R&D NESTER

29 NL abr 2026

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## EDITORIAL

Dear Reader,

As the **energy transition** continues to accelerate, the need for **digitalization**, **interoperability**, **consumer engagement**, and **scientific rigor** becomes ever more evident.

At R&D Nester, we remain committed to contributing to this transformation through research, innovation, and practical implementation across a wide range of energy topics-always guided by our motto, "**Creating a Smart Energy Future**."

This 29th edition of our Newsletter reflects that breadth of activity. In these pages, you will find examples of how R&D Nester is helping address some of the most relevant challenges of today's energy systems: enabling more active consumer participation, supporting the deployment of flexibility services, advancing green hydrogen modelling, and strengthening the metrological foundations required for increasingly digital and decentralized power grids.

A central highlight of this edition is our continued involvement in the **ECLIPSE project**, where we contribute to the implementation of the Common European Reference Framework for consumer energy applications. Through our role in the Portuguese pilot, we are helping to connect grid needs, demand-side flexibility, and end-user engagement in a practical and interoperable way.

We also report on R&D Nester's participation in **ICPEE 2025**, where we presented research on **alkaline water electrolysis modelling** using open-source tools. This work reinforces our growing activity in **green hydrogen** and demonstrates our commitment to transparent, accessible, and high-quality scientific approaches for the energy transition.

In parallel, this Newsletter highlights our contributions to **HEDGE-IoT** and **SOCIAREM**, two European initiatives that illustrate different but complementary dimensions of the **digital energy future**-from **AI- and IoT-based grid intelligence** to the **large-scale adoption of photovoltaic systems and energy communities**. These projects show how innovation must combine technology, system integration, and citizen involvement to generate real impact.

Another strong focus of this edition is **metrology in power systems**. Through our participation in **CONFMET 2025**, the **QUANTUM** project, and the new **GridData** initiative, we continue to explore how accurate, traceable, and intelligent measurement frameworks can support the reliability and evolution of modern electricity networks.

Under the **Technical Information** section, this issue presents a topic closely aligned with these challenges: **error monitoring methods for digital metering** equipment driven by high-accuracy data. As digital substations become more widespread, this is a highly relevant field for ensuring confidence, traceability, and performance in next-generation grid infrastructures.

We hope you enjoy this edition and find in it useful insights into the projects, results, and perspectives that are shaping our work. As usual, we also invite you to explore the **Literature Review**, **Events**, **Links**, and **Quiz** sections.

Thank you for following R&D Nester's activities and for joining us in our mission to create a **Smart Energy Future**.

Sincerely,

Nuno de Souza e Silva

## HIGHLIGHTS

# COMMON EUROPEAN REFERENCE FRAMEWORK ENERGY CONSUMPTION REDUCTION ON ANALYSIS - R&D NESTER PARTICIPATION IN DIGITAL ECLIPSE PROJECT

**ECLIPSE PROJECT GENERAL ASSEMBLY**

**R&D Nester** participated in the 2nd **ECLIPSE** General Assembly hosted by E-Redes at EDP (Lisbon), bringing together project partners to review progress across all 12 pilot sites and work packages, align on delivery timelines, and plan the next implementation and demonstration steps for the Common European Reference Framework (CERF) for energy saving applications for consumers represents an opportunity to promote actions based on recommendations and tips that allow them to make voluntary reductions in their energy consumption and help them in reducing their energy costs.



**Across its 12 pilot sites, ECLIPSE is testing how CERF-based energy apps can work in different real-world contexts:**

1. **France/Estonia/Finland/Denmark/Belgium** scale up smart-home demand response and monitoring (Voltalis Smart Energy Box; Digital4Grids Home Living Lab) including trials with home energy stations/digital-twin apps and replication across markets;
2. **Austria** deploys and evaluates the ECLIPSE solution with ~100 residents across multiple towns to stress-test interoperability and performance;
3. **Spain (Madrid)** focuses on EV flexibility - Smart Charging and Vehicle-to-Grid (V2G) at charging points in an urban office setting;
4. **Bulgaria** pilots a new digital platform spanning the electricity market in West Bulgaria with TSO involvement to improve distribution management at scale;
5. **Slovenia** targets behaviour-based energy reductions while preserving comfort, engaging domestic users and prosumers;
6. **Cyprus** addresses the needs of an isolated island grid by engaging large numbers of consumers in energy-saving actions;
7. **Greece** (Aspra Spitia) demonstrates integrated residential solutions combining PV + batteries + IoT monitoring in a managed settlement;
8. **Sweden** leverages CheckWatt's large prosumer base (PV/wind/batteries) to showcase real-time monitoring, reporting, and grid-interaction insights;
9. **Portugal (Porto/Braga/Guarda)** runs the ECLIPSE app with ~50 LV participants equipped with demand response resources under the DSO (E-REDES), with active participation in SO flexibility market using R&D Nester's market simulator along with exploitation of such flexibility under grid emergency conditions;
10. **Croatia** (TSO) strengthens demand response using existing aggregator/industrial frameworks plus an open call for wider voluntary participation;
11. **Czech Republic** uses CEZ's large service area as a representative testbed for demonstrating new consumer-facing energy solutions;
12. **Poland** (TAURON) focus on prosumers/energy communities in high-activity areas to validate engagement and scalability under incentivized and non-incentivized demand response schemes.

**R&D Nester** has contributed across multiple streams of the project, combining technical, pilot, and project-support responsibilities.

For the current reporting period, **R&D Nester** has been involved in Work Package (WP) 3 as a peer reviewer for two key deliverables (**D3.1 "CERF architecture specification and ECLIPSE interoperability profiles"** and **D3.2 "Specific Data Protection Analysis"**), supporting quality assurance of the CERF architecture/ interoperability profiles and the specific data protection analysis.



**R&D Nester** has also been active in Work Package (WP) 5 "Deployment & Demonstrations" as part of the Portugal pilot, contributing to the pilot definition and progress reporting, which is presented in Deliverable D5.1 "**Integration, Deployment and Stakeholder Engagement Results**".

In addition, **R&D Nester** completed the internal six-monthly financial reporting required at consortium level, ensuring project governance remains on track.




**R&D Nester**'s demonstration activities in the Portuguese pilot (WP5) focus on implementing and validating the operational logic that turns grid flexibility needs into participant actions under both normal and extreme operating conditions.

Within the end-to-end pilot flow, **R&D Nester** provides the grid simulations that generate/justify grid needs and supports the TSO-DSO interaction layer, while E-REDES leverages smart meter data and the "Balcão Digital" app to communicate flexibility requests and feedback to LV participants in Porto, Braga, and Guarda.

**R&D Nester** has completed the core components required for the demonstrations:

*** the Market Simulator**, which under normal conditions validates bids, performs selection and clearing, issues activation instructions, and records activated power as the basis for post-event calculation and reporting;

*** the Emergency (extreme conditions) model**, which generates events, quantifies and communicates needs, and coordinates the communication flow from the R&D Nester perspective, with participation handled via the dedicated emergency request/response handshake. These modules are now undergoing final integration testing and fine-tuning with E-REDES, to ensure the complete chain from request intake and bid/participation handling through activation and calculation/consultation operates reliably for the live demonstrations planned in the next project phase.

## ECLIPSE NEXT PHASE

During the Lisbon meeting, partners aligned on the next project phase moving from preparation toward live demonstration and data collection.

