



# FINAL PUBLISHABLE REPORT

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## 1 Overview

Electricity grids are a key enabler of the “**Energy Transition**” towards a sustainable energy system, but face huge challenges due to, for example, the desired uptake of renewable energy sources and electric vehicles. So far, over 20 joint research projects (JRPs) funded by EURAMET’s European metrology research programmes have provided crucial metrology support for the development of (smart) electricity grids, but their impact has been hampered by a lack of higher-level coordination. This project accelerated the full establishment of a European Metrology Network on Smart Electricity Grids (EMN SEG) to realize a coherent National Metrology Institute (NMI) response to smart electricity grid measurement challenges, to provide a single point of contact for stakeholders, and to maximize the impact of R&D activities.

## 2 Need

The European Commission’s Energy Union strategy to “build a low-carbon, climate resilient future” via “secure, clean and efficient energy”, has a profound impact on electricity grids – the backbone of our modern society. Grid stability and quality of supply is negatively affected by the significant uptake of renewable energy sources (RES) and grid energy losses need to be reduced in order to meet EU climate targets. Over 20 joint research projects under the iMERA-Plus, EMRP and EMPIR programs have so far provided crucial metrology and normative support to the development of smart electricity grids, with extensive stakeholder interaction and support. However, there was a significant need for more coordination in electricity grid metrology focusing on stakeholders’ technological and strategic objectives.

Stakeholders needed long-term commitment and a coherent, well-considered joint R&D agenda to ensure that all their metrology needs are adequately addressed, and that measurement solutions are available when they need them. The metrology community recognised that it could only meet these challenges by agreeing, well in advance with all relevant stakeholders, what metrology is needed and when, and by carefully coordinating national programs within the framework of a European joint Strategic Research Agenda (SRA). Once R&D results were available, the stakeholders needed easy access to these results. They did not want to navigate a plethora of individual project websites but instead needed a simple, comprehensive platform that provides all information and answers across the full range of their needs. Next to easy access to R&D results, there was a need for practical knowledge transfer. Whilst utility engineers, manufacturers, and companies lacked the particular metrological knowledge required to fully implement the smart electricity grid, there was no systematic program satisfying the full metrology training needs of this stakeholder community.

The stakeholder needs in smart electricity grid metrology are extensive and call for major investments in an adequate European metrology infrastructure. Given these investments, a complete and comprehensive European metrology infrastructure can only be sustained by smart specialisation, where each country focusses its activities and investments based on its (unique) expertise and the national stakeholder needs. At the same time the complete range of NMI capabilities in Europe will optimally cover the needs of all EU stakeholders.

For measurement issues related to the energy transition and smart electricity grids, European stakeholder organisations wanted to move away from the present ad-hoc and project-based contacts with individual NMIs, to a more systematic contact with a recognizable entity that represents the metrology community. On the NMI side, there was an increased need to become more visible as utilities and industry were all too often unaware of the significant added value that metrology research can provide. EURAMET decided to initiate a European Metrology Network on Smart Electricity Grids to optimize the use of limited NMI resources in meeting smart electricity grid industry and standardisation challenges. Given the urgency to achieve this aim, there was a need to support and accelerate the full implementation of the EMN.

## 3 Objectives

The overall aim of this project was to support the European Metrology Network on Smart Electricity Grids and to accelerate its full implementation via the achievement of the following objectives:

1. To establish systems within the EMN to coordinate and align national R&D strategies, including:
  - Developing a European joint strategic research agenda together with all relevant stakeholders, describing current and future stakeholder metrology needs related to smart electricity grids.



- Defining roadmaps and strategies to meet these needs. To discuss prioritisation of national R&D strategies with the aim of preventing unnecessary duplication and optimizing the use of precious resources.
  - Liaising with instrument manufacturers and other relevant stakeholders to ensure that early take-up of future metrology R&D is incorporated into the defined strategies.
2. To significantly enhance exploitation and uptake of research results from multiple EMRP and EMPIR joint research projects and national research activities through the realisation of a virtual knowledge hub, which will serve as a single point of contact to stakeholders, providing easy access to the full range of smart electricity grid metrology research results, relevant NMI calibration services, and a help desk to submit metrology needs and/or request further information.
  3. To develop a plan for a joint sustainable European metrology infrastructure for Smart Electricity Grids by stimulating smart specialisation of European NMI facilities and services, including:
    - Producing a comprehensive overview of existing facilities and services across Europe and identifying deficiencies.
    - Promoting alignment of national R&D priorities with these deficiencies and with the future needs of stakeholders.
    - Stimulating sharing and use of existing large grid-metrology infrastructure by all participants in the network and by the wider stakeholder community.
  4. To create a widely visible identity as the voice of the European electricity grid metrology community (including logo, flyers, newsletters, etc) and to establish liaisons with relevant European stakeholder organisations such as ENTSO-E, CENELEC, WELMEC, EURELECTRIC, TD Europe, ESMIG and similar organisations worldwide such as IEC, OIML, CIGRÉ, with the European JRC on Smart Electricity Systems and Interoperability, and with related European H2020 research projects.
  5. To set up an extensive knowledge transfer program for the associated EMN consisting of training courses, webinars, best practice guides, and other materials such as publications, events and R&D activities with a significant training component, and a web-based platform to attract and stimulate exchange of metrology R&D researchers.

## 4 Results

### ***4.1 Strategic research agenda and technical implementation roadmap***

A Strategic Research Agenda (SRA) including technical implementation roadmaps was developed during the course of the project and is published on the website of EMN SEG. The purpose of the SRA is to give an overview of the major metrological challenges faced by electricity grids in an era of major changes, driven by the need for a more sustainable energy supply. It presents a vision and ambition for Europe over the coming five to ten years for addressing needs expressed by stakeholders via further strengthening and coordinating a sustainable and effective research strategy at European level. This section and its subsections describe the process and rationale behind the design of the SRA.



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Figure 1: A screenshot of the SRA cover and list of contents.

### 4.1.1 Shaping the SRA through Stakeholder Surveys and Workshops

In line with the goal of EMNs to engage with stakeholders, it was recognised that developing a Strategic Research Agenda (SRA) should be done in close consultation with representative stakeholders of the EMN SEG community. The project structured this activity along three main stakeholder consultation tracks:

- I. Online survey
- II. One-to-one interviews
- III. Stakeholder workshops

Prior to setting up the online survey, an initial SRA was drafted by experts from the EMN SEG members. Nine themes were identified and described with special focus on specific measurement challenges. The SRA was compiled step-by-step involving as much stakeholder input as possible.

The initial draft SRA, in particular its list of measurement challenges, was then submitted via a survey to a wide group of stakeholders across Europe (consultation track I). Here are for example the measurement challenges on efficiency presented for evaluation to the stakeholders:

- Measurement systems for loss measurement in transformers, converters/inverters
- Traceable measurement of distorted three-phase power with harmonic content of significant amplitude
- Measurement of DC power characterized by high frequency ripple and/or fast transient event
- Measurement of small DC component in AC system
- Measurement of small AC component in a dynamic DC system
- Accurate impedance measurements performed in a short time interval

The survey produced a very good return with 80 participants. It focused on collecting feedback from the participants about the measurement challenges identified for all 9 themes. Some general background information about the surveyed participants was also collected.



Another approach to the stakeholder community consisted of interviewing a set of key stakeholders. These interviews yielded deep insights into the views held by these stakeholders on some of the themes of interest to them. The interviews were conducted by national representatives of EMN SEG members.

The project plan foresaw a stakeholder workshop to be held in a central European location. Instead, three workshops were held online owing to the Covid-19 travel restrictions, each covering several of the 9 themes of the SRA. Having the workshops conducted online resulted in a good turnout, approximately 60 participants for each workshop, probably much larger than the initially envisioned single workshop in a single location.

