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Metrology matters: the hidden science driving the green and digital transition

Often overlooked, metrology – the science of measurement – underpins countless aspects of daily life, from accurately telling the time to ensuring the security of digital communications.

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As Europe ramps up efforts to transition to a greener economy, hydrogen is taking centre stage as a clean energy solution, particularly for decarbonising sectors like transport and heavy industry. But turning hydrogen into a reliable, large-scale energy source depends on something deceptively simple: the ability to measure it accurately as it moves through the supply chain.

“Deciding how to best measure hydrogen flow is crucial,” said Annarita Baldan, chief scientist at VSL (the Dutch national metrology institute) and chair of the European Metrology Network for Energy Gases.

“We need to learn how to accurately metre the quality and quantity of hydrogen, how to detect leaks and how to ensure that everything is safe.”

Baldan is closely involved in a research project funded under the European Partnership on Metrology called Met4H2 – short for Metrology for the Hydrogen Supply Chain – which brings together national metrology institutes, research organisations and industry.

This European initiative, which will conclude in September 2025, set out to develop and refine the measurement standards essential for the safe development and integration of hydrogen technologies into existing energy systems.

It is a necessary step if Europe is to achieve its goal of increasing the market share of hydrogen from 2% in 2020 to 14% in 2050.

Consistency counts

This is one of the many key contributions that metrology, a relatively little-known field of science, makes to our daily lives. It does virtually everything, from ensuring we can accurately see how much hydrogen is flowing

through a pipeline to making sure the time shown on our phones is correct.

“When you look at your watch, the time it shows will largely be the same as that of the watches of the people around you,” said Baldan.

“When you drink water from the tap, in most European countries, you know it is clean. That is because of metrology. It is taken for granted, but behind the scenes, we make sure that all these things are possible.”

The importance of this field is celebrated every year on 20 May, World Metrology Day. This year also marks the 150th anniversary of the signing of the Metre Convention.

This international treaty, signed in 1875 in Paris, France, laid the foundations of a global system of measurement, ensuring that measurements like length, mass and time were consistent worldwide.

Quantum security

Metrology is an extremely diverse field. Metrology institutes in each country ensure, for example, that the fuel put into a car at a petrol station is the amount that it says on the meter. But they also study high-tech issues, such as how to make quantum communication secure.

Quantum computers are high-speed computers that work on principles of quantum physics. It is feared that the potential speeds at which these computers work may render current security measures for digital communication obsolete. This is why cryptographers are busy working on the development of quantum-proof security systems.

“We are working on a concept called quantum key distribution,” said Ivo Pietro Degiovanni, research director at the Italian national metrology institute (INRiM), and chair of the European Metrology Network of Quantum Technologies. “This will allow us to communicate safely, even when quantum computers become a reality.”

But there is one weak point in this new way of encoding messages: a transformation needs to happen between the quantum and physical world.

But at this point, “information leakage” might occur, said Degiovanni. “A hacker might then observe your message and intercept it.”

Thanks to work carried out through an EU co-funded initiative named MeTISQ, which ran from 2019 to 2024 under the European Metrology Programme for Innovation and Research (EMPIR), metrologists from across Europe were able to develop ways of spotting and blocking this kind of information leakage. Chalk one up for metrology!

Boosting sustainability

Metrologist Annette Röttger of the German National Metrology Institute has been looking at how metrology can contribute to battery technology and, particularly, the way we recycle them.

“In 2030, we will have 150 million lithium-ion batteries available for secondary use,” said Röttger. “That is an enormous number. But to recycle them well, we also need to know when and if we can reuse them.”

Röttger was involved in an EU-funded research project called LiBforSecUse, which ran from September 2018 to August 2021.

Co-funded by the EU under EMPIR, this initiative allowed researchers to look at ways to accurately measure impedance – resistance to the flow of electrical current in a battery.

Lithium-ion batteries are commonly used in electrical vehicles. As they age, their performance goes down and they may need to be replaced. However, they could still be in good enough shape for other uses, such as energy storage. Checking the impedance of these second-hand batteries is therefore important for deciding on their reuse potential.

“You can compare it to how – when water flows through a pipe – it gets slowed down when there are bends, twists or blockages,” said Röttger. “We looked at how to best measure impedance and define when a battery can still be reused.”

European standards

Whether measuring the flow of hydrogen, the vagaries of qubits or the power potential of second-hand batteries, it is not only important to make sure measurements are accurate, it is also essential that people are measuring in the same way everywhere.

Through EURAMET and the European Partnership on Metrology, Europe is an important player in standardisation and coordination.

“Europeans need to collaborate to work out these measurements. Metrology is the foundation upon which much of what we produce and trade is built,” said Röttger.

The EU’s support for research in this area allows metrologists across Europe to work together on a wide range of problems.

“It is key that we are able to meet each other and compare results,” said Baldan. “We need to align our measurement standards. We need to go beyond national concerns in metrology.”

Degiovanni also agreed that cooperation on metrology is fundamental for Europe’s sustainable competitiveness. “Particularly in new fields like quantum computing and sustainable technologies, we need to verify claims and make sure everyone is on the same page. Working together with colleagues like this has a huge impact.”

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More info

- LiBforSecUse
- Met4H2
- MeTISQ
- EURAMET