recently by the EU's Green Deal ambition to become climate neutral by 2050, renewable energy gas sources are gradually entering the market. The European Metrology Network (EMN) for Energy Gases, with a broader remit than traditional metrology, has demonstrated to be the glue that attracts the European measurement community active in energy gases and related stakeholders.

This project has supported the EMN for Energy Gases in its initial tasks, thus providing the basis for a harmonised and sustainable European measurement infrastructure to catalyse the energy transition. Specifically, it contributed to create a strong EMN brand and to set up the tools for the network to continue to operate in the future. The Strategic Research Agenda for energy gases metrology, in combination with a successful stakeholder engagement, has led to the identification and prioritisation of research topics in the metrology research programme. A platform of measurement services, embedded in the newly created network website, has created the opportunity to showcase the EMN member capabilities in energy gases including calibration, reference materials, training and proficiency testing. A report on the main outputs of metrology research projects in the field of energy gases was developed to enhance awareness of the role of metrology and to support standardisation activities in energy gases. Furthermore, potential synergies for collaborative schemes have been identified and worked out, that will facilitate an integrated European metrology for energy gases.

2 Need

The energy gases stakeholders have established national and European platforms to address the fundamental challenges caused by the diversification of energy sources and by the fluctuations in renewable energy supply and demand. In July 2020, the European Commission released the Hydrogen Strategy for a Climate-neutral Europe as part of its efforts to deliver the European Green Deal. The strategy defines a target of 1 million tonnes of hydrogen and an electrolyser capacity of 6 GW by 2024, and 10 million tonnes and 2x40 GW by 2030. Lately the European REPowerEU plan was published to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition.

The robustness of the measurements performed in these areas is often compromised by a lack of the quality infrastructure: namely of traceable measurement standards and of appropriate quality control, standardisation and procedures. Addressing these needs and bridging the gap between the metrology and end user communities goes beyond the current activities of National Metrology Institutes (NMIs), Designated Institutes (DIs) and technical committees under EURAMET and the International Committee for Weights and Measures (CIPM).

The energy transition needs European harmonisation and implementation, which will extend beyond national boundaries. Therefore, a coordinated effort has been needed to create a strong single metrological point of contact: the EMN for Energy Gases (under the auspices of EURAMET). This coordinated effort facilitates the prioritisation of the energy gases measurement challenges that are of pan-European importance, thus avoids duplication, and generates research that represents good value for money. It addresses the needs for measurement standardisation for renewable gases, such as biomethane and hydrogen, by successfully incorporating EMRP/EMPIR research results into documentary standards, thus ensuring the formal standing and uptake of these results by the relevant stakeholders.

The fragmentation of the measurement capabilities of individual NMIs and calibration and testing organisations in the energy gases sector did not allow the end-user to easily find information, whether it was a calibration service or a technical question. A centralised point-of-contact for knowledge transfer, support and metrological services, strengthened by the provision of integrated solutions, has now been created to bridge this gap.

3 Objectives

The overall aim of this project was to enable the EMN for Energy Gases to become the European metrology centre for the energy gas transition, where knowledge, needs and services are identified and easily accessible by the metrology community and the relevant stakeholders' categories. Therefore, the specific objectives were:

1. To develop and publish a strategic research agenda (SRA) with an emphasis on the European energy transition process. The SRA identifies the key measurement gaps and challenges (roadmap) as experienced by regulators and stakeholders working in the energy gases industry and prioritises these, with the aim of focusing European research capacity. The SRA is regularly reviewed to take account of the changes in the market trends and rapid technology evolution.
2. To develop a freely accessible online measurement service platform to boost the dissemination and knowledge transfer of metrological services in the energy gases field to European industry. This platform allows customers to access all available energy gases measurement services in Europe through one easy-to-use platform. The platform advertises all measurement and calibration services, including those developed in the EMRP and EMPIR Programmes. In addition, to develop a brand identity for the “Energy Gases Metrology Network” in close consultation with EURAMET so that the EMN becomes easily recognisable by stakeholders and to facilitate the use of the platform by the whole energy gases industry to find the right measurement service or proficiency testing scheme.
3. To develop processes to create synergies between the NMI/DI signatories of the EMN MoU, stakeholders and other parties to address emerging issues related to energy gas production, trade, transmission and use. These collaborations facilitates the provision of services that cannot be provided by one single party and deliver solutions at a scale relevant to the needs of the sector. Examples of synergies are developed for a training programme, collaborative research, and a proficiency testing scheme.
4. To disseminate results from European metrology research activities related to energy gases (e.g. EMRP, EMPIR) for the benefit of relevant policy makers and regulatory bodies to support their ongoing standardisation activities. This impact activity is achieved through presentations and the distribution of reports at relevant technical committee meetings, through the regular distribution of a newsletter, and through stakeholder workshops. Furthermore, the stakeholder group of the EMN is expanded by the addition of relevant policy makers and regulatory bodies.