#### 4.1.2 Drafting the final SRA

The core of the SRA are the 9 themes that were identified as highly relevant to smart electricity grids. The nine themes explore a range from modern-day embodiments of revenue meters to digital substations, and emerging fields such as DC grids and efficiency. For each theme, outstanding measurement challenges are pinpointed and structured in implementation roadmaps. In the figure below, the 9 different themes are shown alongside their specially developed icons.

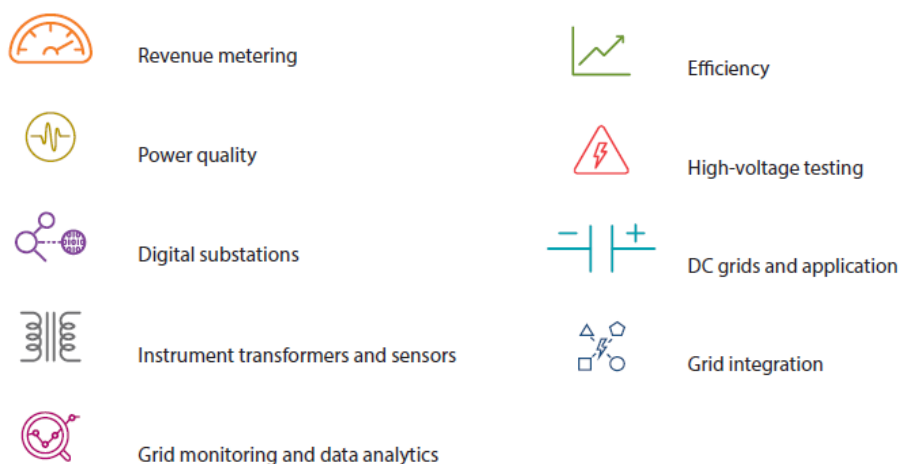


Figure 2: The 9 different themes presented in the SRA with their specially developed icons.

The drafting of the final SRA followed a systematic step-by-step process of:

1. Consolidation of all findings from all stakeholder consultation tracks into a final document.
2. Development of technical implementation roadmaps by categorizing each measurement challenge and proposing a time plan.
3. Review by selected experts of the EMN SEG member community.



#### 4.1 Revenue metering

Metering for billing purposes has always been crucial for fair trade and customer confidence. For many decades, conventional AC electricity meters have been based on the very reliable Ferraris concept, derived from a purely electro-mechanical transducer relating the metered electrical energy to counting the number of revolutions of a disc. Electronic meters use current sensors based on Rogowski coils, shunt resistors, Hall-effect magnetic sensors, or current transformers. As a result, they have no moving mechanical elements, but can rather be seen as an electronic board with sensors, a microprocessor, and an interface port.

Smart meters are electronic meters offering the possibility of recording detailed consumption and two-way communication between the meter and the measurement infrastructure, either by wireless link (mobile networks, radio) or physical link (Ethernet, fiber optic, power line carrier - PLC). They operate in conjunction with a gateway or a data concentrator on the other side of a two-way communication scheme and represent a network of IoT devices. In turn, this requires a high level of IT security to prevent malevolent coordinated intrusions from destabilising the grid control. This is subject to non-harmonised national legislation and, in many instances, remains underestimated.

Recently, the current immunity requirements of the European Measuring Instruments Directive 2014/32/EU (MID) for electricity meters have been put into question. Electricity meters may be subject to much more electro-magnetic interference today, resulting from the use of solar panels and other renewable energy sources, amongst other things. Some electronic meters have shown vulnerability to these under specific circumstances. Research is underway to understand the (non-)immunity of several types of meters to these interferences, and to support the revision of European and international standards for electromagnetic compatibility.

Interest in DC active electrical energy metering is developing fast owing to solar PV energy generation, fuel cells, electric energy storage, transport systems, electric vehicles, and DC power distribution in IT networks and data centres. A key challenge will be the development of the required DC power metrology infrastructure and metrologically sound, harmonised legislative frameworks – possibly following similar principles as for AC active energy meters.

#### 4.1.1 Measurement challenges - Revenue metering

- Development of a DC power metrology infrastructure, including a harmonised legal framework for DC active electrical energy metering
- Novel interfering factors in energy measurement, for instance related to dimmers, LEDs, etc.
- Revenue metering with digital measurements and low-power instrument transformers
- Metering of AC electricity in the presence of DC components
- DC metering of low energy consumption in the presence of DC offsets
- Definition of bandwidth in the case of DC energy meters
- Addressing IT security of smart meters

#### 4.1.2 Implementation roadmap - Revenue metering

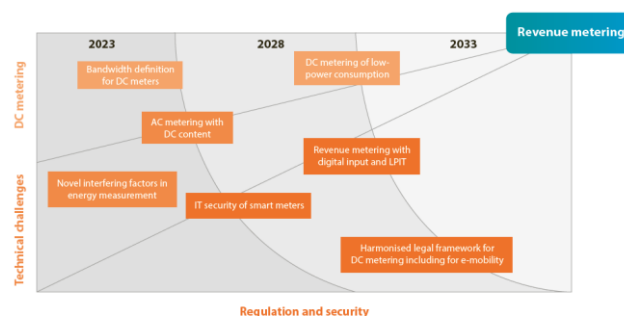


Figure 3: Example of one of the 9 themes in the SRA: Revenue Metering, its measurement challenges and implementation roadmap.

Above is an example of one of the themes featured in the SRA, namely, revenue metering. As indicated in the figure above, particular attention was paid to the graphic design of the SRA document. Each theme was developed carefully to match the colour palette of the EURAMET's parent website while being mindful of reader friendliness.

#### 4.1.3 Developing the implementation roadmaps

The rationale behind development of implementation roadmaps was to provide the readers with foresight on the most important measurement challenges in the relevant fields within the Smart Electrical Grid research. Each implementation roadmap was carefully designed in consultation with a selection of experts coming from the field in order to provide the most actual foresight to the readers. The figure below shows an example of the implementation roadmap that was developed for the theme on Power quality. It can be seen that the various measurement challenges recognized within this theme are divided in three categories: harmonic propagation, standardization and characterisation, and that the challenges have been placed on an appropriate timeline.

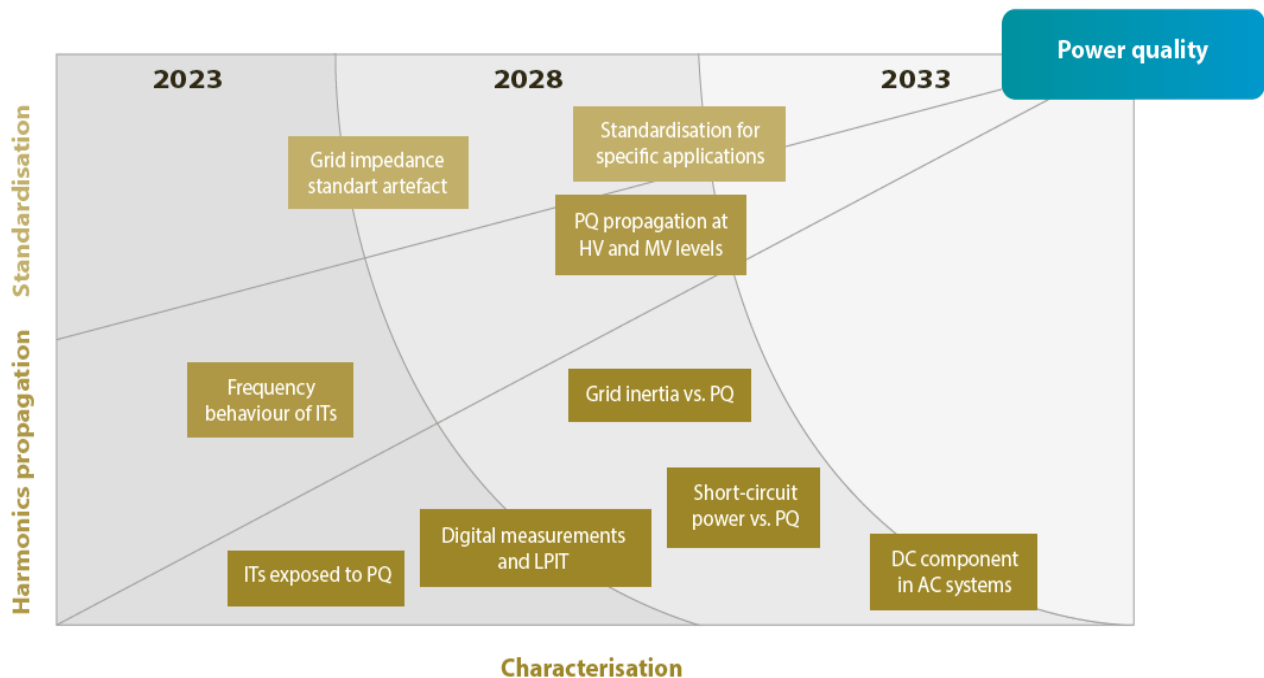


Figure 4: Implementation roadmap of one of the 9 themes in the SRA, Power Quality.