The discussions focused on keeping pilots aligned with the project timeline and ensuring readiness for upcoming project completion at the end of August 2026, continuing integration and deployment activities so pilots can progressively demonstrate real operational value, and strengthening the connection between technical developments (architecture, interoperability, and data protection) and the practical needs of pilot implementation.

Final updates included an ongoing online campaign focused on **ECLIPSE** pilot sites (with recorded videos to be published), plus external outreach and coordination discussions on privacy/security alignment with related initiatives.

## ECLIPSE PROJECT 1ST REVIEW MEETING

Building on the alignment achieved in Lisbon, the consortium reconvened for the **ECLIPSE** 1st Review Meeting in Valencia (January 2026).

The review meeting enabled the European Commission Project Officer and invited experts to assess progress from the first reporting period (month 1 until month 15).



## WORKSHOP "FROM DATA TO ACTION HOW DIGITALIZATION ACCELERATES THE ENERGY TRANSITION"

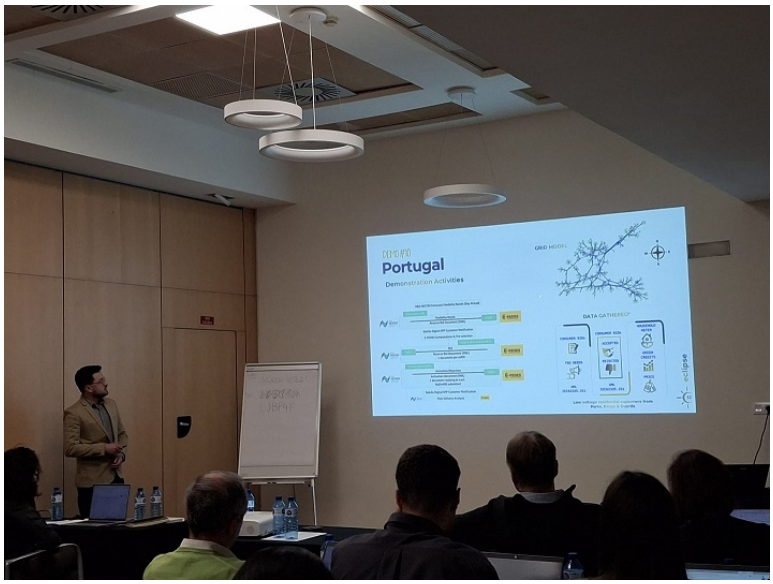
In the same venue in Valencia was held the workshop "From Data to Action: How Digitalization Accelerates the Energy Transition" in the scope of ECLIPSE project.

This Workshop brought together projects (OPENTUNITY, ODEON, BEGONIA, and INSIEME) working on the "digital backbone of the energy system" to share implementation experiences and lessons learned.




**R&D Nester** delivered a status update on the Portuguese pilot, including pilot progress, the number of customers currently onboarded and planned for deployment and testing, and the current development and integration status between **R&D Nester** and E-REDES.

This included a short demo of the TSO-DSO coordination and workflow for showcasing the complete (simulated) value chain from flexibility needs to bids consumer activation and post-delivery analysis.




**ECLIPSE NEXT STEPS**

A key expert question focused on whether the end-to-end communication pipeline effectively reaches low-voltage residential customers; this was confirmed as a central design objective and will be demonstrated once integration is finalized.

In the panel discussion, participants highlighted the need to move beyond siloed approaches in the energy sector and accelerate practical interoperability, drawing a relatable comparison with the seamless experience of telecommunications across Europe and noting that EU innovation is increasingly shifting from defining standards to implementing them at scale.

For more information:

ECLIPSE Project @ R&D Nester website

ECLIPSE Project website

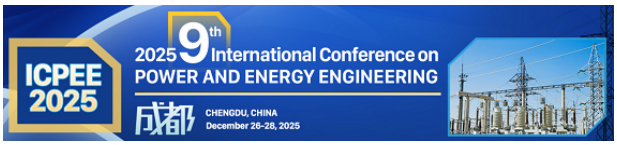
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# R&D NESTER PRESENTS HYDROGEN ELECTROLISER MODELLING RESEARCH AT ICPEE 2025

**R&D Nester** participated in the **ICPEE2025 - 9th International Conference on Power and Energy Engineering** in Chengdu, China.

**R&D NESTER'S CONTRIBUTION TO ADVANCING GREEN HYDROGEN RESEARCH**

The conference, organized with support from Sichuan University, brought together researchers, industry professionals, and energy specialists to discuss the latest developments in **power engineering, renewable integration, smart grids, and sustainable energy systems**.




**R&D Nester** presented the paper: **"Simulation of Alkaline Water Electrolysis in DWSIM: An Open-Source Comparison with Aspen-Based Results".**

This work develops and validates an **alkaline water electrolysis model implemented in DWSIM**, based on a reference model previously built in Aspen Plus.

The study demonstrates that open-source platforms can accurately reproduce the electrochemical and thermodynamic behavior of alkaline electrolysers, offering a robust and transparent alternative for **green hydrogen production simulations**.

**Key outcomes include:**

* The development of a **power-controlled iterative solver**, designed to reflect realistic industrial electrolyser operation;

* A detailed analysis of how **temperature, pressure, and electrical power** influence electrolyser efficiency and hydrogen output;

* Strong alignment between DWSIM and Aspen Plus results, with **very high consistency** across essential performance indicators.

This publication will be indexed in IEEE Xplore, Ei Compendex and Scopus (Elsevier), as well in other renowned databases.

## INTEGRATION IN THE GENESIS - GREEN HYDROGEN PROJECT

The paper presented at ICPEE2025 is part of the technical activities of **GENESIS - Green Hydrogen Project (2024-2027)**, which aims to study, model, and demonstrate solutions for the **production and integration of green hydrogen** in the national energy system.

**The presented research directly supports:**

* The development of **advanced, high-fidelity electrolysis models** for predicting hydrogen production, efficiency, and energy consumption;

* Operational analysis of **Power-to-Hydrogen** systems under diverse renewable and power-supply conditions;

* The creation of simulation tools that will enable GENESIS to evaluate real-world integration scenarios, reinforcing Portugal's commitment to **energy transition and system decarbonisation**.

## COMMITMENT TO INNOVATION AND OPEN SCIENTIFIC KNOWLEDGE

**R&D Nester**'s participation in **ICPEE2025** reaffirms its commitment to scientific excellence, technological innovation, and the promotion of open and accessible knowledge within the energy sector.

The development of open-source modelling approaches, such as the one presented in this study, represents an important step in democratising advanced simulation tools and supporting the deployment of sustainable, high-impact energy solutions.

For more information:

GENESIS Project @ R&D Nester website
ICPEE 2025 Conference website

# R&D NESTER IN EUROPEAN PROJECT HEDGE-IOT: EMPOWERING THE POWER GRID WITH AI AND IOT

The energy transition demands smarter, more resilient systems - and **HEDGE-IoT** is leading the way.

Co-funded by **Horizon Europe**, HEDGE-IoT is a pioneering European project that aims to **revolutionize energy systems** by deploying **IoT assets** across all grid levels, from behind-the-meter to Transmission System Operators (TSOs). By integrating **AI and Machine Learning** at both the **edge and cloud layers**, the project is unlocking new levels of intelligence, flexibility, and resilience in the power grid.