4 Results

The overall aim of this project was to enable the EMN for Energy Gases to become the European metrology centre for the energy gas transition, where knowledge, needs and services are identified and easily accessible by the metrology community and the relevant stakeholder categories.

4.1 Publication of the EMN for Energy Gases Strategic Research Agenda

A significant transformation of the energy mix across Europe is on-going, strongly led by the need of complying with the climate change targets by 2050. Whilst there are some uncertainties and differing predictions regarding the outlook of the supply mechanism for energy, it is clear that the electricity grid alone cannot support the user demands for energy. It is also clear that energy gases field plays a key role during the transitional phases pre 2050 and the future energy mix post 2050. A notable criterion to ensure a smooth and accelerated energy transition in Europe will be a coordinated collaboration amongst countries in Europe with respect to research and development. This is to ensure that vital information, resources, best practices, and lessons learnt are shared, but also to continue to import and export energy between each other.

The change in the energy outlook and the addition of low carbon gases have led to several new measurement challenges and needs. In this perspective, this project has been very successful in identifying the needs and in prioritising these important measurement challenges, collated in the Strategic Research Agenda (SRA, <https://www.euramet.org/european-metrology-networks/energy-gases/strategy/strategic-research-agenda>).

The development of the SRA was led by NPL with support of the project partners VSL, NEL, RISE and IMBiH and of the EMN for Energy Gases members, including BAM, PTB, LNE-LADG, FORCE, JV, etc . After EURAMET approval, the document was handed over to the EMN for Energy Gases and it was published for the first time on the EMN website in November 2020. A second revision was carried out in 2022 and published on the website (see Figure 1). A third version is in preparation and will be publicly available soon. The identified measurement needs of this agenda are taken forward by the EMN members as research priorities to ensure they are addressed appropriately.

The SRA is an informative document, targeted to the metrology community and relevant stakeholders in energy gases, about the emerging measurement challenges associated with the energy transition. The SRA describes

the current energy gases market and legislation in Europe, provides a list of the identified measurement gaps and defines the priority measurement challenges. The main challenges are explored for each energy gas:

- Natural gas
- Liquefied natural gas and Liquefied biogas
- Biogas and biomethane
- Hydrogen
- Hydrogen enriched natural gas
- Carbon Capture, Utilisation and Storage (CCUS)

It includes for example flow metering, physical properties, gas composition, gas metrology, materials characterisation, combustion, leak detection and storage.

These challenges cover the critical areas of the energy gas transition:

- Decarbonising natural gas
- Decarbonising industry
- Energy transport and storage
- Cleaner fuel for mobility

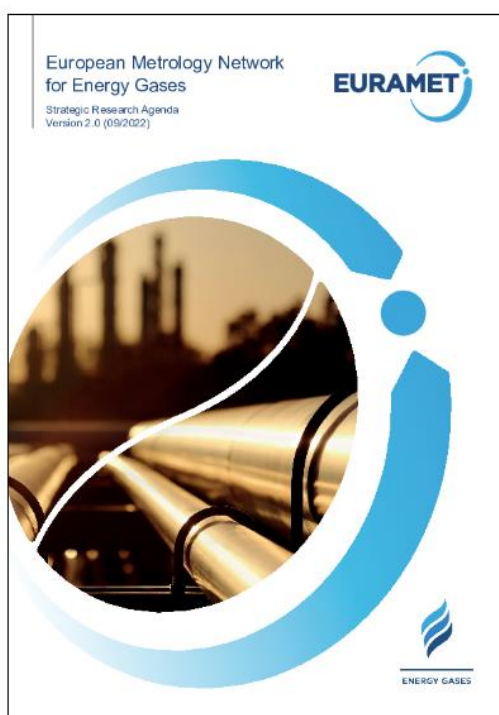


Figure 1: 2nd revision of the Strategic Research Agenda published in 2022 on the EMN for Energy Gases website

By using these themes, it is easier for the EMN for Energy Gases to approach specific stakeholder categories (e.g. gas distribution system operators versus hydrogen refuelling stations manufacturers) and align the SRA with their needs.

