R&D NESTER

28 NL dez 2025

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EDITORIAL

Dear Reader,

As 2025 draws to a close, the global energy landscape continues to evolve at remarkable speed - and R&D Nester remains deeply engaged in shaping this transformation. Through our participation in European and national initiatives, we are contributing to the development of intelligent, data-driven, and consumer-centric solutions that underpin a carbon-neutral energy system.

This 28th edition of our Newsletter reflects that diversity and momentum. It features a wide range of topics - from **peer-to-peer energy sharing** and **consumer empowerment**, to **AI testing infrastructures**, **data spaces**, and **applications of artificial intelligence in power systems** - demonstrating how our activities span from research to real-world implementation.

We begin with **U2DEMO**, a Horizon Europe project that advances **peer-to-peer (P2P) energy trading** and **energy democratization**. R&D Nester plays a leading role in the Portuguese pilot in Évora, developing methodologies for distributed energy resources (DERs) valorization, flexibility markets, and the cybersecurity and interoperability of the platform. This work supports the emergence of **active energy communities** capable of providing grid services and participating in balancing markets.

Also featured is **ECLIPSE**, a project that promotes **sustainable consumption behaviour** and the **empowerment of final consumers**. Together with E-REDES, R&D Nester contributes to the Portuguese pilot enabling **demand-side response mechanisms** and improved collaboration between local and wholesale energy markets - a vital step toward a more flexible, consumer-driven energy ecosystem.

Our involvement in **HEDGE-IoT** continues, where we and REN contribute to the **Portuguese Living Lab** for interoperable AI-based energy services. The project aims to deploy IoT and AI solutions to enhance grid intelligence and flexibility, while our **Market Simulator** tool supports techno-economic analysis of energy communities' participation in ancillary service markets.

A major milestone this quarter was R&D Nester hosting the **first plenary meeting of the EnergyGuard project in Lisbon**. EnergyGuard is building a **large-scale Testing and Experimentation Facility (TEF)** for the validation of AI solutions across the energy sector. Our team leads the coordination of TEF pilot experiments and the integration of a **Digital Twin of a large-scale transmission network** - a key element in the European effort to ensure safe and trustworthy deployment of AI in energy systems.

We also report on the **final review meeting of the ENERSHARE project**, held in Bilbao, marking the successful completion of the first **Common European Energy Data Space**. R&D Nester's contributions included leadership of work on **data governance models** and **business frameworks**, as well as support to **interoperability standards** for regulated entities. The results of ENERSHARE provide a foundation for future digitalization initiatives, such as our upcoming participation in the **INSIEME** project.

In addition, R&D Nester participated in several knowledge-exchange and dissemination activities, including the **"Artificial Intelligence Applied to Electrical Engineering"** event at ISEC, where we discussed the **impact of AI on power grids** and presented ongoing work in this area. This was also a strong quarter for scientific dissemination, with our participation in the **European Energy Market (EEM25) conference in Lisbon**, where we presented multiple papers on **energy data spaces, electric vehicles, and aggregated flexibility** - reinforcing our role as a reference player in applied research and innovation.

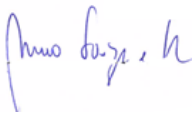
Under the **Technical Information** section, this edition features a study on **flexibility from electric vehicle charging**, addressing the optimization of EV charging clusters through clustering methods and advanced data analytics. As EV adoption accelerates, this research provides valuable insights into how

charging infrastructure can support both grid stability and the integration of renewables.

Finally, as usual, we invite you to explore our **Literature Review, Events, and Links** sections - and to test your knowledge in the **Quiz**, this time dedicated to *Green Ports*, where electrification, hydrogen, and smart operations are redefining sustainability at maritime hubs.

We hope you enjoy reading this Newsletter and discovering the projects, results, and perspectives that reflect R&D Nester's mission: to **create a Smart Energy Future** through innovation, collaboration, and scientific excellence.

Sincerely,



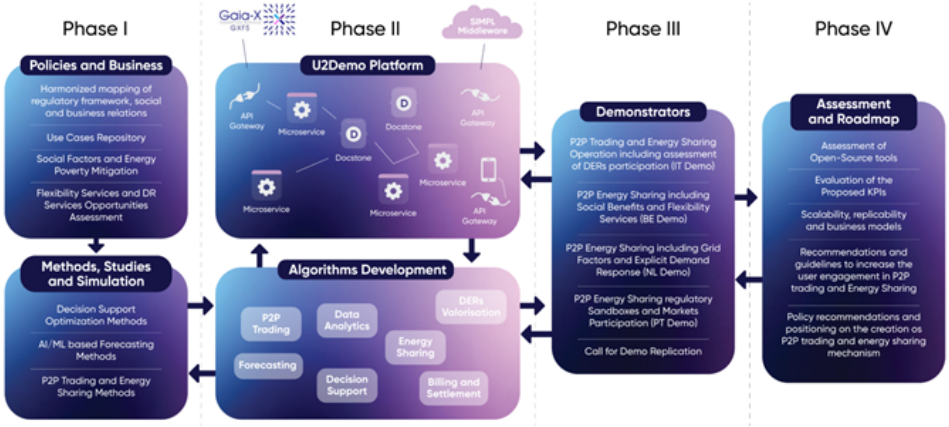
Nuno de Souza e Silva

Managing Director

HIGHLIGHTS

ADVANCES PEER-TO-PEER ENERGY SOLUTIONS IN U2DEMO PROJECT

Last March, **R&D Nester** participated in the General Assembly of the project **U2DEMO - "Use of open-source P2P energy sharing platforms for energy DEMOcratization"**, marking the project's six-month milestone and an important moment to discuss the current progress and future steps of this innovative project that aims to demonstrate scalable and interoperable peer-to-peer (P2P) energy trading and sharing.