## A DIGITAL FRAMEWORK FOR THE FUTURE

At the heart of **HEDGE-IoT** is a **groundbreaking Digital Framework** that bridges the cloud/edge continuum. This framework enables **federated applications** governed by advanced **computational orchestration**, paving the way for:

* Enhanced grid resilience

* New flexibility markets

* Scalable, interoperable energy services

## 1ST PERIODIC REVIEW MEETING - BRUSSELS, SEPTEMBER

The consortium gathered in **Brussels** for the **1st Periodic Review Meeting**, marking **18 months of progress**. The meeting featured:

*** Project Officer**: Mariana Stantcheva (European Climate, Infrastructure and Environment Executive Agency - CINEA)

*** External Expert**: Luciano Boloni (Università di Bologna)

*** Consortium Partners**: 42 leading organizations across Europe.

## KEY HIGHLIGHTS

### 1. ESTABLISHMENT OF A ROBUST PROJECT ARCHITECTURE AND USE CASE FRAMEWORK

The project successfully defined **14 Business Use Cases (BUCs)** across six pilot countries, capturing diverse regulatory, climatic, and societal conditions. These use cases were supported by a comprehensive review of the state of the art, stakeholder requirements, and system specifications. Two evolutionary versions of the **HEDGE-IoT Reference Architecture** were developed, aligned with **SGAM** and **BRIDGE Data Exchange Reference Architecture (DERA 3.0) architectures**, laying the foundation for interoperable, scalable energy services across Europe.

### 2. DEVELOPMENT OF TECHNOLOGICAL ENABLERS AND AI/ML TOOLS

Significant progress was made in designing and prototyping key technological components, including **AI/ML tools, federated learning algorithms**, and a **computational orchestrator** for cloud-edge coordination. These tools are central to enabling intelligent decision-making and operational planning across the energy infrastructure. The development of services for flexibility optimization, energy-efficiency, and edge-cloud AI integration demonstrates the project's commitment to advanced digitalization.

### 3. IMPLEMENTATION OF THE DIGITAL INTEROPERABILITY FRAMEWORK

The project delivered a comprehensive **interoperability framework**, including the adoption of the **Eclipse Dataspace Connector (EDC)** for secure data exchange, a **semantic interoperability framework**, and a **Knowledge Engine**. An operational **App Store prototype** was also launched, integrated with the project's data space, offering standardized access to services and applications. Over **42 services** were specified, covering edge, cloud, and user interface components.

### 4. PILOT PREPARATION AND PRE-DEMONSTRATION PHASE COMPLETION

All six pilots entered the **pre-demo phase**, with baseline definitions, evaluation methodologies, and component procurement completed. These pilots span a wide range of energy scenarios-from grid automation in Finland to energy communities in Italy-ensuring broad validation of the HEDGE-IoT framework. Initial insights from pilot preparations are already informing the next stages of implementation and testing.

### 5. LAUNCH OF OPEN CALL AND IMPACT OUTREACH ACTIVITIES

The first **Open Call** was successfully launched in July 2025, attracting **35 applications** aimed at complementing the pilot demonstrations. This initiative supports stakeholder engagement, cross-validation with sister projects like **ODEON**, and broader replication of project outcomes. The project also began analyzing multi-dimensional barriers (legal, economic, social) and initiated ethics assessments to ensure compliance with EU regulations.

### 6. EFFECTIVE DISSEMINATION, EXPLOITATION, AND STANDARDIZATION EFFORTS

HEDGE-IoT executed a strong **communication and dissemination strategy**, including the launch of its website, social media channels, newsletters, and participation in over **20 industry events**. The consortium published **18 scientific papers**, engaged with European initiatives (AIOTI, IDSA, FIWARE), and contributed to standardization bodies (ISO/IEC, ETSI, CEN-CENELEC). These efforts are enhancing visibility, fostering collaboration, and preparing the ground for future exploitation.

## SIX PILOTS ACROSS EUROPE

**HEDGE-IoT** is being tested in **real-world scenarios** through six innovative pilots:

**FINLAND** - Grid automation with IoT and edge/cloud data (*ABB*)

**GREECE** - Local Flexibility Markets powered by Edge Computing (*PPC*)

**ITALY** - Digital Energy Communities and EV stations (*ARETI*)

**NETHERLANDS** - Arnhems Buiten Energy Innovation Campus (*AB*)

**PORTUGAL** - Living Lab for AI-based Energy Services (*CEVE*)

**SLOVENIA** - Flexibility services for asset lifetime extension (*EG*).

## WHAT'S NEXT?

The consortium presented the **first MVP (Minimal Viable Product)** of the pilot technologies, showcasing:

* Innovative IoT and cloud-based tools

* Achieved milestones and deliverables

* A clear roadmap for the next phases.

The **HEDGE-IoT** project is now preparing to enter the **full testing phase**, a crucial milestone where the developed solutions will be **tested under real-world conditions**.

This stage will validate the interoperability, robustness, and intelligence of the implemented systems, putting the services and technologies to the test in each of the six European pilot projects.

It's time to transform innovation into tangible results, with a direct impact on the digitalization and resilience of electricity grids.

**HEDGE-IoT** is not just a project - it's a **vision for the future of energy**.




**Infographic about project workflow organization**




**Consortium members**




**HEDGE-IoT Pilots**




**Pilot 5 - Portugal - Being presented by CEVE, Pilot Leader**

HEDGE-IoT website | HEDGE-IoT @ R&D Nester website | HEDGE IoT Project @ LinkedIn | HEDGE IoT Project @ Twitter/X

HEDGE IoT Project @ YouTube | HEDGE IoT Project @ Instagram

This research received funding from the European Union's Horizon Europe research and innovation program under the Grant Agreement number 101136216.

Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure, and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

# R&D NESTER AT THE FOREFRONT OF SOLAR ADOPTION AND CITIZEN-DRIVEN ENERGY SOLUTIONS: EUROPEAN PROJECT SOCIAREM KICKS OFF

The EU-funded project **SOCIAREM** will foster innovative solutions for large-scale adoption of photovoltaic (PV) systems and renewable energy communities across Europe. It combines research, technology, and community engagement to boost social acceptance of renewables.




The project brings together 15 partners from nine countries to drive the clean energy transition in a 42-month project co-funded by the European Union's Horizon Europe program. It was officially kicked off with a consortium meeting last **October** in **Madrid, Spain**.




Co-funded by the European Union's **Horizon Europe** programme, **SOCIAREM** brings together a multidisciplinary consortium of 15 partners from 9 countries to accelerate the uptake of **photovoltaic (PV) systems** and energy-sharing models by addressing social, regulatory, technical, and economic barriers.

**SOCIAREM** aims to deliver **innovative tools and services** tested in real-world settings to simplify photovoltaic adoption for citizens, renewable energy communities, and grid managers.

The project will explore **gamification strategies for energy education, open-source models** for energy communities, **unbiased guidance tools** for consumers, while engaging policymakers to **streamline permitting processes** and regulatory frameworks.

## ABOUT SOCIAREM

Running from October 2025 to March 2029, **SOCIAREM** is a 42-month Horizon Europe project with a total budget of around 5,6 M€, co-funded by the European Union.

**SOCIAREM** promises to support PV adoption with user-friendly solutions tailored to consumer needs via training workshops while addressing regulatory market challenges across borders.