The development of this agenda was based on consultation, led by NPL with support of the project partners, with European stakeholders from industry, regulation, standardisation and research organisations and on the expertise of the EMN for Energy Gases members. A number of activities were carried out to establish input regarding how measurements, specifically NMIs and DIs represented by the EMN for Energy Gases, could assist in the energy transition and decarbonisation of the energy systems in Europe.

The first key-event to engage with stakeholders was the EMN for Energy Gases Launch, which was organised by VSL and that took place in June 2019 at VSL in Delft (NL). This was a great opportunity to promote the network and to receive stakeholder inputs on the measurement needs they face in view of the energy gas transition. Some of the measurement challenges were perceived to be of high priority in short to mid-term scenarios. To be able to effectively prioritise the measurement needs and produce an impactful strategic research agenda, it was essential to understand more in-depth the perception of external stakeholders working in the field of energy gases in Europe. Therefore, a workshop was organised by NPL and held at NPL, Teddington (UK) in January 2020. On this occasion, the outcome was a list of priority metrological challenges that constituted the basis for a stakeholder survey. The survey was developed and launched by NPL and supported by EURAMET and VSL in 2020. The new inputs from stakeholders, as results of the survey, were used by NPL to validate trends in energy gas utilisation, country strategies and policies, as well as progression within the R&D landscape in relation to energy gases. These challenges included flow metering and purity assessment for hydrogen refuelling stations, gas quality measurements and energy metering of hydrogen enriched natural gas, validation of online purity analysers (hydrogen and biomethane) and representative sampling of gas. Further revisions of the SRA, led by NPL with support of the project partners, are based on the inputs from key-stakeholders, such as Hydrogen Europe and Hydrogen Europe Research associations and the European Gas Research Group (GERG). These inputs are provided on a regular basis, in occasion of dissemination events (e.g. GAS Analysis 2022, CIM 2023) and at the opening of the calls for needs under the European Partnership on Metrology programme. Further, revision is also based on inputs from the EMN for Energy Gases members and stakeholders.

An extract of the SRA has been used for the preparation of the public orientation paper in support to the Green Deal call 2021 under the European Partnership on Metrology. Further, it has been successfully used in large brainstorm events organised by the EMN for Energy Gases for NMIs/DIs and stakeholders in 2021, 2022 and 2023 to help formulate research topics for project calls.

Meanwhile, some of these challenges are being or have already been addressed in existing European projects such as the EMPIR MetroHyVe, Si/S Biomethane SIP, NEWGASMET, DECARB, MetHyInfra, MefHySto, and the European Partnership on Metrology Met4H2, MetCCUS and BiometCAP.

In conclusion, the development of SRA, first of this project's objectives, has been a key focus point of the project's activities and it has been completed at an early stage of the project. It is an informative document, targeted for the metrology community and relevant stakeholders in energy gases, about the emerging measurement challenges associated with the energy transition. The third edition, that takes into account the changes in the market trends and the rapid technology evolution, will be soon available.

4.2 The EMN for Energy Gases brand and the Platform of Measurement Services

Driven by many factors, renewable energy gas sources are gradually entering the market. At the same time, measurement capabilities are developed across Europe through collective and individual efforts in order to support the gas industry in this process. There is a need to gather all services provided into a single platform to allow end-user to easily find information, whether it is a calibration service or a technical question.

A key activity of this project was setting up a strong brand for the EMN for Energy Gases which could facilitate recognisability and easy engagement with stakeholders and with the energy gases community. First, an EMN logo, in EURAMET style, was developed by RISE and the EMN for Energy Gases members in close consultation with EURAMET. The EURAMET logo in combination with the Energy Gases icon are used in presentations, banners, events and they have proven to be a good approach to represent the NMIs and DIs members of the EMN.

Secondly, RISE, with the support of project partners, designed the EMN external website (www.euramet.org/energy-gases/). This comprehensive website, live since 2021, is the "business card" of the EMN for Energy Gases, because it nicely introduces the EMN, the members, network events, news, the SRA and the EMN Strategic Agenda and the research projects/outputs related to the energy gases under the portfolio of the EMN.