The very active engagement of the EMN SEG stakeholders in the various stages of the SRA development greatly contributed to achieving a relevant and credible Strategic Research Agenda, thus fulfilling objective 1 of the project

#### 4.2 Virtual knowledge hub

The virtual knowledge hub (VKH) is a web-based platform that is intended to serve as the online access point for EMN SEG stakeholders. Through this web site, the stakeholders and the wider impact group will be able to access a whole range of EMN knowledge, capabilities and activities. This includes R&D results of all smart electricity grid metrology Joint Research Projects (JRPs), as well as relevant H2020, Horizon Europe and national projects easily accessible, in a systematic way, both by project and by topic.

The VKH can be accessed directly using its dedicated URL:

<https://www.euramet.org/smart-electricity-grids>

or via the EURAMET website <https://www.euramet.org/>, selecting 'EUROPEAN METROLOGY NETWORKS' on the top banner, and then 'Smart Electricity Grids'.

Once accessed, the home page appears as in the pictures below, depending on whether it is accessed on a PC or on a mobile device.

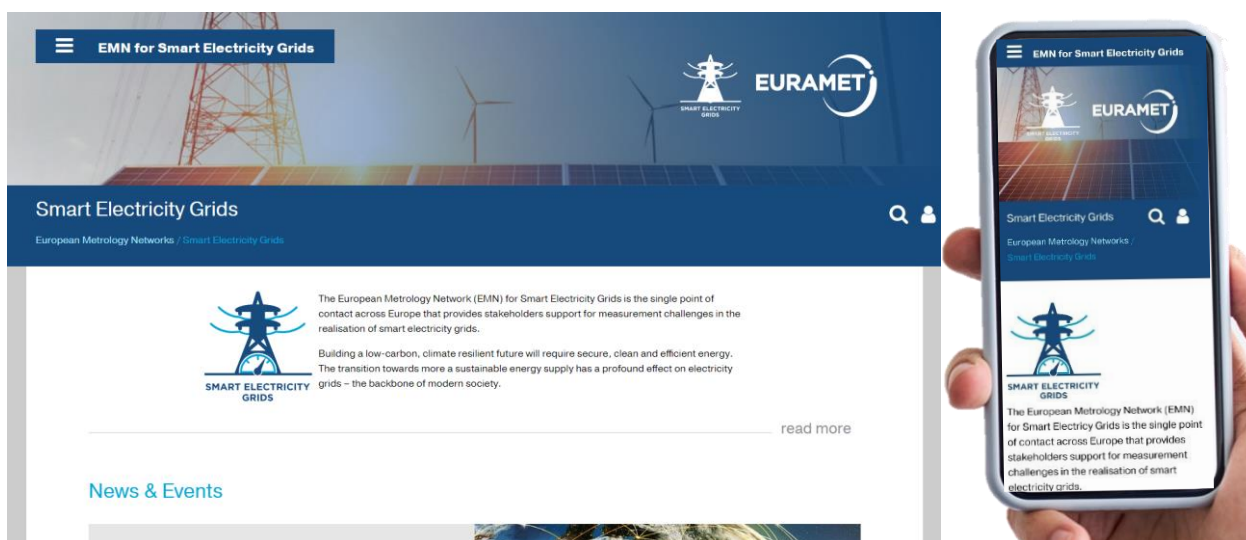


Figure 5: A screenshot of the landing page of the EMN Smart Electricity Grids on a laptop and mobile device.

#### 4.2.1 Content

The most significant part of the content of the VKH is the R&D results from years of JRPs, from 2007 up until today. All the results have been collated and each work package has been converted into an individual project result. Then, these have been categorised as belonging to one or more of the EMN SEG Themes. A text describing the content of each work package (WP) or project result has been drafted, removing the references to typical JRP language (e.g. tasks, work package, etc.) and reformulated to be understandable by users unfamiliar with the terminology of these projects. Moreover, each WP has been drafted to be self-standing, reducing the dependencies to other WPs to a minimum so they can be read stand-alone. Each individual WP from approximately 20 JRPs has been then reviewed by the respective project coordinator to ensure the correctness of the content. The approval email has been stored. The rest of the content includes case studies, publications, news and events, the majority of which makes use of the already existing processes of EURAMET website, without duplicating content.

#### 4.2.2 Design

The initial part of the work consisted in identifying the core functionalities required for the website. It was decided that the categorisation of content is important for organising the information structure, and that content tagging plays an important part in achieving this. The tagging and filtering functionalities needed careful consideration to ensure functionality. Moreover, it was decided that the page layouts will be dynamic, and the view is personalised to aid navigation. The VKH is aligned to the EURAMET brand, and at the same time the brand of the EMN has been established. Different graphic elements have been developed, using a subset of the EURAMET colour palette. The Themes icons are a representative example (see Figure 2). The website has been designed in a responsive fashion, that displays well whether it is on a desktop or a mobile device, so the position of text, images, links and menus has been done with an awareness of how everything moves in relation to everything else, depending on the device the reader is using to view the content. A set of wireframes has been developed to guide the realisation of the VKH.

#### 4.2.3 Structure

The structure of the VKH includes the following pages:

- Home
- About us
- Themes
- Projects
- Case Studies
- Publications



- News & Events
- Search
- Contact us
- Newsletters

These pages can be accessed by the navigation menu in the home page, as illustrated in the following image:

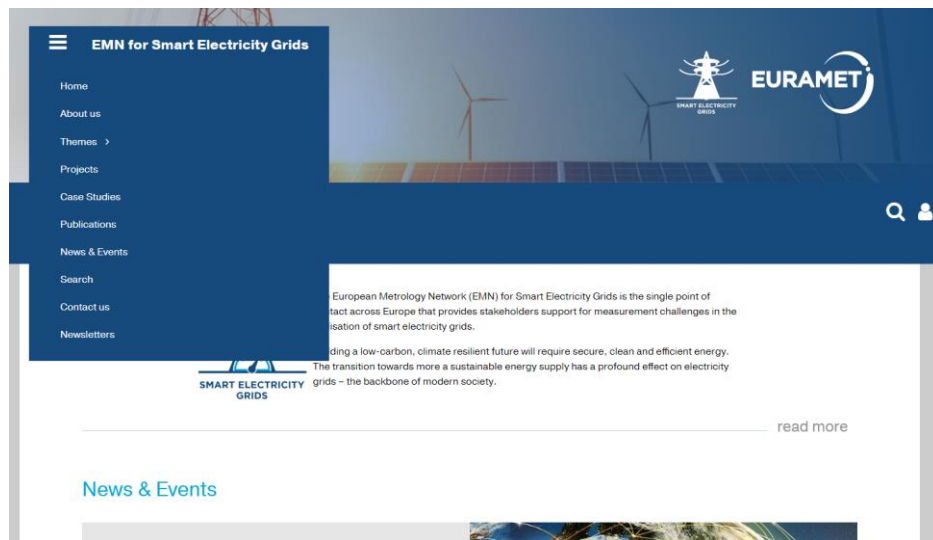


Figure 6: Navigation menu on the EMN-SEG website.