By bridging technology, regulation and society, the project will contribute directly to Europe's renewable energy targets by making solar adoption more inclusive and widely accepted.

## THE CONSORTIUM BEHIND SOCIAREM

The consortium is coordinated by **Comillas Pontifical University** (Spain), leading the project's energy and social research, PV optimisation tools, and serious game development.

**The partnership gathers 15 organisations with complementary expertise:**

* SMEs such as **AKUYARI** (Spain) and **8D-Games** (Netherlands) contribute innovation in user engagement and gamification;

* Research centres including **R&D Nester**, **Watt-IS** and **CEVE** (Cooperativa Eléctrica do Cale d'Este, Portugal) bring strong technical know-how in renewable energy and P2P exchange;

* **Phoebe Research & Innovation Ltd** (Cyprus) and **EMPA** (Switzerland) advance monitoring, optimisation, and planning tools for PV adoption.

* Academic partners such as the **University of Cyprus**, the **University of Deusto** (Spain), and the **University of Aswan** (Egypt) contribute leading research in smart energy systems, social sciences, and network planning.

* Civil society and community actors like **FMES** (Fondazione dele Comunità del Mediterraneo Sostenibili e Solidali per l'Inclusione e l'Accoglienza - Ente Filantropico) and **Sinloc** (Italy) ensure close collaboration with local energy communities,

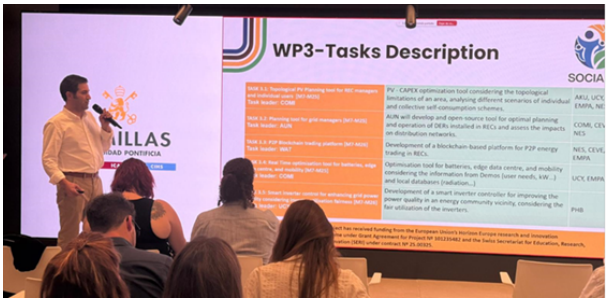
* **Finnova Foundation** (Belgium) drives communication and dissemination, and **Zabala Innovation Consulting** (Spain) manages exploitation and innovation. Together, this diverse consortium combines research excellence, technological innovation, and strong outreach capacity to maximise the project's impact.

## THE ROLE OF R&D NESTER

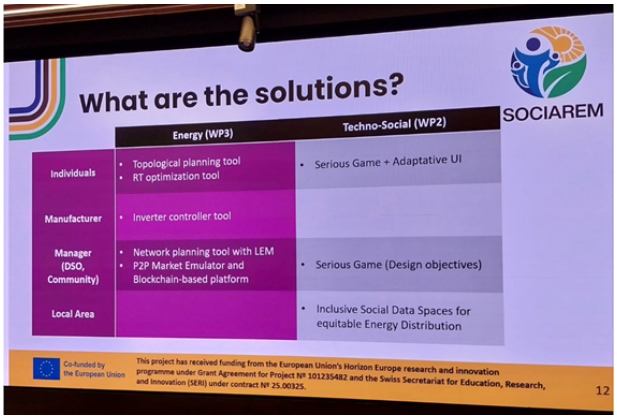
**R&D Nester** leads **SOCIAREM WP3 "Digital energy tools for energy communities"**, focusing on the development, integration, and demonstration of digital energy tools to enable and optimize energy communities (ECs) and peer-to-peer (P2P) energy trading.

This includes coordinating the design and implementation of a set of interoperable digital tools that support local flexibility, consumer empowerment, and market participation.

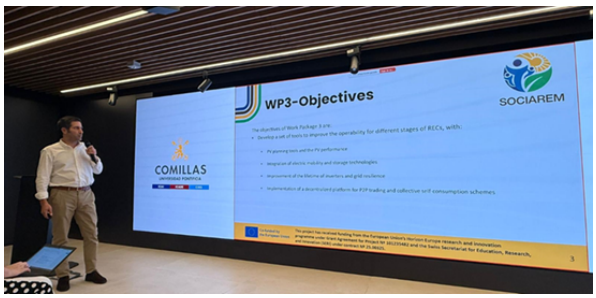
In the context of the Portuguese demonstrator, in Vila Nova de Famalicão (CEVE DSO concession).




**R&D Nester** supports the deployment of these tools in a real-world environment.




Furthermore, **R&D Nester** ensures that the tools align with interoperability and scalability goals across different demos, feeding into broader WP3 objectives.




For more information:

SOCIAREM

SOCIAREM Project @ R&D Nester website

SOCIAREM project web

# METROLOGY IN POWER SYSTEMS - R&D NESTER PARTICIPATES IN THE NATIONAL CONFERENCE ON METROLOGY (CONFMET 2025)

**R&D Nester** was represented at **CONFMET 2025** (**National Conference on Metrology**), at the Portuguese Institute for Quality (IPQ) in Caparica.

Organized by the Portuguese Society for Metrology (SPMet), the Portuguese Association of Accredited Laboratories (RELACRE) and IPQ, the event gathered the national scientific and industrial metrology community under the theme "**Measurements for all times, for all peoples**", marking the 150th anniversary of the Meter Convention and the establishment of the International Bureau of Weights and Measures (BIPM).




The conference featured a multidisciplinary program of technical sessions, invited lectures, and technical exhibitions.

The invited lectures addressed emerging themes ranging from astronauts' lives to standardized measurements in microfluidics, including topics such as metrology for energy transition, automated chemical analyses, and vacuum metrology applied to sustainability.

Representing **R&D Nester**, Raquel Segurado Silva delivered the invited lecture "**Metrology for the Energy Transition in Power Grids**", highlighting the crucial role of metrology in ensuring reliable, synchronized, and traceable measurements across increasingly digital and decentralized power networks.




The two projects from **R&D Nester** that are focused on metrology, **GridData** and **Quantum**, were also presented:

## GridData Project

**"Metrology for reliable power grid data analytics"**

The **GridData** Project aims to develop a metrological framework to test and validate analysis methods of data originating from power grid sensor networks.

This project is funded by EURAMET and has 14 participating entities, including 6 national metrology institutes from Europe.

GridData project @ R&D Nester website

## QUANTUM Project

**"Research on Metrological Characteristics of Quantum Voltage Chip and Traceability Application Verification"**

The **Quantum** Project aims to establish a metrological traceability framework based on a quantum voltage chip. For this, two platforms were built: a quantum platform based on a programmable Josephson voltage standard and a digital metering platform.

The Quantum platform was used to calibrate a merging unit calibrator, which was later used to calibrate the merging unit of the metering platform.

QUANTUM project @ R&D Nester website

By participating in **CONFMET 2025**, **R&D Nester** strengthens its role as a bridge between research, technology, industry, and metrology, supporting the development of more efficient, secure, and sustainable power systems.

For more information:

CONFMET2025 website

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# QUANTUM IN POWER SYSTEMS - NEW METHODS FOR SMART METER DIAGNOSTICS PRESENTED BY R&D NESTER AT ICECCME 2025

The objective of **R&D Nester**'s project "**QUANTUM - Research on Metrological Characteristics of Quantum Voltage Chip and Traceability Application Verification**" is to enhance the accuracy and reliability of digital metering systems through the development and application of programmable quantum voltage chips, supporting metrology in smart grid contexts. More specifically, one of the project's tasks aimed to improve the monitoring and evaluation of digital metering equipment used in smart grids. This included building a platform to compare digital and analog metering systems and developing methods to detect and analyze measurement errors.