Further, and most important activity, RISE developed with the support of the project partners and EURAMET an easily accessible and easy to navigate measurement service platform to search and visualise the metrological services (e.g. calibration capabilities, trainings, proficiency testing) offered by the members of the EMN for Energy Gases (<https://www.euramet.org/european-metrology-networks/energy-gases/service>). The creation of the service platform was performed in a series of steps:

1. Creation of a survey sent to the EMN for Energy Gases members to gather information on actual measurement capabilities in the field of energy gases including gas analysis, flow, density, temperature and humidity, material data, particles and material testing.
2. Identification of the measurement capabilities based on the output of the survey and definition of the number of services and subservices for the platform
3. Design of the database and layout of the measurement service platform
4. Definition of the criteria for quality assurance for the services and evaluation of the provided survey inputs
5. Realisation and implementation of the services into the service platform
6. The services are listed for six distinct gas types: natural gas, biogas/biomethane, hydrogen, carbon dioxide, liquified natural gas (LNG)/liquified biogas (LBG), and hydrogen/natural gas blends.

For each type of gas, services are divided into the following main categories: gas analysis, certified reference materials, flow, material testing, density, humidity and temperature, material data, training courses, interlaboratory comparison, and sampling. Through the interactive map, it is possible to find where a given service is provided (Figure 2). By means of search filters it is possible to find the required service. Alternatively, a table (also with filter) is available on the same landing page to directly access the services provided by a specific EMN member (Figure 3). The resulting overview is a new page showing the details of the service provider, contact information and a table (which can be expanded) of the services available (Figure 4).

This platform has been designed in the first two years of the project and implemented on the EMN website in April 2022 for three energy gases, namely natural gas, biogas/biomethane and hydrogen. The services for the remaining gases and gas mixtures: LNG and biogas, hydrogen enriched natural gas and carbon dioxide were collected and added to the platform in January 2023. The project also developed tools to ensure the quality of the services entered in the measurement service platform and to guarantee their regular update (annual) also after the lifetime of the project.

In conclusion, the objectives of building a strong brand, such as the EMN icon, and of developing an online measurement service platform, easily accessible and easy to navigate to search the metrological services (e.g. calibration capabilities, trainings, proficiency testing) offered by the members of the EMN for Energy Gases, have been achieved. This project has laid the basis for the EMN to become a center of knowledge in measurement for energy gases and the tools to keep the measurement community together.



Figure 2: Interactive map of the measurement service platform on the EMN for Energy Gases website. On the right: filter for gas and service of interest; on the left: map of Europe with the EMN members that have the specific filtered service.

List with filter

All gases

All services

All sub services

Individual service

Country	Abbreviation	Institute
Bosnia and Herzegovina	IMBIH	Institute of Metrology of Bosnia and Herzegovina
Czechia	CMi	Czech Metrology Institute
Denmark	FORCE	FORCE Technology
Finland	MIKES	VTT Technical Research Centre of Finland Ltd, Centre for Metrology MIKES
France	LNE	Laboratoire national de métrologie et d'essais
France	LNE-LADG	Laboratoire Associé de Débitmétrie Gazeuse
Germany	PTB	Physikalisch-Technische Bundesanstalt
Germany	BAM	Bundesanstalt für Materialforschung und -prüfung
Hungary	BPKH	Government Office of the Capital City Budapest
Italy	INRIM	Istituto Nazionale di Ricerca Metrologica
Netherlands	VSL	VSL National Metrology Institute
Norway	JV	Justervesenet - Norwegian Metrology Service
Poland	GUM	Central Office of Measures/Główny Urząd Miar
Portugal	IPQ	Instituto Português de Qualidade
Spain	CEM	Centro Español de Metrología
Sweden	RISE	RISE Research Institutes of Sweden AB
Türkiye	UME	Ulusal Metroloji Enstitüsü
United Kingdom	NPL	National Physical Laboratory
United Kingdom	NEL	TUV SUD LIMITED

Figure 3: Table listing the EMN for Energy Gases members on the measurement service platform of the EMN website . By clicking on the institute name an overview of the services will appear.