R&D Nester's role in U2DEMO

Since the project's launch, **R&D Nester** has been a key contributor across multiple fronts:

- Portuguese Pilot Implementation: Collaborating in the setup of a real-world P2P energy trading demonstration in Portugal, which will test local energy sharing among prosumers and consumers from Évora. The PT pilot will address several challenges, starting with the integration of P2P trading concept to manage the energy transactions between members of a Renewable Energy Community (REC). Hereto, the algorithms governing energy sharing will be subjected to empirical testing. This evaluation aims to facilitate a comprehensive comparative analysis and assessment of P2P energy sharing mechanisms in contrast to alternative energy sharing algorithms that do not encompass the P2P mechanism using a controlled regulatory environment denoted as a "regulatory sandbox". A pivotal challenge to be addressed within the PT Pilot pertains to the active engagement of ECs in the management of balancing services overseen by TSOs.

- Distributed Energy Resources (DERs) valorisation tool: Developing methodologies to support the

flexibility and P2P trading platform to ensure the optimization of DERs integration and DERs valorization. The spatio-temporal distribution of DERs and demand-response will allow the optimization of its penetration in the electricity grid and its valorization.

- Platform Requirements: Contributing to the standardization, interoperability, and cybersecurity framework of the U2DEMO platform.

- Study Black Start service: Investigate business models that are suitable for DERs to contribute to black-start.

Key Achievements to Date

1. Finalized the initial scenarios for the Portuguese pilot, focusing on local energy exchange and grid flexibility;

2. Contributed to the platform interoperability, data models, cybersecurity and data management discussions and definitions;

3. Supported:

a) WP2 - P2P Energy Sharing Functional Architecture for Energy trading and Flexibility Provision

b) WP3 - Open-Source Energy Sharing Communities Platform

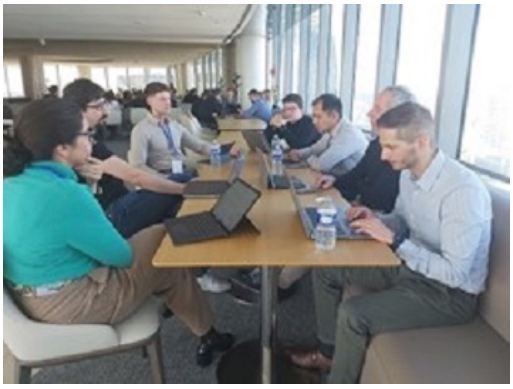
c) WP6- P2P trading and Energy Sharing assessment and roadmap for massive adoption

4. Provided insights on replicability potential and regulatory considerations.

Discussions and Next Steps

During the assembly, several important sessions took place, including updates on each Work Package, a deep-dive into each country pilot (including Portugal), and hands-on sessions about regulatory, social, and business frameworks.

R&D Nester actively engaged in the working sessions concerning platform development and participated in the "Idealization" workshop focused on user adoption and platform functionalities.



Next steps include:

Over the coming months, **R&D Nester** and **U2DEMO** will focus on:

1. Pilot Deployment: Finalize the pilot scenarios and implementation, including stakeholder engagement and real-world testing of P2P transactions;

2. Platform development and enhancing of the U2DEMO platform's cybersecurity, interoperability and scalability;

3. Developing of Forecasting and data analytics methods to support the decision of Active Consumer;

4. Refining metrics to assess the technical, economic, and social impact of energy-sharing models;

5. Contributing to EU-wide guidelines for interoperable P2P energy markets (aligned with WP6).

R&D Nester is proud to be part of a consortium that is pushing the boundaries of energy flexibility, consumer empowerment, and community-driven energy systems.



For more information:

U2-DEMO PROJECT @ R&D Nester website

U2Demo website

PROMOTING SUSTAINABLE ENERGY CONSUMPTION BEHAVIOUR AND EMPOWERMENT OF FINAL CONSUMERS - THE ECLIPSE DIGITAL PROJECT

The **ECLIPSE** project will establish guidelines for creating new energy consumer applications and improving existing ones.

These applications will offer users accessible and practical information about energy savings and associated benefits, such as reduced carbon emissions and other financial incentives.

The project's main goal is to "facilitate energy consumption reduction through the implementation of an open-source reference framework".



In that sense, **R&D Nester** will contribute by participating in the Portuguese Pilot along with E-REDES with the objective to enable demand-side response mechanisms and promoting the collaboration between local and wholesale energy markets.

In addition, **R&D Nester** participates in other work packages such as Use-cases definition and evaluation, User engagement, regulatory framework and dissemination, communication and exploitation activities.

There will be 13 pilot sites across Europe with the participation of 11 grid operators, 2 energy services companies, 2 energy associations and 8 energy R&D entities from 16 EU countries.

To contribute to the coordination of the activities across these pilot sites, **R&D Nester** took part in the project's General Assembly on March 26-27, organized in Paris by the project partners Voltalis and Trialog.





R&D Nester delivered a presentation on the current status of the progress in the Portuguese Pilot, specifically the starting of the implementation phase of the previously defined Use-Cases and technical integration among the partners.