As a result of this work, the **R&D Nester** team presented two scientific papers at the 5th International Conference on Electrical, Computer, Communications and Mechatronics Engineering (**ICECCME 2025**).




The first paper: **"Unveiling Hidden Patterns in Smart Meter Errors Using Spectral Methods":**

* Explores how spectral analysis can uncover periodic structures hidden within metrological error signals of smart and analog meters.

* Using Fourier and Short-Time Fourier Transform (STFT) techniques, the study revealed stable harmonic patterns in meter errors, corresponding to daily operational cycles and systematic influences - offering new diagnostic insights into metrological behavior.

* This methodology is suitable for periodic errors.

The second paper: **"Technology-Divergent Anomaly Detection in Smart Meters: Adaptive LSTM-Autoencoders for Digital vs. Analog Error Signals":**

* Introduces a machine learning approach for detecting metrological anomalies in energy meters using adaptive Long Short-Term Memory - autoencoders.

* This methodology is suitable for non-periodic errors.

Both papers contribute to advancing metrological intelligence and precision monitoring in energy measurement systems, strengthening **R&D Nester**'s research in the field of smart grid metrology.




**ICECCME 2025** brings together industry professionals, academics, and engineers to exchange information and ideas on electrical, computer, communications, and mechatronic engineering.

The proceedings are available in IEEE Xplore, Scopus and Ei Compendex.

For more information:

Quantum Project @ R&D Nester website

ICECCME'25 conference website

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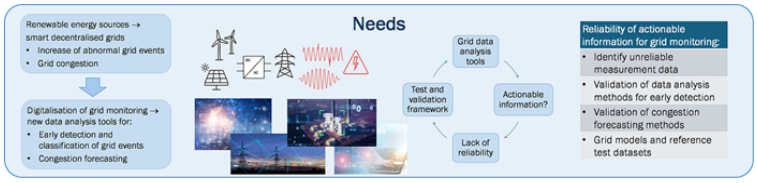
# COMBINING METROLOGY AND DATA ANALYTICS FOR SMARTER GRIDS: R&D NESTER IN THE EUROPEAN “GRIDDATA” PROJECT

The **GridData** project consortium convened in Delft, the Netherlands, for its kick-off meeting.

The event was hosted by the project coordinator VSL, the Dutch National Metrology Institute.



Funded by the European Association of National Metrology Institutes (EURAMET), **GridData** aims to develop a test and validation framework to ensure that data analysis methods can reliably transform grid sensor data into actionable insights for operators.




The consortium is composed of 14 institutions, combining the expertise of six national metrology institutes, five universities, one distribution system operator (DSO), and two companies.

This partnership unites scientific and academic excellence with industrial innovation and operational know-how.




The work will be developed throughout 3 years and address 3 main Work Packages:

1. Data Quality and Unreliable Data
2. Grid models, simulations, and reference test datasets
3. Framework to test and validate analysis methods for abnormal events detection and forecasting grid congestion.

**R&D Nester** will contribute to the project by bringing a transmission system operator (TSO) perspective. Its role will focus on the development of simulation models for grid asset faults, contributing to the design of digital twins and generating high-quality data through both software and laboratory-based grid simulators. This will help ensure that the project's results remain closely aligned with the needs of real-world system operation.

For more information:

GridData website

GridData Project @ R&D Nester website

## R&D NESTER CONTRIBUTE TO THE EUROPEAN FEDERATION OF DIGITAL TWINS FOR ENERGY

**REN** and **R&D Nester** contribute to build a framework for European the federation of the Digital Twins for energy in the **TwinEU project**.

The **TwinEU** project is co-funded by the European Commission under the Horizon Europe programme and proposes to build the kernel of European data exchange supported by interfaces to the Energy Data Space under development. Advanced modeling supported by AI tools and able to exploit High Performance Computing infrastructure will deliver a novel capability to observe, test and activate a pan-European digital replica of the European energy infrastructure. In this process, reaching consensus is crucial. Therefore, the TwinEU initiative gathers 77 partners from 15 countries, an unprecedented number of actors committed to achieving this common

In this project, **R&D Nester** participate in the developments related to cyber-physical grid resilience and smart coordinated planning of the grid.

In particular, **R&D Nester** leads the Portuguese pilot and the task concerning with the probabilistic-based cross-border capacity calculations and cross-border assessment of flexibility and prequalification. With the participation of REN, this task coordinates the implementation of the multi-area system dynamic behaviour assessment enabled by digital twin and the equivalent model for distribution grids, as well as the execution of the use cases on:

* Probabilistic cross-border capacity allocation

* Cross-border assessment of flexibility and pre-qualification

* Enhancement of short-circuit models and TSO/DSO information exchange for operational planning

Furthermore, **R&D Nester** contribute to task dealing with abnormal market participation detection and protocol activation for mitigating the risk and consequences, through the execution of the use case on
For more information:

* The integration of TSO-DSO-MO-Prosumer and market coordination.

The Kick-off meeting for this project was held last year in Brussels, where **R&D Nester** team was represented.

This meeting was the opportunity to align on milestones and objectives that steer the consortium ambition: to leverage a unique combination of competences coming from grid and market operators, technology providers and research centers to create a concept of Pan-European digital twin based on the federation of local twins so to enable a reliable, resilient, and safe operation of the infrastructure while facilitating new business models that will accelerate the deployment of renewable energy sources in Europe.




Months later, **TwinEU** partners presented the mid-term results to the European Commission in Brussels. Following the presentation of the current policies to drive the digitalization and the application of artificial intelligence in the energy sector by the European Commission, the consortium presented the work progress: it is according to the plan.



Namely the consortium finished the design of all 50 use cases and 5 Pan-EU scenarios were defined to demonstrate the applicability of the digital twins developed in the **TwinEU** project.

Furthermore, the architecture to coordinate the federation of digital twins is also developed and the execution of tools and use cases are ongoing according to planned.

In particular, some tools already achieved the 1st release stage, such as the Equivalent model for Distribution Grids from **R&D Nester**.

A publication of the work developed in the Iberia pilot, which brings together the Spanish and Portuguese demonstrations, was published on the Enlit's library: Smarter grids, safer supply: Digital twins in the Iberian Peninsula | Enlit World.

The next steps of the project will focus on the next releases of the tools, development of the data space of the federation of the digital twins and the implementation and demonstration of the Use Cases.

For more information:

TwinEU Project @ R&D Nester website

TwinEU Project website

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101136119

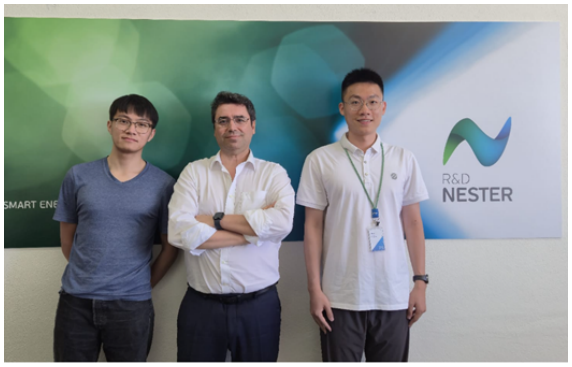
## R&D NESTER INTERNSHIPS IN RESEARCH AND DEVELOPMENT

**R&D Nester** hosted 4 students who contributed in research, studies and projects.

They were from Instituto Superior de Engenharia de Lisboa (ISEL), Instituto Superior Técnico (IST) and North China Electric Power University.