RISE Research Institutes of Sweden AB (RISE)

Address
50115 Borås
SwedenHomepage
www.ri.seContact
Karin Arhenius
karin.arhenius@ri.se

Get additional information about the institute on the euramet website

Services	Gases	CO2	Hydrogen	H2NG	Biogas / Biomethane	LNG/LBG	Natural Gas
+ Training courses							
+ Sampling for gas analysis		✓	✓	✓	✓	✓	✓
+ Interlaboratory comparisons							
> Speed of sound							
> Material data					✓		
+ Material testing							
+ Calorimetry							
> Density (direct)							
+ Flow							
+ CRM							
- Gas Analysis		✓	✓	✓	✓	✓	✓
> Tube material							
> Sorbent bed							
+ Per standard			✓	✓	✓	✓	✓
+ Per compound		✓	✓	✓	✓	✓	✓
+ Physical properties from composition		✓		✓	✓	✓	✓
+ Humidity							
> Temperature							

Figure 4: Example of visualisation of the measurement services provided by the EMN member (RISE) after search on the EMN for Energy Gases website

4.3 Creation of tools to enhance synergies between the EMN for Energy Gases members, stakeholders and other parties

An important objective of this project was to investigate potential synergies between the EMN members, and also between members and stakeholder that could help providing solutions to complex measurement needs that one single party could not provide and to enable a prompt response to requests from, e.g. industry, regulators, and other bodies related to metrological challenges in the field of Energy Gases.

Initially, the work carried out by RISE with support of VSL and IMBiH consisted of identifying gaps in metrology services by performing an analysis of the services provided by the EMN members for the different energy gases (natural gas, LNG/LBG, biogas/biomethane, hydrogen and carbon dioxide). The primary information source for the gap analysis was the survey and the database developed for the measurement service platform. A report was then prepared that helped identifying the key measurement gaps that need to be prioritized in order to support the gas industry and facilitate the gradual increase of renewable energy gas sources in the market. While gas composition services, certified reference materials and flow services are widely available for natural gas and well developed for biogas/biomethane and hydrogen, for other measurement services, such as calorimetry, density, only few EMN members are active and in a number of cases, only one EMN member can offer a specific service. Carbon dioxide and CCUS is then a new field and only few services are available.

Secondly, a pilot market analysis was carried out in the form of a survey targeting the potential service users and stakeholders in the Balkan region. The survey, prepared by IMBiH in cooperation with EURAMET and VSL and published in 2022, aimed at identifying which services are needed in the area of energy gases. The survey is designed in a way to be applicable for all geographical regions (Europe and beyond) and to contain all relevant questions for all participants in the field of energy gases, whether they are technical persons working in laboratories and on-site or managers and decision makers. The research results were used to identify services and topics for which complex and/or innovative metrological solutions are necessary. A strong outcome of the survey was the need for trainings and knowledge transfer.

Based on the outcome of the survey and the gap analysis of the services provided by the EMN members, a framework collaborative document and three collaborative case studies were developed by VSL and IMBiH.

The framework document named “collaboration requirements” was developed by VSL with inputs of the project partners and of the EMN for Energy Gases members and it describes suitable approaches and tools for establishing synergies. An example of schematic representation of a joint metrological service for hydrogen in

shown in Figure 5. A general ‘work-flow scheme’ is also included in the document which could be used when organising a joint service. Special attention was paid to potential geographical distribution of the services, intellectual property aspects, confidentiality, administrative and financial aspects. The document also takes into account the possibility of using ‘shared calibration facilities’ for performing metrological activities and development of measurement standards. This is particularly relevant for hydrogen, for which dedicated and costly calibration facilities are needed.

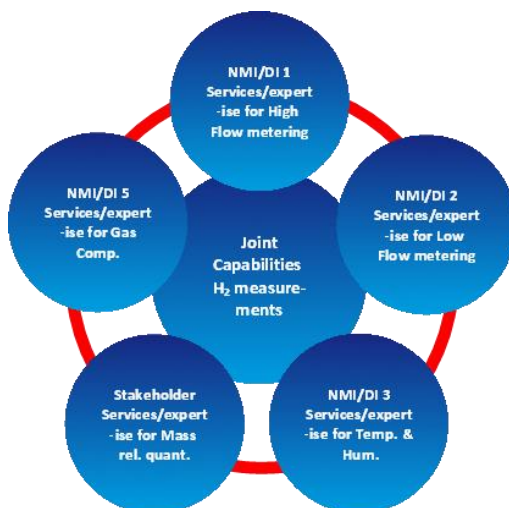


Figure 5: Schematic representation of a possible joint metrological service for hydrogen. Such a scheme could represent a calibration service, a collaborative research or Proficiency Test

In order to demonstrate the capability of the EMN for Energy Gases to address the identified gaps, three examples of collaborative work were developed on paper: a training programme, a collaborative research proposal and a proficiency testing scheme. These case studies describe how such joint services could be established, as well as the process and the content.