The meeting also included a visit to the control room of Voltalis, an energy service company dedicated to aggregate down flexibility from end-users that own electric heating at their homes.

By using the services provided by Voltalis, the user can visualize, control and plan the energy consumption of their heating according to daily routines and by following the control room signals and recommendations.

More information of the project can be found here:



ECLIPSE project webpage

ECLIPSE Project @ R&D Nester website

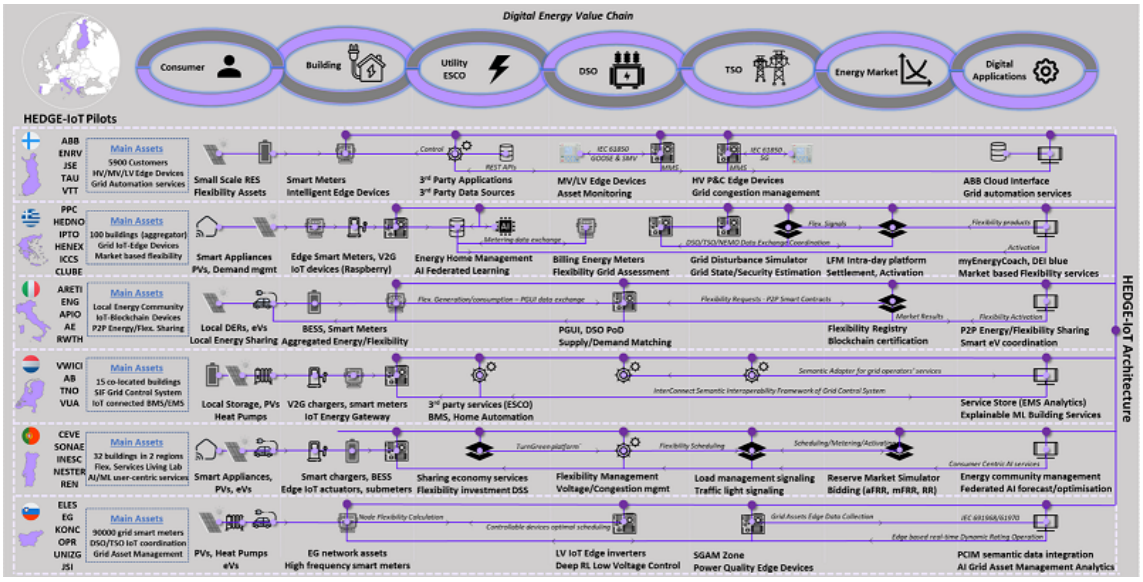
ADVANCING GRID INTELLIGENCE THROUGH AI AND IOT - R&D NESTER AND REN IN THE HEDGE-IOT EUROPEAN

PROJECT

Last March, **HEDGE-IoT** project consortium gathered in Athens, Greece, for its second Plenary Meeting, hosted by the National Technical University of Athens (NTUA).

The event brought together project partners to review the progress achieved, tackle current challenges, and coordinate the next steps toward building smarter and more resilient energy systems.

The main objective of project **Hedge-IoT (Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions)** is to deploy IoT assets throughout the energy ecosystem, integrating AI and machine learning tools to enhance grid intelligence, flexibility, and resilience. The project also targets the expansion of renewables integration, the creation of interoperable energy services, and the standardization of IoT technologies across the sector.



R&D Nester and **REN** are actively contributing to the Portuguese Pilot - Living Lab for Interoperable AI-based Energy Services, focusing on facilitating and optimizing the deployment of grid flexibility services within residential and commercial energy communities.

During the meeting, **R&D Nester** presented the current status of the cloud-based Market Simulator, a tool designed to support the techno-economic analysis of energy communities' future participation in the ancillary services markets.





For more information:

Hedge-IoT website
Hedge-IoT @ R&D Nester website

LARGE-SCALE AI TESTING AND EXPERIMENTAL FACILITIES (TEF) FOR THE ENERGY SECTOR - R&D NESTER IN PROJECT ENERGYGUARD

The **Test and Experimental Facility (TEF)** is a technology infrastructure that has specific expertise and experience with testing in real conditions in the energy sector.

The TEF bridges the gap between lab and market due to lack of in-depth testing of AI technology in the real environment to fully validate them before the deployment.

The Energy AI TEF aims at testing AI-based technologies and solutions that have already been tested in the labs and have to be tested in operational environments. It aims at optimising the deployment of AI-based solutions for a greener, smarter, more resilient and more flexible energy system.

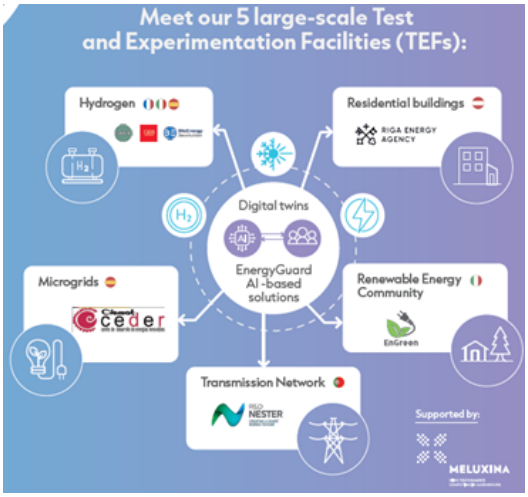
Currently there are 3 EU funded projects developing Energy AI TEF:

- **EnergyGuard**: Large-scale testing and experimentation facility (TEF) for assessing, validating, and enhacing AI-powered next generation solutions (link);
- AI-EFFECT: Artificial intelligence experimentation facility for the energy sector (link); and
- EnerTEF: Common European-scale energy artificial intelligence federated testing and experimental facility (link).