### **Homepage**

The homepage contains from top to bottom a small introduction to Smart Electricity Grid, “News and Events”, “Themes”, and “Projects”. In the top left corner of the page there is a menu button. The menu button is always placed at the same place in the top left corner, even when scrolling down the page.

### **About us**

This page contains a description of the EMN SEG with button to access a list of EMN members and EMN contact persons.

### **Themes**

The themes are the main feature of the VKH. All the content on the VKH is categorised into themes, by using tags. Currently, the existing themes on the VKH are:

- Revenue Metering
- Power Quality
- Grid Monitoring and Data Analytics
- Digital Substations
- Instrument Transformers and Sensors
- High-Voltage Testing
- DC Grids and Applications
- Efficiency

The grid integration theme, present in the SRA (see Figure 2), has not yet been worked on past and running JRPs, so does not yet have its own themes page on the VKH.

Through the theme page it is possible to access all the content tagged with the corresponding theme. This feature is aimed at simplifying the experience for stakeholders visiting the website, who could be unaware of a specific JRP, but interested in a specific topic. By navigating through the topics, the user has the possibility to access project results, news, events, case studies etc. belonging to the topic of interest.



## Themes



Revenue  
Metering



Power  
Quality



Grid  
Monitoring  
and Data  
Analytics



Digital  
Substations



Instrument  
Transformers  
and Sensors



High-Voltage  
Testing



DC Grids and  
Applications



Efficiency

Figure 7: The theme icons used on the EMN-SEG website.

By selecting the desired topic, the corresponding page is accessed which contains an introduction related to the specific topic and information regarding news, projects, and selected publications.

### **Projects**

This page contains link to EMN-related projects, these are categorised in current projects and completed projects. By clicking 'show more', the user is directed further to all of the current projects, and all of the completed projects. The user can read further about the individual projects e.g. who is the coordinator and the information about the coordinator, who participated in the project, and the duration of the project.

### **Case Studies**

This section is dedicated to case studies that the user can read more about. Each preview item leads to a page dedicated to the individual case study, which has information about the corresponding project and the option to download the case study.

### **Publications**

The publications section lists all the publications related to the Smart Electricity Grids in a chronological order. Here the user can be directed further to the full article and download the article based on the DOI provided. These items are automatically fetched from the EURAMET repository of publications, provided they have the SEG tag. This simplifies the maintenance since no action is required from EMN SEG to update this section.

### **News & Events**

This page contains a collection of news items and events related to the EMN SEG. These items are automatically fetched from the EURAMET database of news and events, provided they have the SEG tag. This simplifies the maintenance since no action is required from EMN SEG to update this section.

### **Search**

This page offers search functionality.

### **Contact us**

This page presents the user with a form that can be used to contact the EMN chair, whose contact details are also provided.

### **Newsletters**

This page contains a link to subscribe to EMN SEG newsletter. It also contains the links to all the previous issues of the EMN SEG newsletter.

The project objective of establishing the VKH has been achieved to a great extent. Work will continue beyond the end of the project to add additional sections and functionalities, such as a section on dissemination and training providing access to training materials and programmes, and a section on research or job opportunities.



### 4.3 Smart Specialisation

The aim of the Smart Specialisation activity within the SEG-net project was to encourage further cooperation of the EMN SEG members and partners, in order to most efficiently cover the metrology needs of the EMN SEG stakeholders. The EU Green Deal is putting great emphasis on both renewable generation (wind, solar), as well as further electrification of our society in its energy use. The resulting impact on the electricity grid calls for enhanced cooperation of NMIs/DIs in order to cover the growing stakeholder needs for measurements to assure a stable, clean and efficient electricity grid. In the SEG-net smart specialisation activity, an overview was made of the existing metrology landscape (facilities and services) followed by the development of a strategy to further enhance meeting the stakeholder measurement needs with the present NMI/DI resources. A core element of this strategy is to assure optimal use of the limited resources via minimising unnecessary duplication and overlap in NMI/DI activities by focussing on national needs and core competences of the respective NMIs/DIs.

#### 4.3.1 Designing the landscaping report

A survey was carried out amongst the EMN SEG members to collect the relevant information for making an overview of the landscape of present EMN SEG member measurement capabilities. The survey contained three parts: services, facilities and practical application areas. All information was collected from the perspective of the electrical energy measurement community.

A standard list of categories in the form of services was defined. Each category had its own measurement quantities. The institutes could also define their own categories and quantities, if they could not find any in the default list. The measurement abilities in the survey were not limited to those contained in the BIPM-CMC, but additional measurement abilities were included as well since the target of this survey was to investigate the true metrological ability across the EMN SEG members.

The figure below shows an excerpt of the survey for services sent to EMN SEG members.

Number	Service			Measurand level or range			Expanded uncertainty		CMC		Measurement conditions/ Independent variable				Additional information	
	Category	National priorities and needs	Quantity	Minimum value	Maximum value	Unit	Best possible uncertainty (k=2)	Unit	Services covered by CMC (completely or partly)	Origin of traceability	Parameter	Minimum value	Maximum value	Unit	On-site calibration available?	Comments
1	Category		Quantities								Parameter name					
2	Category		Quantities								Parameter name					

Figure 8: Excerpt of the landscaping survey for services

The following values were asked to be provided in the survey for services as in the figure:

- Measurand range
- Measurand conditions
- Expanded uncertainty
- Availability of on-site calibration
- Origin of traceability

The figure below shows an excerpt of the survey for facilities sent to the EMN SEG members.



Facility	Function	Available
High voltage laboratory	Testing and calibration	
	R&D	
	On-site	
	Consulting service	
	Standardisation	
	Legal metrology	
	Design, construction and sale	
Power laboratory	And so on...	
	Testing and calibration	
	R&D	
	On-site	
	Consulting service	
	Standardisation	
	Legal metrology	
	Design, construction and sale	
	And so on...	

Figure 9: Excerpt of the landscaping survey for facilities

The survey for facilities asked each EMN SEG member to provide information about their available facilities. The following categories of the facilities were provided:

- Testing and calibration
- R&D
- On-site
- Consulting service
- Standardisation
- Legal metrology
- Production and / or sale of equipment

The members could also add categories to the list if necessary.

The last form in the survey was a summary of the coverage of the practical application areas by the member institutions. A total of 35 default practical applications were listed in the sheet as examples. The members could add more ideas in the list if required. The figure below shows part of the survey for practical application areas as sent to the EMN SEG members.

Practical application areas	Your institute name (e.g. PTB)					
	Currently available?	Planned investment primarily for this application?	As a result of running R&D?	Planned or extended in future		
				Name of the European project(s)	National priorities and needs	Comment (e.g. Name of the national projects or specified type of investment)
Renewable Energy Source: wind power						
Renewable Energy Source: solar power						
Renewable Energy Source: power to gas						
Renewable Energy Source: hydro power						
Electric cars/trucks/busses						
Electric trains						
Electric ships						
Electric air vehicles						
Grid energy losses						
Grid stability and quality						
(PMU) Phasor Measurement Units						
Smart meter data						
ITS - CT and VTs						

Figure 10: Excerpt of the landscaping survey for practical application areas

The EMN SEG members were asked to provide the following information about the application areas of their services:

- Present availability



- If they are planned investment primarily for this application
- If they are a result of running R&D
- Name of the European project(s)
- Ambition Level

The default application areas were linked to main themes in the SRA.

The responses from 21 institutes from 19 countries on the three parts of the survey resulted in a very extensive and comprehensive amount of information.

#### 4.3.2 Smart Electricity Grid Metrology Landscape

In the evaluation of the survey data, the BIPM database was used to refine the collected data and to benchmark the metrology services within the EURAMET zone against those in other Regional Metrology Organisations.