The case study “training”, led by IMBiH with support of VSL, covers the content of a possible training in energy gases measurements. This is divided in two sections: general and specialist, where the first is a birds-eye-view of the quality infrastructure for energy gases and therefore more of interest for industrial stakeholders, while the latter is more technical and therefore suitable to teach in-depth knowledge to metrological and technical experts. The format of the training course case study foresees a mix of online and on-location sessions for a maximum number of 50 and 10 participants for the general and specialist in-person training sessions, respectively. Instructors could be selected from a pool of experts (predominantly attached to the EMN members around the geographical location of the training) to teach the different modules. The pool of instructors can always be complemented with an ad-hoc set of EMN for Energy Gases stakeholder experts. Finally, this case study also discusses several secondary benefits from organising joint training programs in addition to the primary goal of investing in human capital.

The case study “proficiency testing and interlaboratory comparison”, led by VSL with support of IMBiH, covers the potential organisation of a round robin for laboratories and research groups that are active in energy gases measurements. The assumption is that the EMN for Energy Gases will play a key role in bridging the demand and offer of complex measurement solutions, and a main aspect could be supporting energy gas industry/organisations in demonstrating their measurement capabilities through the organisation of proficiency schemes and comparison exercises for complex measurement systems. Similarly to training, the case study addresses the organisation process and work flow.

The third case study “joint research collaboration”, led by VSL with support of IMBiH, covers the main steps to perform collaborative research which will lead to an integrated European metrology infrastructure. Research performed within the European metrological community has a strong collaborative component already and NMI’s and DI’s are used to work in Joint Research Projects under the EURAMET metrology programs. This case study expands on the research-related aspects of such collaborations and describe the role of the EMN for Energy Gases in the process.

It is the intention of the EMN for Energy Gases members to realise the case studies described after the project lifetime.

In compliance with the third objective, to create synergy between the EMN members and stakeholders, the project partners have developed a collaborative requirements document which provides the framework for establishing collaborations among members and stakeholders and three collaborative case studies. The case studies, which will be implemented outside of this project by EMN for Energy Gases members, addressed collaborative research for, and in cooperation with industrial stakeholders, training programmes and proficiency testing schemes.

4.4 Dissemination of outputs derived from EU metrology research projects under the portfolio of the EMN for Energy Gases for the benefit of policy, regulation and standardisation

Since the start, and in line with the planned activities of the fourth objective, this project has carried 80 impact and networking activities.

One of the key-events was the EMN for Energy Gases Launch, which was organised by VSL and it took place in June 2019 at VSL in Delft, The Netherlands. A stakeholder workshop to identify in depth and then prioritise measurement challenges in support of the development of the SRA was organised by NPL in January 2020 and it took place at NPL in Teddington, UK. On both occasions, the project succeeded in promoting the network and in receiving stakeholder inputs on the (measurement) needs they face in view of the Energy gas transition. And a third event, the second stakeholder workshop, took place in March 2023 at IPQ, the Metrology institute of Portugal, in hybrid form. The workshop, jointly organised by NEL and IPQ, aimed to highlight EURAMET's support for the energy transition through its research programmes, including EMRP, EMPIR and the European Partnership on Metrology. At all events, the stakeholders were policy makers, standardisation bodies, research associations, the gas industry, as well as gas grid operators and instrument manufacturers.

The project partners and other members of the EMN introduced the network in nine international conferences and a multitude of stakeholder events with posters, presentations and key-note lectures. Among others, it is worth mentioning the poster at the 25th United Nations Climate Change Conference (COP 25) in Madrid in December 2019, the talks at the 11th EU Innovation Summit lunch debate at the European Parliament in February 2020, at the North Sea Flow Measurement workshop in October 2020, at the IPQ-EURAMET virtual science debate: Climate neutral by 2050 in May 2021, the key-note presentation at the GAS Analysis conference in May 2022 and the round table on hydrogen at the CIM in March 2023.