R&D Nester works together with 16 European partners in the project **EnergyGuard**.

The **EnergyGuard** project aims to create a disruptive enabler of AI-supported energy sector solutions with a cost-effective, open testing experimentation facility that leverages Europe's greenest high-performance computing infrastructure, Meluxina.

The project brings together five European testing and experimentation facilities covering a large-scale electricity network with high shares of renewables, a microgrid with distributed energy resources, hydrogen testing platforms, a digital twin of a city's apartment buildings and a renewable energy community. It will enable AI testing of diverse renewable energy systems, energy storage systems, electrolysers, fuel cells and electric mobility via advanced digital twins along with assessment of cybersecurity and regulatory requirements.



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The **EnergyGuard** project and its testing experimentation facility will conduct five pilots case studies.

In the **EnergyGuard** project, **R&D Nester** coordinates the **EnergyGuard** TEF pilot experiments and operation. Also, **R&D Nester** leads the integration of the digital twin of large-scale transmission network and power simulations, as well as the pilot on testing, evaluation and validation of AI solutions to support the operation of smart grids.

In June 2025, took place the 1st plenary meeting of EnergyGuard project which was hosted by **R&D Nester** in Lisbon, Portugal.



The meeting gathered 31 project members in person in Lisbon. Over the two-day event, partners reviewed achievements and plan future activities.



The meeting addressed the design of the EnergyGuard platform, the integration of the TEF infrastructures with the EnergyGuard platform, the technical and legal architecture of the data management and AI testing framework.

These steps will be crucial to validate the robustness, trustworthiness, and regulatory compliance of AI technologies applied in energy systems.

R&D Nester coordinated the workshop on integration of TEFs into the EnergyGuard platform, as it leads the project work package delving with the **EnergyGuard TEF pilot experiments and operations.**

R&D Nester also reported on its leading activities for the development and integration of the Digital Twin of a large-scale electricity gird with high shares of RES, as well as the pilot focused on testing, evaluation, and validation of AI solutions for smart grid operations.



At the end of the first day, a visit to the REN substation provided valuable insights into the real-world infrastructure.





For more information:

[ENERGYGUARD Project @ R&D Nester website]

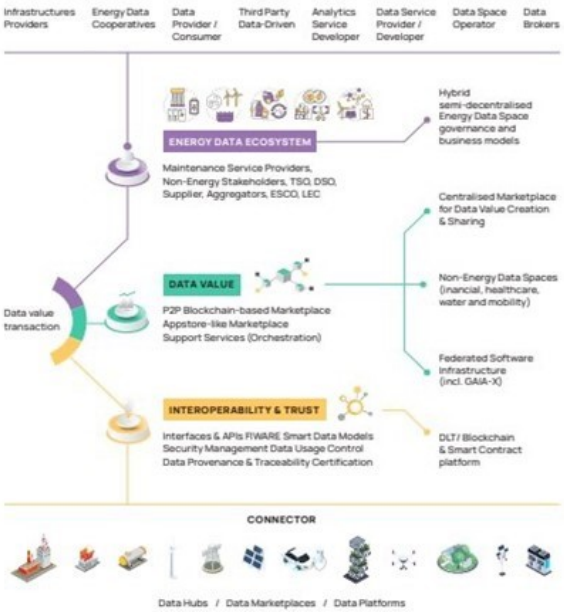
[EnergyGuard Project website]

ENERGY DATA SHARING WITH ENERGY DATA SPACES - R&D NESTER IN THE ENERSHARE FINAL REVIEW MEETING

On June 25, **R&D Nester** joined the consortium partners at the Final Review Meeting of the **ENERSHARE** project, held at TECNALIA's headquarters in the Basque Country Technology Park, near Bilbao, Spain.

This event marked the successful completion of the **ENERSHARE** project, which has worked over the past years to build a trusted, interoperable and value-creating energy data sharing framework for Europe.

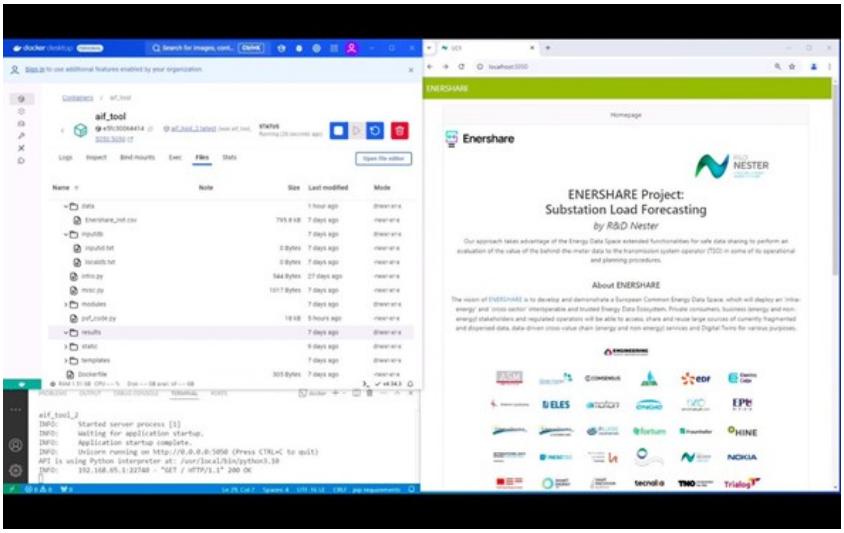
The meeting featured a comprehensive project overview and live demonstration sessions that highlighted the operational achievements and platform capabilities developed through close collaboration between research centers, industrial partners, and technology providers.