The final Smart Electricity Grid Metrology Landscape report contains a large amount of overviews of available services, facilities and application areas. As an example, the following figure shows the service AC power sources and meters from the landscape overview.

Quantity	Measurand		
	Minimum value	Maximum value	Unit
AC current up to 100 A	0	100	A
High AC current	100	30000	A
Pulsating current let-through energy	0.00001	10000	MA <sup>2</sup> s

Measurement conditions			
Parameter	Minimum value	Maximum value	Unit
Frequency	0.01	100000	Hz

Figure 11: Present EURAMET status of service AC current sources and meters

#### 4.3.3 Smart Specialisation report

Once the landscape data were collected and summarised, a report on smart specialisation was produced. The following figure shows the approach that was employed.

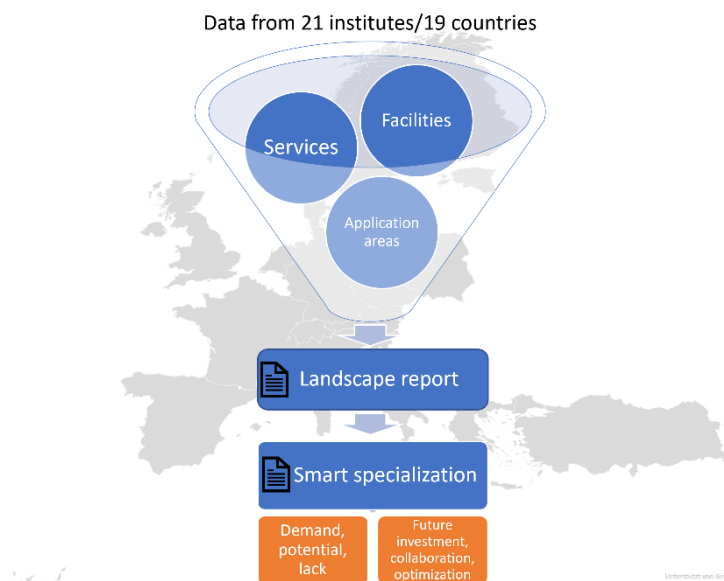


Figure 12: Approach to smart specialisation

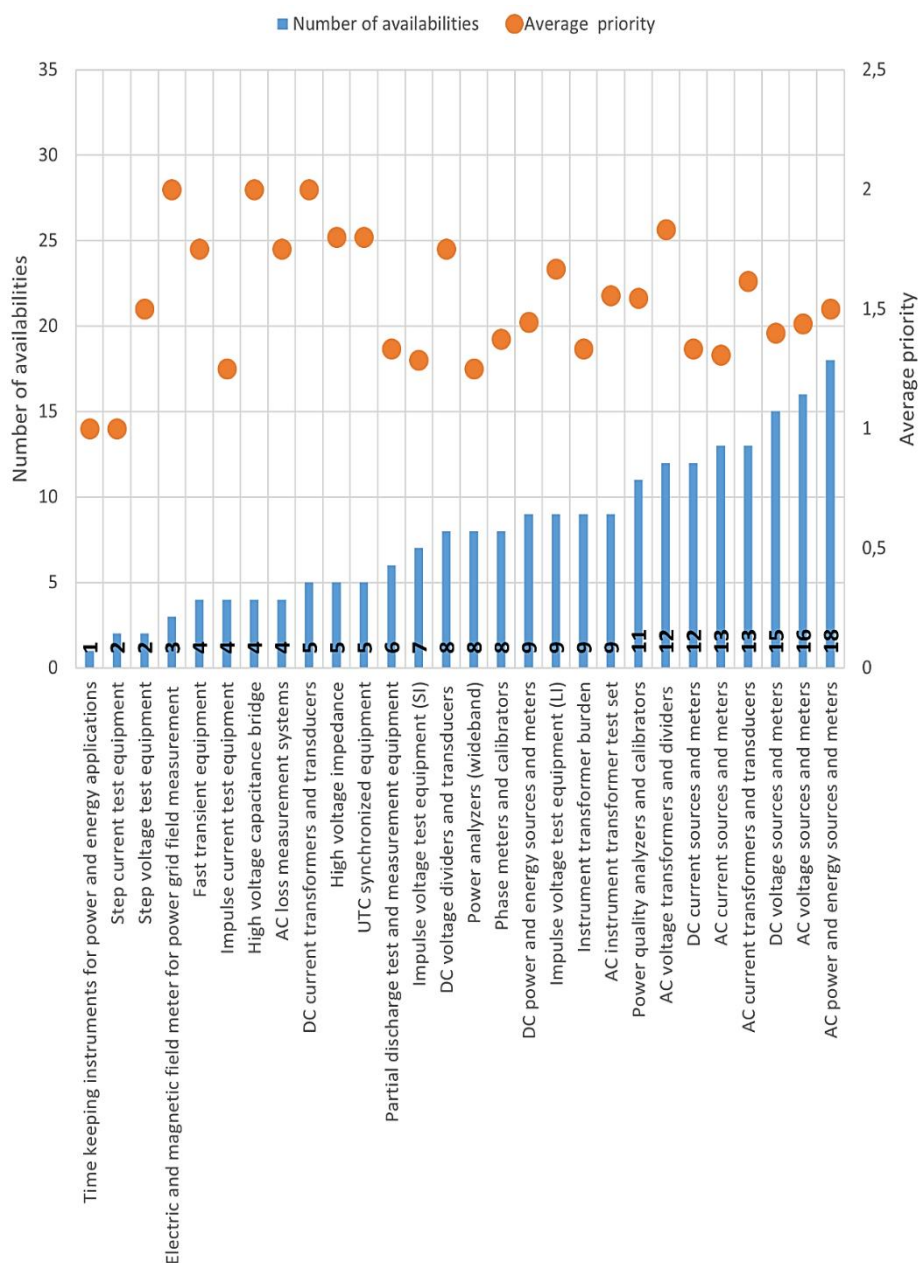


Figure 13: Availability of services and average priority

The figure above shows an example of how the data in the report is analysed. The NMIs and DIs can use the information from this report to evaluate the demand, potential, and lack of services. This could lead to smart specialisation of services, for instance, to obtain cost-effectiveness of investments by considering joint investments in the operation of large facilities or by building of a virtual lab infrastructure.

Countries can choose to optimise their portfolio by agreeing to offer mutually complementary scopes. This would ensure that stakeholders can obtain all required services in close geographical proximity, without NMIs having to maintain a full suite of services that is not economically viable for their national stakeholder base alone.


Countries can also consider possibilities for optimising the range of available metrology services. This could take the form of collaboration between countries where each specialises in a particular service, so that the whole scope of required services is available for stakeholders at the accuracy level they require, whilst

The project succeeded in achieving objective 3 by producing a detailed analysis of the European metrology landscape for electrical energy, thus revealing opportunities for NMIs and DIs to coordinate their activities and development plans and strategically approach the challenge of efficiently meeting stakeholder needs. Based on the progress achieved in this project, the EMN SEG will continue to promote a sustainable European metrology infrastructure for Smart Electricity Grids. As an example, to further stimulate enhanced NMI and DI cooperation, a series of national research projects were presented at the 2023 EMN SEG General Meeting that are open for contributions from other EMN SEG members and partners.

As the EURAMET EMNs are focussing on stakeholder contacts and meeting stakeholder needs, an important part of the SEG-net project was devoted to getting more insight in and contacting of the relevant EMN SEG stakeholders. To increase stakeholder interaction and to make the EMN SEG community better known to stakeholders, a regular EMN SEG newsletter was launched.