Around 20 TCs, dealing with energy gases, were identified by NEL as possible receivers and they have been contacted by NEL and VSL: this project actively engaged with nine. Through this project, the results of past and on-going metrology research projects on energy gases were disseminated by the project partners and EMN members to standardisation and regulatory bodies through presentations at Technical Committee (TC) meetings (e.g. ISO TC 193 natural gas, CEN TC408 natural gas and biomethane). A comprehensive report on the 18 research projects outputs relevant to energy gases was produced by NEL and it will be distributed by the EMN to standardisation TCs in the field (ISO, CEN, National and OIML technical committees), where the results can be used to improve national and international standards and guidelines.

All stakeholders are kept updated on the EMN and its activities through regular e-newsletters. Five issues were published by EURAMET during the lifetime of the project and they are available on the EMN website. NEL in cooperation with EURAMET developed an e-newsletter template (and filled in the content) comprising of: updates on EMN activity, reports on the latest outputs from EMRP/EMPIR research projects, opportunities to participate in the formulation of new metrology research projects and it also promoted other EU programmes such as the Clean Hydrogen partnership. Each newsletter includes a focus article on an individual NMI or DI member of the EMN by featuring their research activities and technical services offered. The newsletters are also a good platform to publicise forthcoming events such as workshops and conferences.

With the objective to promote the activities and results of the EMN for Energy Gases a video script was prepared by NEL in cooperation with VSL team and the narration sequences recorded at NEL. Following a number of edits by the project partners and the NEL graphics team, two videos were created using EURAMET brand guidelines covering respectively: introduction of the EMN for Energy Gases and infographic to explain the role of metrology in the energy gases. They will be publicly available soon.

Finally, the engagement with key stakeholders led by VSL resulted in the establishment of the EMN Stakeholder Council which is currently made up of four official members, representing the energy sector, with the aim of increasing them to a maximum of ten: Hydrogen Europe and Hydrogen Europe Research, the two largest industrial and research associations dealing with hydrogen; the European Gas Research Group (GERG) and Marcogaz, the technical association of the European Gas industry.

In conclusion, the objective of disseminating outputs of European metrology research in the field of energy gases to relevant stakeholders, including standardisation, policy makers and regulatory bodies have been achieved. In general, this project has managed to engage with a broad group of key stakeholders and to build long lasting collaborations that will go beyond the lifetime of the project.

5 Impact

This project, in support of the EMN for Energy Gases, has impact on the societal needs related to the energy transition, enabling the diversification of energy sources and facilitating the introduction of renewable fuels in the European market. The whole energy gases supply chain is targeted from production to transport, to storage and utilisation. Only through a complementary network composition and by focusing on the specific societal challenges associated with energy gases is possible to achieve the “next level” in creating impact, innovation and metrological services, surpassing the possibilities of a single NMI or a EURAMET technical committee.

To create the broadest impact and become the knowledge centre for energy gases measurements, the EMN is very focused on engaging with stakeholders from different fields, namely the (energy) gas and manufacturing industries, energy gases associations, research groups, standardisation and regulatory bodies, and policy makers.

During the lifetime of the project, the project partners in collaboration with the EMN members, have developed a structured engagement with key stakeholders. This has led to multiple collaborations with top European associations such as Hydrogen Europe (HE) and Hydrogen Europe Research (HER), representing the largest group of industries and research organisations respectively involved in hydrogen. The successful engagement has led to a Memorandum of Understanding (MoU) signed by EURAMET and the two associations in March 2023. The project partners established also long term relationship with other European Research groups such as the European Gas Research Group (GERG), which led to a MoU signed by EURAMET in November 2022, and the European Research Institute for Gas and Energy Innovation (ERIG). The EMN has also engaged with energy gas industry and European technical associations, such as MARCOGAZ, with gas grid operators, such as the European Association of gas grid transmission operators (ENTSOG), with policy makers, such as the EC DG-Energy, with international organisations, such as the International Renewable Energy Agency (IRENA) and with standardisation bodies (e.g. ISO and CEN). These engagements resulted in the mutual participation at EMN and stakeholders’ events with valuable presentations and contributions.

All these interactions have allowed to align the respective strategic research agendas, to jointly propose new topics for research under the European Partnership on Metrology, to be successful in the project selection, and to establish long-term collaborative relations. Since start of the Clean Hydrogen Partnership in 2022, the chair of the EMN for Energy Gases has become member of the stakeholder group on behalf of EURAMET.