R&D NESTER'S CONTRIBUTIONS

R&D Nester has played a pivotal role in **ENERSHARE**'s innovation journey, contributing to both the technical and governance layers of the platform. Our main areas of involvement included:

- Supporting the real-life demonstration of the project with particular focus on flexibility services and smart data-driven use cases.
- Leading WP7 on data space governance and business models, proposing frameworks to ensure trust, value creation, and regulatory alignment.
- We also collaborated on interoperability standards and dataspaces specifications for the regulated entities for TSOs





KEY ACHIEVEMENTS

- Successful demonstration of the **ENERSHARE** platform in a real-life setting, showing tangible benefits of secure data exchange across energy actors.
- Development of innovative services leveraging AI to unlock new value chains for grid operators and energy communities.
- Robust proposals for data governance and business models, paving the way for a future European Energy Data Space.
- Engagement in strategic dialogues with European initiatives such as GAIA-X and other dataspaces initiatives, enhancing interoperability and cross-sectoral integration.





As the project concludes, **R&D Nester** looks forward to building on the outcomes of ENERSHARE in future initiatives, such as the ongoing INSIEME European project, and continuing to contribute to a smarter, more connected and data-centric European energy system.

More information:

ENERSHARE Project @ R&D Nester website

ENERSHARE Project website

ARTIFICIAL INTELLIGENCE IN ELECTRICAL ENGINEERING - R&D NESTER DISCUSSES THE IMPACT ON POWER GRID AND POWER SYSTEMS

R&D Nester was represented at *Jornadas* of the Department of Electrical Engineering of ISEC - Instituto Superior de Engenharia - Politécnico de Coimbra, last May.

"Artificial Intelligence Applied to Electrical Engineering" was the theme that defined this event of the Department of Electrical Engineering of ISEC. Around 160 students and teachers participated in this event that strengthened the connection between academia and the professional sector, with the presence of excellent speakers and topics of great impact for the future of engineering.



R&D Nester was invited to be represented as a speaker, along with other leading institutions such as the Portuguese Association for Artificial Intelligence, E-REDES, REN, Critical TechWorks and Siemens. Together these speakers promoted reflections on real applications, challenges and opportunities of Artificial Intelligence in electrical grids, in the automotive sector and in sustainable digital transformation.



R&D Nester made his contribution with a presentation entitled **"AI-Powered Transformation of Modern Power Grids: Applications, Challenges and Future Directions"**, where he discussed the following points:

- How AI is applicable to power grids;
- Key Areas of AI Application in Power Grids and Power systems;
- AI Techniques and Applications in Energy Grids;
- Benefits of AI in Power Grids;
- Overview of AI Work at R&D Nester.

Sonam Parashar, researcher at **R&D Nester**, also presented the projects in which **R&D Nester** is involved and in which these topics are already being put into practice:

1 TwinEU
Developing a concept of Pan-European Digital Twin of the electricity system

2 New Generation Storage

3 WeForming
Buildings as Efficient Interoperable Formers of Clean Energy Ecosystems

4 HEDGE-IoT
Holistic Approach towards Empowerment of the DiGitalization of the Energy Ecosystem through adoption of IoT solutions

5 eclipse
The new ECLIPSE project will facilitate energy consumption reduction and support the stability and resilience of European power grids through the implementation of an open-source reference framework

This event was an opportunity to analyse the impact that AI is already having on the energy sector, and that it is even transforming this sector, confirming that it is a powerful tool that brings great opportunities - but also raises technical, ethical and social issues.

This ISEC Electrical Engineering Department event thus fulfilled their mission: to prepare students for the present and future of Electrical Engineering.



R&D NESTER PUBLISHES RESULTS ON THE TOPICS OF ENERGY DATA SPACES, ELECTRIC VEHICLES AND AGGREGATED FLEXIBILITY

Last May, **R&D Nester** was represented in the 21st edition of the **International Conference on the European Energy Market - EEM25**, that was held in Lisbon, Portugal.

EEM25
21st INTERNATIONAL CONFERENCE ON THE EUROPEAN ENERGY MARKET
Lisbon, 27-29 May 2025 | Portugal

For the last 20 years, the EEM Conference has been bringing together experts from academia, industry

and policy makers, to discuss cutting edge topics in energy markets. These include approaches and solutions related to energy modelling, market design, regulatory policies, climate change, technological developments, among other. In addition to the core areas, the recent editions have given more emphasis on energy storage, renewable and synthetic fuels, and energy citizenship.

The EEM25 three-day program included plenary sessions with keynote speakers from recognized energy institutions, industry, and prominent academics, as well as scientific sessions that cover a wide variety of energy markets related topics.

R&D Nester presented four papers on the topics of **Energy Data Spaces**, **Vehicle-to-Grid** and **Aggregated Flexibility**:

1)

Paper produced in the scope of **ENERSHARE project**: **"Comprehensive Governance Models for Energy Data Spaces: A Path to Secure and Interoperable Data Sharing in Europe"**.