A joint effort of the EMN SEG members, led by the JNP team, made it possible to identify the different types of stakeholders and collect 178 existing and potential EMN external relationships. Based on this input, a list of contacts was developed and subsequently continuously updated. The list contains the following information:

- Organisation name
- Type of organisation
- Country
- Sphere of activity (National, European, International)
- Liaison levels (sent a letter of support, member of stakeholder council, formal liaison agreement, key stakeholder for SRA consultation, key stakeholder for feedback on hub website)
- Main contact person
- Joint Research Projects in which the stakeholder is involved



European Metrology Network on Smart Electricity Grids  
Organisations and networks inventory - With and without current involvement

**Confidential document. Do not circulate outside the EMN members**

Organisation name <i>See "Stakeholders/Entities" sheet</i>	Type (multiple choices possible) <i>See "Types/Entities" sheet for the definition of each type</i>														Country (or EU or UK)			Sphere of activity			Liaison levels (multiple choices possible) <i>See "Liaison levels/Entities" sheet</i>							Involved in JRP																																																																																																																																																																																																																																																																																																																																																																																																									
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Figure 14: Preview part of the stakeholder liaison file

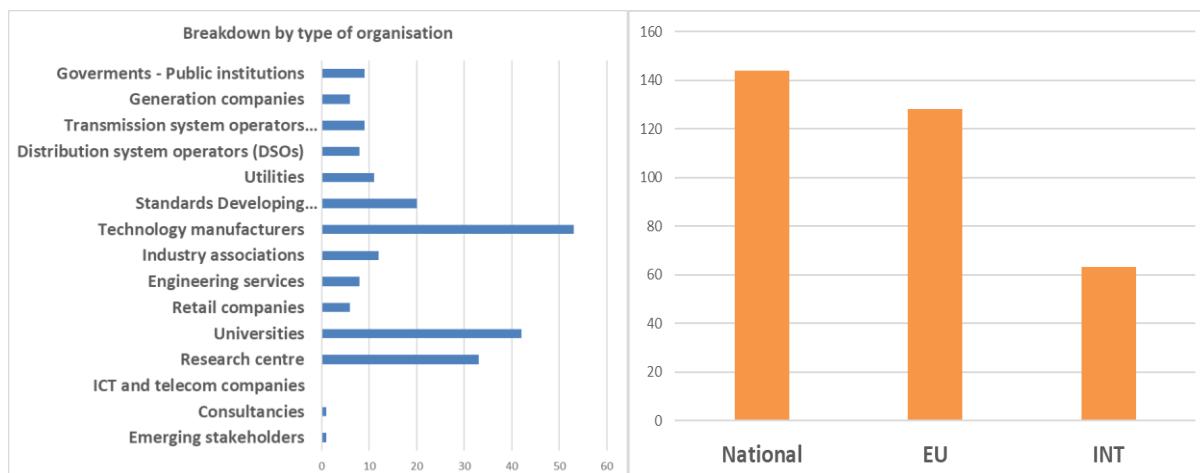


Figure 15: Stakeholder inventory by type of organization and sphere of activity.

The graph above illustrates an inventory of the EMN SEG stakeholders by type of organisation and sphere of activity. Among the compiled actors, 50 stakeholders are involved in 20 finished and ongoing Joint Research Projects (JRPs) of the EMRP, EMPIR and Partnership European metrology research programs. Each of these actors is part of the consortium of one or more joint research projects either as a funded partner or as an unfunded partner.

#### 4.4.2 Strategic Liaison Plan

Following the stakeholder inventory, a Strategic Liaison Plan was developed that defines the objective of the liaison activities of the EMN SEG, identifies key stakeholders and relevant organisations and specifies how the liaison activities will be conducted, by whom and when.

It ensures a cohesion between the different actions of EMN SEG members with external entities and serves as guide for the liaison activities conducted in the 5 EMN SEG' outputs as mentioned in the EMN SEG proposal (29 June 2018):

1. To ensure all stakeholder needs will be met by coordinating alignment of national R&D strategies
2. To significantly enhance exploitation and uptake of research results from multiple EMRP and EMPIR JRPs as well as national research activities through the realisation of a virtual knowledge hub
3. To create a joint sustainable European metrology infrastructure for Smart Electricity Grids by stimulating smart specialisation of European NMI facilities and services
4. To create a widely visible identity as voice of the European electricity grid metrology community and to set up liaisons with relevant (European) stakeholder organisations
5. To set up an extensive knowledge transfer program

The following figure shows the overall contents of the Strategic Liaison Plan, with emphasis on its two main chapters 5 and 6.



Content	
1 GLOSSARY	
2 DEFINITION	
3 INTRODUCTION	
4 OBJECTIVES	
5 STRATEGIC CONSIDERATIONS	Describe the various types of liaisons to which EMN-SEG has to work on: <ul style="list-style-type: none"> <li>• Shaping the smart electricity grid metrology landscape</li> <li>• Coordination of research strategies including SRA, Roadmap</li> <li>• Engaging the wider stakeholder community</li> <li>• Knowledge Transfer</li> <li>• Training</li> </ul> Identify the several liaison objectives <ul style="list-style-type: none"> <li>• Reinforce and widen the strategic exchanges with external relevant entities</li> <li>• Bring several stakeholders to participate in the outputs of EMN-SEG</li> <li>• Increase the numbers of external partners interested in the activities of EMN-SEG's member in term of R&amp;D projects as well as services</li> </ul>
5.1 Liaisons as transversal activities	
5.2 Liaison Objectives in the Network	
6 LIAISON APPROACH	Present how to implement the liaison activities in order to reach the objective <ul style="list-style-type: none"> <li>• First questions to take into consideration prior to any actions</li> <li>• Contact person concept</li> <li>• Different possible status for an external entity</li> <li>• Concrete activities in relation with external partners are listed</li> </ul>
6.1 First questions	
6.2 Contact person	
6.3 Relationship Status	
6.4 Activities and actions	
7 RELATED DOCUMENTS	

Figure 16: Overview of the contents of the EMN SEG strategic liaison plan, with emphasis on paragraphs 5 and 6

#### 4.4.3 Stakeholder Council

The Strategic Liaison Plan defines setting up a Stakeholder Council, consisting of other European and international organisations and industrial stakeholders. The EMN SEG's second General Meeting accepted the proposition to merge the notion of stakeholder committee and stakeholder council in a single term "stakeholder council" and decided it was not necessary for the stakeholder council members to sign a MoU and proposed the formulation of Stakeholder Council Rules. The Stakeholder Council Rules were drawn up and proposed at the EMN's General Meeting on 3-4 June 2020 and were subsequently approved.

At present, experts from key stakeholders as identified in the strategic liaison plan are asked to join the EMN SEG Stakeholder Council in order to provide high-level evaluation and steering of the EMN SEG activities.

EMN Smart Electricity Grids Stakeholder Council Rules
Version 1
Approved by the EMN General Meeting on 3-4 June 2020
<u>Membership</u>
Members of the EMN SEG Stakeholder Council (SC) will be senior-level representatives from key stakeholder organisations that are willing to act as advisors to the EMN SEG and promote the EMN mission within their network.
The EMN SEG Steering Committee will nominate individuals for a position on the SC, with final approval by the General Meeting.
It is envisaged that the SC will be approximately 10 persons.
<u>Tasks</u>
The general task of Stakeholder Council members will be to provide advice to the EMN SEG from the stakeholder perspective.
These include, but are not limited to:
<ul style="list-style-type: none"> <li>• The Strategic Agenda of the EMN SEG</li> <li>• Development and review of the Strategic Research Agenda</li> <li>• Support in the development of a liaison plan</li> <li>• Contributions to stakeholder events organized by the EMN SEG</li> </ul>
<u>Rights and obligations</u>
<ul style="list-style-type: none"> <li>• Members of the SC participate on personal title, based on their individual expertise. Their advice is understood not to represent the official position of their organization of employment.</li> <li>• Members of the SC act to the best of their knowledge, but are not accountable for any damages resulting from their advice or the withholding of advice.</li> <li>• The EMN is entirely free to adopt or not adopt the advice of the SC.</li> <li>• The EMN will provide access to any draft documents that fall within the scope of the SC task.</li> </ul>

Figure 17: The drafted stakeholder council rules



#### 4.4.4 Newsletters

In August 2021, SEG-net launched the initiative to create and publish periodic EMN SEG newsletters in strong collaboration with EURAMET and the EMN SEG partners. The EMN SEG Secretary with two EMN members coordinate the newsletters. The content might be provided by EMN SEG Chair, EMN SEG members and JRP coordinators. EURAMET takes care of the lay-out and e-mailing.