**Ricardo Pastor, Marta Valente, Pedro Costa e Rui Pestana**




**Jinhua Chen, Nuno Pinho da Silva e Weihao Ye**

These selected students were from courses as **Electrical Engineering and Computers, Electrical and Computer Engineering** and **Mathematics Applied to Technology:**

**Instituto Superior Técnico:** JINHUA CHEN

**North China Electric Power University:** WEIHAO YE

Both Jinhua and Weihao supported during their internship the **CARBON FOOTPRINT** project team, in which R&D Nester is involved.

This project aims to study and develop methodologies for quantifying the carbon footprint of electrical equipment and analyzing carbon emissions throughout the production process.

The interns performed activities focused on the following topics:

* develop a Product Carbon Footprint (PCF) methodology applicable to electric equipment;

* research the differences and common attributes between the PCF methodology and the Carbon Border Adjustment Mechanism methodology;

* research the required data to perform PCF of specific electric equipments used in the electricity transmission grid;

* and design a database enabling the calculation of the PCF.

CARBON FOOTPRINT project @ R&D Nester website

**Instituto Superior Técnico:** MARTA VALENTE

Marta Valente supported during her internship the **HEDGE IoT** project team, in which R&D Nester is involved.

This project aims to support the green and digital transformation of the energy ecosystem and enhance its resilience through the development and piloting of AI-IoT Edge-Cloud and platform solutions.

These solutions are trained according to different generation and consumption scenarios based on real data.

The objective of the summer internship is to provide those scenarios using clustering techniques by grouping sets of data where a certain generation technology is predominant.

HEDGE-IoT project @ R&D Nester website

HEDGE IoT project website

**ISEL - Instituto Superior de Engenharia de Lisboa:** PEDRO COSTA

Pedro Costa supported his internship on the **QUANTUM** project team, in which R&D Nester is involved.

This project aims to research the accuracy improvement technology using a quantum voltage chip, to obtain a reference AC voltage for calibrating metering devices. It also includes the research and development by Pedro Costa, on error monitoring methods of digital metering, which contributed to the submission of three papers.

QUANTUM project @ R&D Nester website

This initiative allows students to make productive use of their summer break by gaining hands-on experience with real projects, enriching their understanding of the energy sector.

During their time at **R&D Nester**, students deepen their knowledge of key concepts in electricity and energy-moving beyond theory into practical application. The experience bridges the gap between the abstract knowledge acquired in their academic courses and the real-world challenges faced in the energy industry.

**R&D Nester** offers an ideal environment for such programs, as it operates at the intersection of Research, Development, and Innovation-often closely aligned with the students' fields of study and real business applications.

The work carried out by these trainees is integrated into ongoing projects, contributing directly to current research needs at **R&D Nester**. Their collaboration typically spans 6 weeks to 3 months.

This experience aims to be both memorable and professionally valuable, helping to launch the careers of these four promising researchers and future professionals in the energy sector.

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TECHNICAL INFORMATION

# ERROR MONITORING METHODS FOR DIGITAL METERING EQUIPMENT DRIVEN BY HIGH ACCURACY DATA

As IEC 61850-based digital substations become increasingly widespread, energy metering is progressively shifting from "wired analogue" measurements (currents/voltages) to fully digital acquisition via Sampled Values (SV).

This evolution brings clear advantages (interoperability, reduced copper wiring, easier data access), but also introduces new metrological challenges: measurement errors can be influenced by the full digital chain (instrument transformers, merging units, time synchronization, SV communication, data concentration), and these errors must be monitored continuously to preserve traceability and confidence in billing and network operation.

One of the tasks of the Quantum project was focused on how to measure, compare, and monitor the metrological performance of digital metering equipment using high-accuracy reference data and data-driven analytics. The main technical outcomes of this task can be summarized as:

* A **metering testing platform** to compare analogue and digital measurement chains under identical, controlled electrical conditions.

* A test plan (functional, short-term, long-term) to quantify errors across currents, power factors, and energy flow directions, using IEC-based admissible error limits.

* A **merging unit (MU) calibration procedure** supporting traceability.

* A dual-method error monitoring toolbox, combining spectral methods (FFT/STFT) and a machine-learning anomaly detector (LSTM Autoencoder).

The comparison platform (Fig. 1) was assembled in the R&D Nester laboratory and includes: a programmable three-phase source, analogue meters (receiving currents/voltages) - AM1 and AM2, a merging unit (digitizing currents/voltages into IEC 61850 SV) - MU, digital meters (receiving SV) - DM1 and DM2, and a centralized metering device collecting and exporting data at fixed integration intervals. This architecture enables the comparison of electrical quantities between technologies.

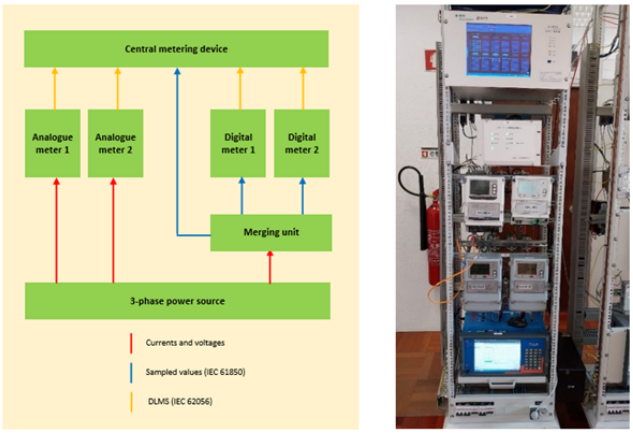



**Fig.1 - Conceptual diagram and picture of the comparison platform**

Meter performance was assessed against the admissible error envelopes defined by IEC 62053-22 (active energy) (Fig. 2) and IEC 62053-24 (reactive energy), ensuring that comparisons and pass/fail checks are meaningful and aligned with standard practice.

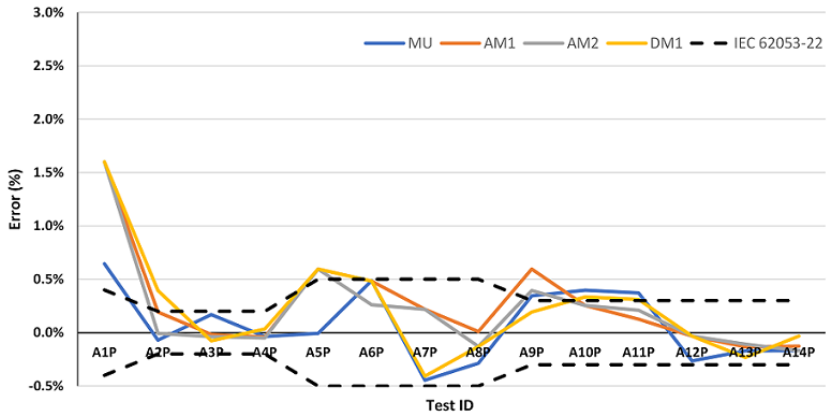



**Fig. 2 - Error of the average active energy in the positive direction and acceptable error according to IEC 62053-22**

A key metrological step is the calibration of the merging unit, since the MU is upstream of all SV-based measurements and directly influences the accuracy observed by digital meters. The MU was calibrated using a dedicated MU calibrator, which in turn was calibrated by a Programmable Josephson Voltage Standard (PJVS), creating a metrologically grounded link between the quantum reference and the digital metering data stream. The calibration results (Fig. 3) indicate that amplitude (ratio) errors of the MU channels can remain within the ±0.2% limits, while phase errors can exceed the specified limits - motivating periodic phase checks as part of operational monitoring.