The paper introduces a systematic approach specifically designed for the energy sector to address governance challenges in Energy Data Spaces. Based on an in-depth analysis of questionnaires from pilot projects involving regulated and non-regulated entities, it identifies key practices, needs, and difficulties in real-world data sharing. The resulting Governance Models aim to ensure clear responsibilities, compliance with EU regulations, and seamless interoperability across energy data exchange frameworks.

Enershare project website



2)

Paper produced in the scope of **V2Grid project**: **"Study on the impact of electric vehicles' charging in the national load profile: an analysis on Portuguese power system"**.

The paper analyzes the impact of electric vehicle (EV) charging on Portugal's national electricity grid, using real-world data to model residential, workplace, and public charging behaviors under various adoption scenarios. It concludes that without smart charging strategies and infrastructure upgrades, especially in high EV penetration scenarios, EV adoption could significantly increase peak loads and stress the grid, while technologies like Smart Charging and Vehicle-to-Grid (V2G) offer promising mitigation solutions.

V2Grid PROJECT

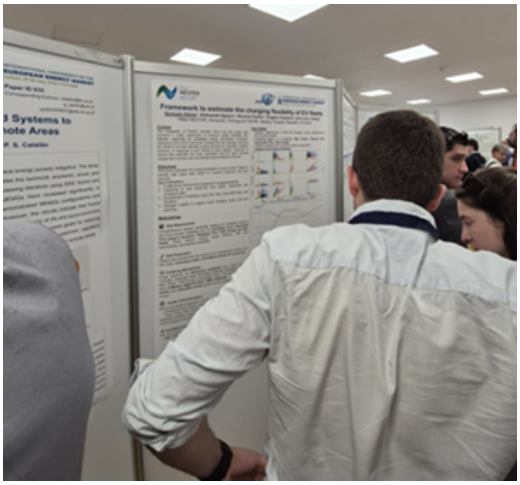


3)

Paper produced in the scope of **V2Grid project**: **"Framework to estimate the charging flexibility of EV fleets"**.

This paper presents a data-driven framework to estimate the charging flexibility of electric vehicle (EV) fleets by clustering real-world charging behaviors into distinct user profiles based on multiple variables, including power usage, session duration, and idle time. The analysis reveals that EV users with long idle times, particularly in residential and fleet configurations, offer the greatest potential for demand-side management and smart charging strategies, enabling improved grid performance and renewable energy integration.

V2Grid PROJECT



4)

Paper produced in the scope of **Next Generation Storage project**: **"Assessing the Impact of Grid Constraints on Aggregated Flexibility for Energy Market Participation"**.

This paper presents a scenario-based co-simulation that quantifies how low-voltage grid constraints reshape the flexibility an energy community can realistically bid into electricity markets. It couples a causal-inference elasticity model producing prosumer flexibility envelopes with two sequential PSSE power-flow runs that estimates feeder losses to a community battery enforcing thermal and voltage limits. Results show that technical constraints shave 5 - 15 % of theoretical flexibility on calm hours and up to 50 % during evening peaks, occasionally even enlarging flex when reverse-power voltage rise is mitigated. The workflow offers DSOs and aggregators a repeatable way to size market bids that are both economically attractive and grid-feasible.

New Generation Storage project website





R&D Nester was also represented in the Plenary Session 7 that took place on the 3rd day of the event, with the title: **"Transmission and Distribution Grids: Key Enablers for the Energy Transition"**.

Nuno Souza e Silva, Managing Director of R&D Nester, participated in this panel together with other speakers from REN, Siemens and IST.





For more information:

[EEM25 Conference website]
[V2Grid PROJECT]
[Next Generation Storage PROJECT]
[ENERSHARE PROJECT]

R&D NESTER PRESENTS AT INDIA-PORTUGAL EVENT

Sonam Parashar, Researcher from **R&D Nester**, received a Certificate of Achievement from His Excellency Shree Puneet Roy Kundal, Ambassador of the Indian Embassy in Lisbon.



This recognition was awarded for securing a position among the top candidates in the prestigious "Bharat Ko Janiye (Know India) Quiz", a flagship initiative by the Ministry of External Affairs, Government of India.

Additionally, Sonam Parashar participated at 'Indians in Portugal-Advancement of Science and Technology' conference, celebrating 50 years of re-establishment of diplomatic ties between India and Portugal.



This Researcher of **R&D Nester** had the opportunity to showcase **R&D Nester**'s work "**Energy Grid Flexibility Management with Smart Technologies**" and engage in insightful discussions with experts from various fields.



This one-day event, organized by Prof. Manas Sutradhar (Universidade Lusófona, Lisboa) and Bhoomi, Portugal, provided a fantastic platform to explore the evolving connections between India and Portugal, fostering meaningful exchanges and collaboration in science and technology. It brought together researchers, innovators and thought leaders. Events like this play a crucial role in fostering collaboration and knowledge exchange, driving progress in science and technology.

R&D Nester is proud to have one of its researchers recognized for their involvement in activities promoted by prominent entities.

Sonam is currently involved in **R&D Nester** teams in 3 projects, namely the **NGS - Next Generation Storage** project and the European projects promoted by Horizon Europe **WeForming - "Buildings as Efficient Interoperable Formers of Clean Energy Ecosystems"** and **ECLIPSE - "Energy Consumption reduction based on Open-source Reference framework"**.