Three issues have been sent to date and the plan is to continue at a frequency of 2 to 3 annual publications. The first issue was sent to the entire stakeholder community in March 2002 via the e-mail address [secretariat@euramet.org](mailto:secretariat@euramet.org). The mailing list has 1187 recipients. The second issue was sent in September 2022 and the third issue was sent in March 2023. The issue 4 is scheduled for Summer 2023, focussing on the publication of the EMN SEG's Strategic Research Agenda.



Figure 18: The first issue of the EMN Smart Electricity Grid Newsletter released in March 2022.

Objective 4 of the project has been achieved. A strong and visible identity has been established for the EMN SEG and the implementation of the Strategic Liaison Plan, with the Stakeholder Council, will ensure effective cooperation with stakeholders of smart electricity grid metrology into the future.

### 4.5 Knowledge transfer programme

To underpin the dissemination of the knowledge resulting from the smart electricity grid metrology JRPs and to raise awareness of the EMN SEG specific expertise, a knowledge transfer and dissemination programme was developed and relevant implementation actions were undertaken. The knowledge transfer plan covered sharing the experience and research results acquired by the signatories of the EMN SEG MoU on smart electricity grid metrology with stakeholders. A comprehensive training programme enabled the EMN SEG to transfer the knowledge gathered to stakeholder and end user communities.

#### 4.5.1 Set up of a knowledge transfer programme

As a first step, a list of international events, conferences and national events has been created, where speeches, talks and presentations can be given to illustrate and promote the EMN SEG competence and activities. Metrology and trade journals, as well as stakeholder journals are also suggested for publication of non-peer-reviewed papers. Further sections are dedicated to EURAMET and standardisation or technical committees, as well as to direct stakeholder communication activities.

The recording of the actions performed by all the different EMN SEG partners has allowed the creation of an inventory of the KT performed, together with a variety of suggestion/proposals of new future events. During the four years of the project, the EMN SEG contributions to the implementation of EU green policies were presented at two high-level EU events: the 11<sup>th</sup> European Innovation Summit, organised by the Knowledge for information (K4I) platform in the European Parliament in Brussels on 3-6 February 2020 and the Policy debate hosted by IPQ and EURAMET on the role of measurement science networks in delivering the EU's Green Deal (virtual). Both presentations were given by the EMN SEG chair, Gert Rietveld.



Further highlights were invited keynote presentations of the EMN SEG at other conferences specifically focused on measurement and metrology, such as CPEM 2022 and SMAGRIMET 2023, as well as presentations at Conferences with significant industry participation such as CIM 2023.

As an additional noticeable result, the first EURAMET joint booth involving the Green Deal related EURAMET EMNs (Smart Electricity Grids, Energy gases, Climate, Ocean and Earth Observation and Pollution Monitoring, together with the proposed EMN Clean Energy) was organised by INRIM, with the support of LNE and METAS and active contribution from the involved EMNs. The booth was set up at the CIM 2023 partner exhibition Global Industrie, in the core of the “Village” dedicated to metrology. Objectives and activities from all the EMNs were presented through focused roll-ups and leaflets, which were distributed among the visitors. People from at least 10 countries from 3 continents visited the booth.



*Figure 19: EURAMET EMN Joint Booth on Energy and Environment*

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#### 4.5.2 Set up an extensive training and knowledge dissemination framework

Special attention was dedicated to the development and implementation of training actions. As a first step, an inventory of the training material already available within the EMN SEG partnership has been made via an extensive survey carried out within the involved partners.

Information on training material was collected and made available to all the EMN SEG partners, in terms of training subjects, type (in person, on-line course or lecture, self-study) and duration of the course, type of material provided (slides, videos, etc.) and contact point. The material is also differentiated by target audience covering both academia, engineers and technicians.

Thirteen of the nineteen partners provided information for a total of 34 courses, proving the interest of the NMI / DI community in setting up training actions. An analysis of the collected data by subject is shown in the pie chart below (Figure 21:), where the courses are classified as per ten main categories including instrument transformers, HV and loss measurement, measurement uncertainties, introduction to metrology, Smart Grid and Power and Energy among others. According to the classification of data, about 50 % of the courses are dedicated to basics of metrology and uncertainty (general or applied). Among the EMN specific topics a consistent number of courses are dedicated particularly to Power quality, whereas a few courses concern topics like PMU, Smart Grid metrology and High voltage testing.

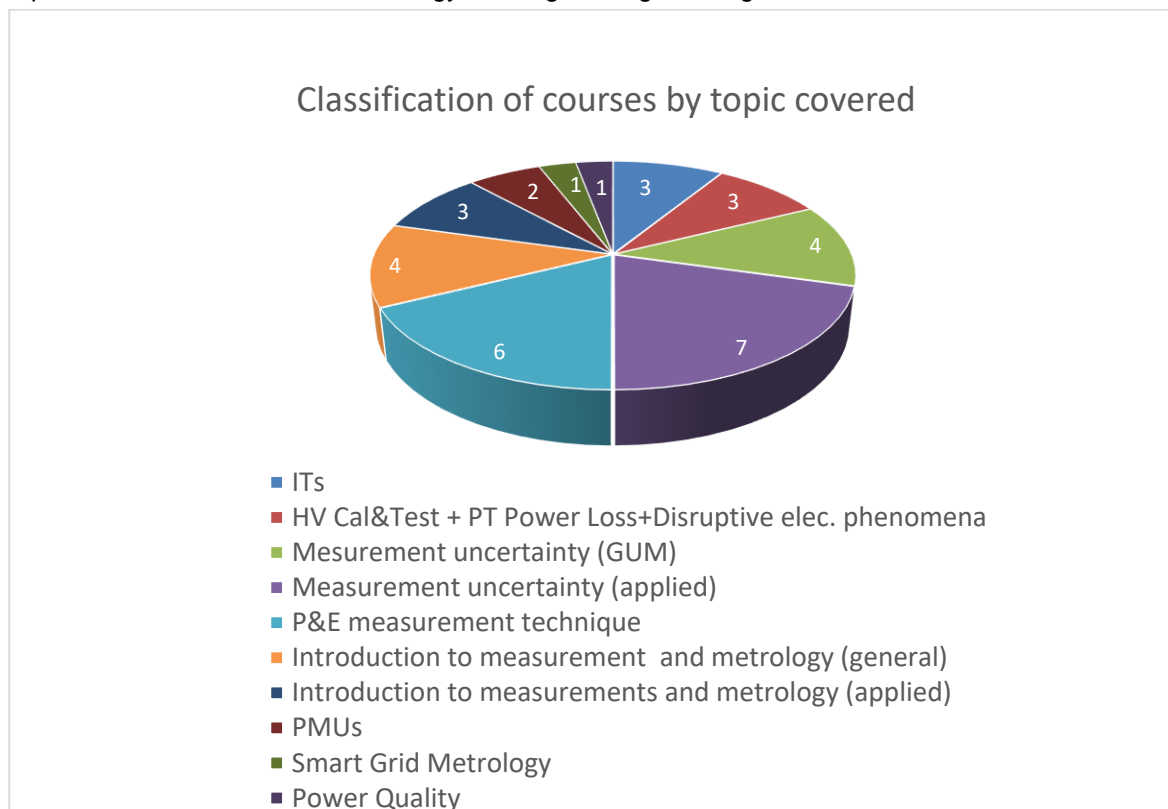


Figure 21: Classification of courses held by the EMN SEG NMI members.