Objective 1: *The identification of a strategic roadmap for future research, (SRA) is key to ensure the best allocation of research funds thereby generating research that represents good value for money. Furthermore, by promoting dedicated research, in collaboration with industry and research groups, the EMN will **strongly impact and support innovation**.* The SRA has proved to be a key tool in defining the role of metrology in the European research arena. The SRA has been taken up by EMN members, EURAMET TCs members and other stakeholders to align their strategies in the area of energy gases and to scope potential research topics (PRT) in the calls 2021-2023 of the European Partnership on Metrology. As a result, two of the three research proposals derived from the EMN SRA were selected for funding in 2021. In 2022, two virtual joint brainstorms were organised in collaboration with HE and Hydrogen Europe Research (HER) to identify needs and priorities in research for hydrogen using the EMN and the HE/HER strategic research agendas. And in 2023, based on the inputs of key stakeholders, four SRA research topics were prioritised and submitted under the European Partnership on Metrology call.

Objective 2: *The added value and strength of this project lies in its cross-cutting approach which will enable the various metrological aspects and challenges in e.g. gas composition, gas transport and flow metering, material data, humidity, temperature, pressure, density, particles and material testing to be simultaneously addressed.* The EMN external website gives the opportunity to showcase joint projects, results, news and

events that cover the complex field of energy gases measurements. In addition the Measurement Services Platform, part of the website, allows stakeholders to quickly find the services and measurement capabilities of the metrology community. It is expected that this unique and easy-to-access web-based platform of measurement services will enable in the near future the creation of a European “hot spot” for the exchange of knowledge with stakeholders, the identification of research topics and the dissemination of (new) measurement services. By doing this, the project will have a **major impact on industry and on the scientific community** dealing with conventional and renewable/sustainable energy sources.

Objective 3: *Building synergies to create collaborative activities between the NMIs/DIs members of the EMN, stakeholders and other parties.* It is expected that the framework document that defines collaborative requirements and the developed case studies, such as enabling the calibration of complex equipment as a follow-up of EMRP/EMPIR projects, organising a proficiency testing scheme where more disciplines are involved, providing training courses addressing all relevant metrological aspects, when implemented, will have a strong socio-economic impact. The increased collaboration in research and services will firstly benefit the metrology community, stimulating knowledge transfer and a more efficient use of resources. Secondly, **industrial and testing laboratories** that are involved, for instance, in the production or distribution of energy gases, will be able to efficiently access these services and prove their measurement results or gain know-how at reduced costs and in a shorter time frame.

Objective 4: *This project aims at supporting the uptake of specific research results, either from ongoing or previous research activities funded by the European metrology research programmes, by for example feeding them into new documentary standards.* This project has promoted the recognition of the EMN for Energy Gases as a knowledge center. As main example, the key hydrogen research challenges reported on the SRA, have been used to feed the standardisation roadmap developed by the European Clean Hydrogen Alliance. The roadmap was published in March 2023 and delivered to CEN/CENELEC for prioritising their standardisation work. The project successes allow the EMN to **strengthen the link with standardisation and regulatory organisations** (e.g., the European Committee for Standardisation (CEN), the International Organisation for Standardisation (ISO), the European Cooperation in Legal Metrology (WELMEC)) and, finally, to hasten the uptake of metrology concepts by users. Finally, it is expected that this will help the energy gases stakeholders to comply with regulation and become more sustainable and competitive in the energy market.

This project and therefore the EMN for Energy Gases, ensure that metrology in the field of energy gases directly meet the requirements of policy makers, industry, networks, associations, and standardisation committees, and thereby society at large during the energy transition.

In broader terms, this project outcome and the EMN contribute to greater societal prosperity by providing diversification of energy sources for a growing global population while finding ways to emit much less carbon dioxide and therefore starting to tackle climate change.

6 List of publications

Arul et al., 2022, Vision for a European metrology network for energy gases, Environ. Res.: Infrastruct. Sustain. 2 012003; <https://doi.org/10.1088/2634-4505/ac57f6>

This list is also available here: <https://www.euramet.org/repository/research-publications-repository-link/>

7 Contact details

Contact person objective 1: Arul Murugan, NPL, arul.murugan@npl.co.uk

Contact person objective 2: Karine Arrhenius, RISE, karine.arrhenius@ri.se

Contact person objective 3: Annarita Baldan, VSL, a.baldan@vsl.nl

Contact person objective 4: David Learmonth, NEL, david.learmonth@tuvsud.com