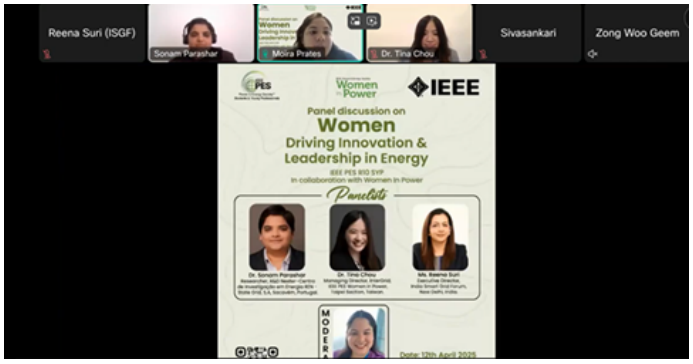
More information: "Indians in Portugal" Conference website

R&D NESTER AT “WOMEN DRIVING INNOVATION &

LEADERSHIP IN ENERGY”

R&D Nester was represented at the Panel Discussion on **"Women Driving Innovation & Leadership in Energy"** hosted by IEEE PES Region 10 SYP Committee in collaboration with Women in Power.

Sonam Parashar, Researcher at **R&D Nester** was part of an inspiring panel discussion as a speaker.



This virtual stage took place last April 12th with esteemed leaders in the energy sector and was able to engage meaningful conversations between professional women in the energy sector, thoughtfully moderated by Moira Prates (IEEE PES SYP R9), Salvador, Bahia, Brazil.

The session highlighted the pivotal role women continue to play in shaping the future of energy and innovation.

This session had 2 other speakers, in addition to the **R&D Nester** Researcher: Dr. Tina Chou - Managing Director, InterGrid, IEEE PES Women in Power, Taipei Section, Taiwan, and Ms. Reena Suri - Executive Director, India Smart Grid Forum, New Delhi, India.

These 3 speakers had the opportunity to share their professional journey, reflecting on the challenges, milestones, and growth they had encountered while building a career in the energy sector - from transitioning out of academia to contributing to industrial research.

This session is available on video.

Sonam Parashar, Researcher at **R&D Nester** shared her reflection "from conducting fundamental studies to driving applied innovation in real-world settings, one key lesson has stayed with me: growth begins the moment you step out of your comfort zone. As a researcher, staying curious and open to new areas is essential it's often in unfamiliar territory that the most impactful discoveries are made."

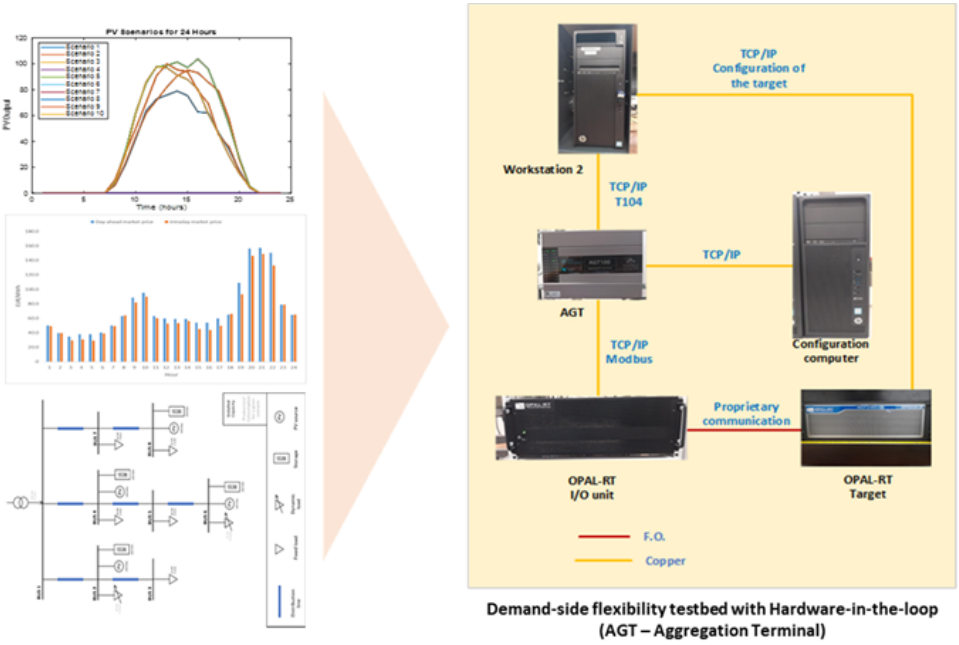
TECHNICAL INFORMATION

RISK-AWARE OPERATIONAL PLANNING FOR DISTRIBUTED ENERGY RESOURCES AGGREGATION

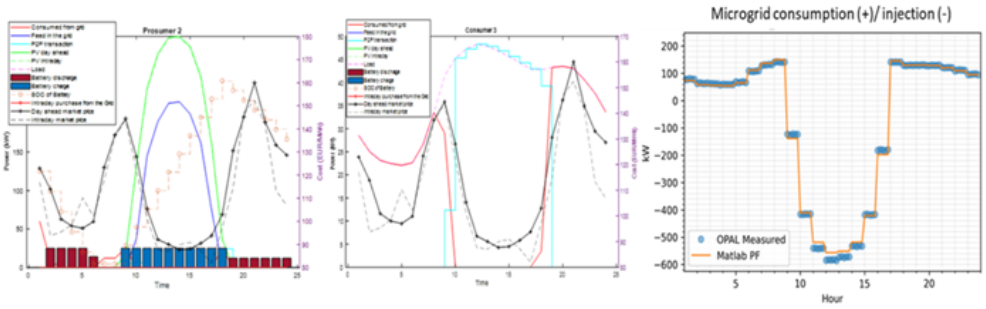
As the energy transition accelerates, the aggregation of distributed energy resources (DERs) is becoming a cornerstone of the decentralized and decarbonized power system. Enabled by regulatory support and technological advances, these aggregations integrate local renewable energy generation, flexible consumption, and shared energy infrastructure to generate, store, and exchange electricity efficiently. However, operating these ecosystems efficiently and reliably in volatile market conditions, while guaranteeing grid stability, requires advanced decision-support tools.