As a joint action, an Excellence Course was organised in May 2022 providing an extensive overview of the general measurement challenges related to smart electricity grids together with in-depth training on selected key measurement challenges, considering the grid evolution in the context of the ongoing energy transition. The course was organised jointly by the EMN SEG, INRIM, and Politecnico of Torino, and was held as an Excellence Training within the PhD Programme of the Doctorate School of Politecnico of Torino. The course topics ranged from basics of metrology and measurement uncertainty to key measurement challenges relevant to the development of measurement tools for observing and controlling the grid, including tools for monitoring grid stability, tools for determining grid quality, revenue metering systems, substation digitalisation issues, instrument transformers and sensors and high voltage test of sensors and grid components. The course was



subdivided in ten lessons for a total of 25 hours given by five EMN SEG scientists (from VSL, METAS, INRIM and VTT).

About 80 people registered for the course with a mean attendance of more than 30 people/lesson. The course was attended by PhD and MSc students (50 %), as well as researchers from NMIs and participants from industry (50 %). Given the great success of the course, plans are made to give a similar course in the coming years.

With these achievements, Objective 4 of the project has been largely achieved. The booth materials developed in the project will be used in future attendance of the EMN SEG members and partners at national and international workshops, conferences and trade shows. Based on the overview of existing metrology courses in the area of the EMN SEG, the members and partners are presently discussing which new courses can be best developed for further meeting the stakeholders' training needs. Part of this discussion is a possible repeat or extension of the Excellence Course on Smart Grid Metrology.

## 5 Impact

The project partners presented EMN SEG at 13 International and European conferences, including EURAMET events. Additionally, 14 presentations were made to key IEC and CEN-CENELEC technical committees. A significant highlight was the joint EMN SEG - EMN Energy Gases (EG) promotion of metrology research in support of the energy transition during a stakeholder event at the European Parliament held on 4 February 2020. This event was part of the "11<sup>th</sup> European Innovation Summit" organized by the Knowledge for Innovation (K4I) platform, to advocate the role of metrology in achieving the EU Green Deal aims. With two Members of Parliament hosting the event, and more than 60 attendees, the fully-booked event was highly successful in promoting the relevance of the EMN SEG and EMN EG in realizing the EU Green Deal objectives. In a follow-up event on 5 May 2021, organized by IPQ and the Portuguese Government, again the role of measurement science (as promoted by the EMN SEG, EG and COO) in delivering the EU's Green Deal was presented.

For stakeholders, this project and its associated EMN has greatly reduced the previous ad hoc approach to meeting their smart electricity grid metrology needs. Increased specialisation of NMIs stimulated by the project will enable more efficient use of resources, thus allowing stakeholders' needs to be covered more effectively. Aligning and focusing R&D activities via the strategies for implementing the joint SRA developed in the project will increase the scientific output and stimulate scientific cooperation between NMIs and with universities and other research institutes. Most of all, it will ensure that the needs of all stakeholders will be met more consistently. Impact studies have proven that such consistent metrology support enhances the competitiveness of companies and that it results in more jobs.

Furthermore, the realisation of the virtual knowledge hub has significantly contributed to increased exploitation and uptake of electrical grid metrology R&D. Allowing stakeholders to access R&D results by topic rather than by project alone has greatly increased the accessibility of the project's results. The concise knowledge transfer program developed in this project and implemented within EMN SEG has further enhanced the dissemination of the acquired metrology knowledge to the stakeholder community. In terms of long-lasting impact, the project's outputs will lay the foundations for the realisation of a 'natural metrology partner' for stakeholder organisations, as a single voice of the European smart electricity grid metrology community, which will greatly enhance the formal interaction with stakeholder organisations. The impact of this cannot be overestimated, as one of the major deficiencies encountered by all NMIs active in the area was the low visibility of metrology and the lack of awareness of what metrology can contribute to solving stakeholders' business challenges.

The SRA and smart specialisation strategy developed by the project will allow NMIs to use their scarce resources in a more effective and complementary way, and this will lead to a more structured approach in national R&D programs. Easy access to large and expensive facilities in other countries will enlarge the service portfolio that NMIs can offer to national customers. As such, the increased visibility realized by the project and its associated EMN via a recognizable identity and high-level liaisons will be a major asset to NMIs for increasing general awareness and recognition of the metrology contribution to the realisation of smart electricity grids. More involvement in solving stakeholder problems will not only generate new income, but also prove the impact and added value of metrology to society.

Moreover, the enhanced visibility and the dedicated training program developed by the project aims to attract students, young researchers and electrical engineers to the area of smart electricity grid metrology, increasing their skills and providing them with a specific and deep metrology background. This will help alleviate a



significant problem that is encountered by NMIs i.e. in hiring staff that are both interested and adequately trained in smart electricity grid metrology. In the course of this project, several requests for student opportunities within the EMN have already been received. Moreover, there was a significant interest in the "Excellence Course" on Smart Grid Metrology, held in May 2022, with more than 80 students attending.

The SRA, including the prioritisation and implementation plan, as realized by the project will be crucial to ensure that the challenges with the largest economic impacts will be covered by future metrology research. The cooperation and smart specialisation stimulated by the EMN will help to ensure that the metrology efforts will lead to a larger portfolio of facilities in Europe, covering a wider range of stakeholder needs than without EMN coordination. This increased and more effective metrology support to stakeholders will further improve the already strong competitive position of European manufacturers. Indeed, early impact was already achieved in the first three project years: as already mentioned above, based on the early drafts of the SRA, 17 new project proposals have been submitted in the EMPIR 2019 Energy Call, the EMPIR 2020 Normative Call, and more recently in the 2021 Green Deal, 2022 Integrated European Metrology and 2021 – 2022 Normative Calls of the European Partnership on Metrology, to cover the most urgent needs identified in the SRA. The exceptional success of the PRTs in these calls indicates the high degree of impact the EMN has had on recognizing the most relevant topics in the field of Smart Grid through the development of the SRA.

The CEN-CENELEC market perspective and innovation director already testified that metrology makes an important contribution to standardisation for smart electricity grids. This has been confirmed by several national standardisation committees and by the strong standardisation component in the over 20 smart electricity grid-related JRPs, 7 of which are fully dedicated to standardisation support. The regular interaction between CENELEC and the smart electricity grid metrology community, realized via this project and its associated EMN, has helped to identify standardisation R&D needs at an earlier stage and resulted in better coverage of these needs by research projects. In this way, the project and its associated EMN have given an impetus to the development of pan-European documentary standards and grid codes that are vital to ensure that equipment from different smart electricity grid vendors can be used inter-changeably and that common grid limits and constraints are applied, based on reliable measurements. This added value is recognized by key technical committees of IEC and CEN-CENELEC and has led to strong contacts with CEN-CENELEC TC38 "Instrument Transformers", CEN-CENELEC TC14 "Power Transformers" and IEC TC42 "High voltage and high current technology".

The most significant social impact of the associated EMN lies in its contribution to a more reliable and more efficient electricity grid as the key enabler of the "Energy Transition": the electricity grid is essential for reliable integration of sufficient renewable energy sources to meet the EU 2050 target of 50 % renewable energy supplies. Improved metrology support to a stable and high-quality electricity supply, based on sustainable energy sources such as wind and solar, is at the heart of the EMN on Smart Electricity Grids. This project and its associated EMN are improving the coordination and organisation beyond individual research projects, thus reducing the risk of key metrology not being ready when needed and avoiding potentially delaying the successful implementation of EU energy policies. The coherent, pan-European approach to smart electricity grid metrology, as realized by this project, will thus have a profound impact on society. Finally, this project and the EMN will ensure reduced emissions of carbon dioxide and greenhouse gases in two ways: firstly, via support to the increased uptake of renewable energy sources (RES) to the EU energy mix, and secondly, via support to the implementation of more efficient electricity grids. In this wider sense, this project and the EMN for Smart Electricity Grids will thus help to address the requirements of the Paris agreement by tackling climate change.

## 6 Contact details

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