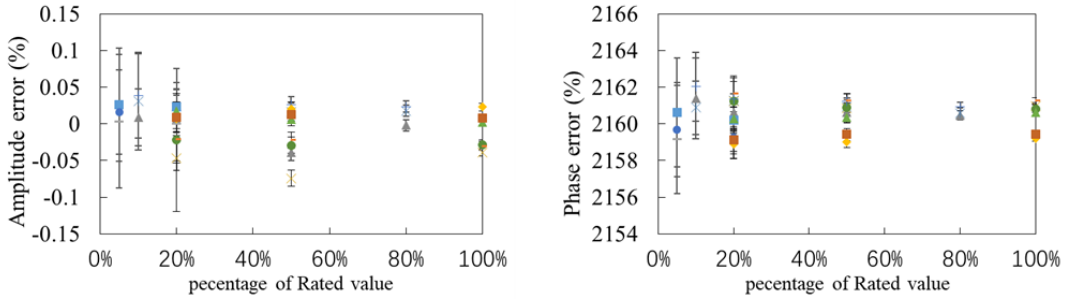



**Fig. 3 - Amplitude error and phase error calibration results of the MU calibrator**

Beyond the experimental setup and test execution, this work delivered a continuous error monitoring methodology, using two complementary analytical layers:

* Spectral analysis (FFT and STFT) to reveal whether error signals contain stable periodicities, harmonic structures, or time-localized spectral changes - useful to diagnose systematic behaviours (e.g., cyclic patterns, harmonic distortion signatures, recurring operational cycles).

* An LSTM Autoencoder anomaly detector to identify non-periodic and nonlinear deviations, using reconstruction error as an indicator of "departure from normal" behaviour, and defining an anomaly threshold statistically (95$^{th}$ percentile approach).

These methods were applied to long-term datasets recorded at 15-minute resolution, demonstrating how the same metering platform can support both classical metrological assessment and modern data-driven diagnostics.

Fig. 4 presents the spectra obtained after applying the FFT to the signals of the MU, duly normalized and with the application of a Hamming window and zero-padding.

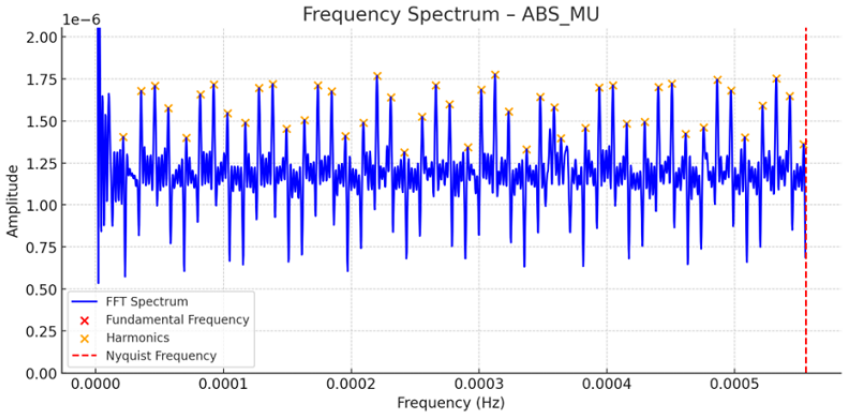



**Fig. 4 - Frequency spectrum of MU after applying FFT with zero-padding**

The anomaly detection logic is illustrated by plotting reconstruction error per time window and flagging windows above the defined threshold (Fig. 5).

Overall, this work provided a practical, end-to-end framework - hardware testbed, traceable calibration approach, and data-driven monitoring methods - for evaluating IEC 61850 digital metering performance under controlled conditions.

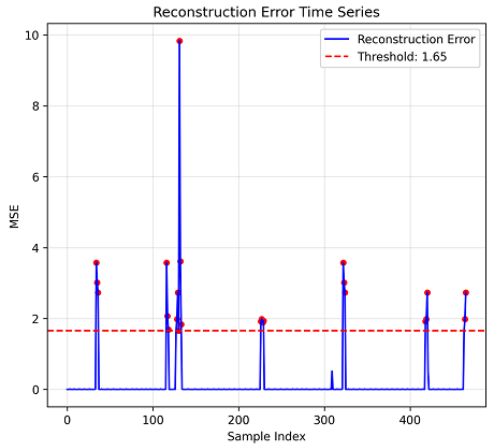



**Fig. 5 - Reconstruction error calculated for each time window in one test set, with indication of the anomaly detection threshold based on the 95th percentile**

LITERATURE REVIEW

## Digital Twins – Feb/2026 - Towards a Federated Approach (ENTSO-E)

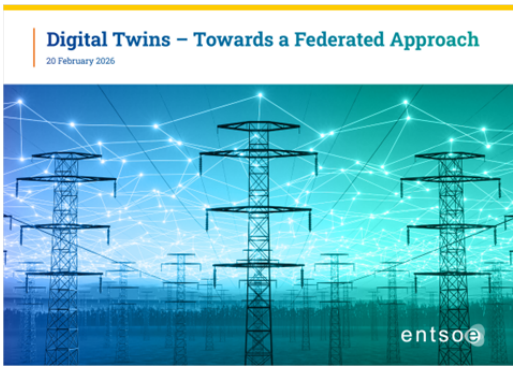
ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association of the European transmission system operators (TSOs). The 40 member TSOs, representing 36 countries, are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world.

ENTSO-E was founded to fulfil the common mission of the European TSO community: to power our society. At its core, European consumers rely upon a secure and efficient electricity system. Our electricity transmission grid, and its secure operation, is the backbone of the power system, thereby supporting the vitality of our society. ENTSO-E was created to ensure the efficiency and security of the pan-European interconnected power system across all time frames within the internal energy market and its extension to the interconnected countries.

In the realm of digital innovation, digital twins provide dynamic virtual representations of real systems, enabling more informed and faster decision-making1. As transmission system operators (TSOs) accelerate the deployment of digital twins, many implementations have been developed to address specific operational needs.

These tailored solutions ranging from predictive maintenance and dynamic line ratings to 3D building information modelling (BIM) have delivered tangible value and driven meaningful innovation within individual domains. As the expected scale of digital twin deployments grows exponentially, the next step is to ensure that these successful initiatives can interoperate and scale efficiently across organisations and borders. To unlock this next level of value, TSOs should pursue a federated digital twin (FDT) architecture.

A federated approach promotes interoperability through shared semantics, open standards, and strong governance, allowing diverse digital twins to communicate and work together without reliance on a single monolithic platform. This enhances efficiency, decision-making, data liquidity, and synchronisation across networks, while strengthening overall system resilience.




LINK FOR PUBLICATION

## Electricity 2026 - Feb/2026 - Analysis and Forecast to 2030 (IEA)

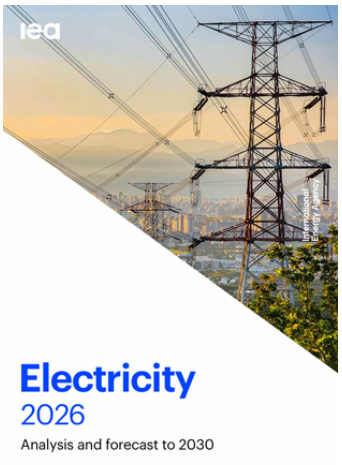
The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand,

renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 32 Member countries, 13 Association countries and beyond.

Global power demand growth continues to rise rapidly as the Age of Electricity gathers pace, supported by the increasing electrification of industry, transportation, and the buildings sectors. Growing consumption is also coming from some of the most dynamic segments of global economies, such as artificial intelligence (AI), data centres, and evolving technological innovations.

Against this backdrop, Electricity 2026 - the IEA's annual report on global electricity systems and markets - provides in-depth analysis of the recent trends and policy developments underpinning this new era. It includes forecasts for electricity demand, supply and carbon dioxide ($CO_2$) emissions for select countries, by region and worldwide. This year the forecast period has been expanded to five years, 2026-2030, compared with the previous three-year outlook.

As electricity use grows, power systems will need greater flexibility to securely and cost-effectively integrate an increasingly diverse mix of electricity generation sources while accommodating evolving demand patterns and technologies. This year's report has a special focus on these challenges with chapters on grids and flexibility. It also includes detailed updates on demand response and utility-scale battery developments.




LINK FOR PUBLICATION

## EVENTS

**5 -6 May 2026**

BRUSSELS, BELGIUM

SOLAR+ (SOLARPOWER SUMMIT 2026) - SOLAR & STORAGE SECURING EUROPE

**27 -28 May 2026**

LISBON, PORTUGAL

APREN - FUTUREDIALOGUE - ABOUT THE LISBON FUTURE DIALOGUE

**8 -12 Jun 2026**

LIMASSOL, CYPRUS

XXIV POWER SYSTEMS COMPUTATION CONFERENCE (PSCC 2026)

**22 -24 Jun 2026**

TRONDHEIM, NORWAY

INTERNATIONAL CONFERENCE ON THE EUROPEAN ENERGY MARKET (EEM) 2026

**23 -28 Aug 2026**

PARIS, FRANCE

CIGRE 2026 SESSION

**2 -4 Sep 2026**

CIUDAD REAL, SPAIN

8TH INTERNATIONAL CONFERENCE ON SMART ENERGY SYSTEMS AND TECHNOLOGIES (SEST)

**22 -24 Sep 2026**

DUBROVNIK, CROATIA

IEEE ISSE 2026 - IEEE INTERNATIONAL SYMPOSIUM ON SYSTEMS ENGINEERING

**28 -2 Sep /Oct 2026**

OPORTO, PORTUGAL

WIND & SOLAR INTEGRATION WORKSHOP

## QUIZ

1) WHAT ARE THE TYPICAL VOLTAGE LEVELS USED IN PORTUGAL'S TRANSMISSION SYSTEM?

- A) 60 kV and 110 kV
- B) 10 kV, 15 kV and 30 kV
- C) 150 kV, 220 kV and 400 kV
- D) 110 kV, 220 kV and 400 kV

2) WHAT IS THE MAIN PURPOSE OF PROTECTION SYSTEMS IN THE ELECTRICAL GRID?

4) WHICH MARKET MECHANISM DETERMINES THE MAJORITY OF ELECTRICITY PRICES FOR THE NEXT DAY IN PORTUGAL?

- A) Day-ahead market
- B) Real-time balancing market
- C) Intraday market
- D) Forward/ futures contracts

5) PORTUGAL IS PART OF WHICH LARGER INTERCONNECTED ELECTRICAL GRID?

- ◯ A) Reduce electrical losses
- ◯ B) Detect faults and isolate affected sections
- ◯ C) Store excess electrical energy
- ◯ D) Shoot down incoming threats

3) WHAT IS THE PRIMARY FUNCTION OF ELECTRICAL SUBSTATIONS IN PORTUGAL?

- ◯ A) Generate electricity from renewable sources
- ◯ B) Store electricity for later use
- ◯ C) Provide radio channel coverage
- ◯ D) Convert between voltage levels

- ◯ A) Western European Grid
- ◯ B) European Union Grid
- ◯ C) Continental European Grid
- ◯ D) Iberian Grid

Correct answers will be provided to you soon.
If you have problems answering this quiz, click here to answer this via browser.

1. Answer: D) 110 kV, 220 kV and 400 kV
2. Answer: B) Detect faults and isolate affected sections
3. Answer: D) Convert between voltage levels
4. Answer: A) Day-ahead market
5. Answer: C) Continental European Grid

## LINKS

### OTHER ENTITIES

**Portugal**

- Laboratório Nacional de Energia e Geologia (LNEG)
- Associação de Energias Renováveis (APREN)
- Associação Portuguesa da Economia da Energia (APE)
- Portugal Energia
- Portal de Ciência e Tecnologia | Fundação para a Ciência e a Tecnologia (FCT)
- ERSE - Entidade Reguladora dos Serviços Energéticos
- DGGE - Direção-Geral de Energia e Geologia
- Observatório da Energia
- Agência Portuguesa do Ambiente (APA)

**Europe**

- European Network of Transmission System Operators for Electricity (ENTSO-E)
- The European Wind Energy Association (EWEA)
- The Alliance for the Internet of Things Innovation (AIOTI)
- Joint Research Centre - Smart Electricity and Interoperability
- Strategic agenda 2024-2029 - Consilium
- The European Commission's Priorities
- A European Green Deal | European Commission
- European Climate, Infrastructure and Environment Executive Agency (CINEA | ex-INEA)
- EUASP - The European Union Agency for the Space Programme
- ESA - The European Space Agency
- European Distributed Energy Resources Laboratories (DERlab)

**Rest of World**

- CIGRE - International Council on Large Electric Systems
- CTCN - Climate Technology Centre and Network
- GEIDCO - Global Energy Interconnection Development and Cooperation Organization
- World Intellectual Property Organization (WIPO)
- International Energy Agency (IEA)
- International Electrotechnical Commission (IEC)

### ON RESEARCH, DEVELOPMENT AND INNOVATION

**Portugal**

- Portugal 2030
- Portal da Inovação
- Agência Nacional de Inovação (ANI)
- Agência para o Desenvolvimento e Coesão (AdC)
- Direção-Geral de Estatísticas da Educação e Ciência (DGEEC)

**Europe**

- BRIDGE (H2020)
- European Energy Research Alliance (EERA)
- ETIP SNET - European Technology and Innovation Platform Smart Networks for Energy Transition
- Horizon 2020
- Horizon Europe
- BlueInvest
- EIT InnoEnergy
- Eurostat - Science, Technology and Innovation
- Funding, Tenders | European Commission
- Research and Innovation | European Commission
- Energy, Climate Change, Environment | European Commission
- CRESYM – The Non Profit Association Delivering Future Collaborative Opensource Tools for Energy System Simulation

**Rest of World**

- China Electric Power Research Institute (CEPRI)
- Mission Innovation
- Innovation – Department of Energy (USA)
- NREL – National Renewable Energy Laboratory
- EPRI- Electric Power Research Institute
- EU-GCC Clean Energy Technology Network

EDITORIAL | HIGHLIGHTS | TECHNICAL INFORMATION | LITERATURE REVIEW
EVENTS | LINKS | QUIZ

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