R&D Nester has developed an advanced optimization framework to support the coordination and market participation of aggregated DERs. The solution orchestrates local assets such as photovoltaic systems, battery storage, electric vehicles (EVs), and peer-to-peer (P2P) energy sharing, enabling dynamic operational planning under uncertainty, all while ensuring compliance with grid constraints.

The tool addresses the challenges posed by variable renewable generation and fluctuating electricity prices by integrating a predictive, risk-aware optimization model. It leverages distributionally robust optimization techniques to anticipate and mitigate the impact of forecast errors, particularly in solar energy production. A central feature of the framework is its use of Conditional Value at Risk (CVaR) to manage financial and operational risk, allowing community operators to adjust the level of conservatism in their strategies based on a configurable risk aversion parameter. The framework also incorporates grid constraints, ensuring that operational plans remain physically feasible within low-voltage distribution networks.



Demand-side flexibility testbed with Hardware-in-the-loop (AGT – Aggregation Terminal)



Electricity trading is managed in both the day-ahead and intraday markets, with the tool dynamically adapting to changing conditions. Peer-to-peer (P2P) energy exchanges are coordinated within the aggregated pool of distributed energy resources (DERs), ensuring that individual surpluses and deficits are efficiently balanced at the local level. This enhances self-consumption and reduces dependency on the external grid. At the same time, detailed models for energy storage systems and electric vehicles (EVs) ensure that charging and discharging actions respect user schedules, technical constraints, and market opportunities.

The framework has been validated using high-resolution operational data, demonstrating its capacity to optimize DER aggregation under realistic network and market scenarios.

By combining flexibility, resilience, and economic efficiency, this tool enhances the role of DERs and

energy communities as proactive stakeholders in the evolving power system, accelerating the deployment of smart, decentralized energy assets.

FRAMEWORK TO ESTIMATE THE CHARGING FLEXIBILITY OF EV FLEETS

The integration of Electric Vehicles (EVs) into the power grid represents a transformative opportunity for energy system optimization. With the increasing penetration of renewable energy sources, grid stability has become a critical challenge for system operators and flexibility a valuable feature to address it. Vehicle-to-Grid (V2G) technology and smart charging strategies have emerged as viable solutions to enhance grid reliability by leveraging the charging flexibility of EV fleets.

However, understanding the extent of this flexibility and its potential contributions to system services requires an in-depth analysis of real-world charging data. This study aims to assess the charging flexibility potential of different EV fleets by analyzing real-world charging behaviors and clustering users based on their charging patterns.

By categorizing EV users, we identify key factors that influence their ability to participate in demand response programs, grid balancing mechanisms, and energy market optimization. The research focuses on evaluating charging flexibility across various user clusters, determining their potential for participating in flexibility services.

The key contributions of this work include:

- A detailed clustering analysis of EV charging behaviors to classify users based on flexibility potential.
- A comprehensive framework for assessing EV time- and power-related flexibility of different EV user groups.
- A case study analysis highlighting the potential of integrating EV fleets into grid services.

METHODOLOGY

A. Data requirements

The development of a framework for estimating EV charging flexibility requires a comprehensive dataset combining public and private charging events. Public data provides broad behavioral and power-level variations, while private data enriches the analysis with residential profiles, together capturing key factors like peak demand and user constraints for reliable predictions.

Critical data elements include the Transaction ID for integrity, Start/Stop Timestamps for temporal patterns, Connected Time to identify idle periods for deferred charging, and Charging Time with Total Energy to determine rescheduling flexibility. Max Power reveals peak draw to inform demand response strategies.

Data preparation involves cleaning (addressing missing values, normalizing formats) and transforming data to derive metrics like Idle Time. This prepared data is used in clustering analysis to group sessions by characteristics such as peak power and charging time, revealing behavioral patterns and flexibility potential for optimizing grid services and EV integration.

B. Clustering Mechanisms

The clustering module aggregates cleaned EV charging data from all sites to identify flexibility patterns and demand response opportunities. Charging events are grouped based on shared attributes such as plug in time, charging duration, energy consumption, and maximum power. This reveals distinct behavioral profiles, for example short duration high power or long duration low power sessions, which inform tailored strategies like load shifting for sessions with extended idle periods.

The process involves key technical steps: feature selection of flexibility relevant attributes; data normalization using StandardScaler to ensure equal weighting; and rigorous algorithm evaluation. Multiple algorithms, including K-Means, Agglomerative Clustering, Gaussian Mixture Models (GMM), and DBSCAN, are optimized and compared using metrics like inertia and silhouette scores to identify the best performing model for forming distinct clusters.

Cluster analysis then profiles each group statistically, for example by analyzing means and variances, and visually, categorizing behaviors such as commuter or overnight charging. Flexibility potential is assessed through metrics like idle

time ratios and responsiveness to signals, enabling strategies such as time-shift charging, peak shaving, and dynamic power adjustments that align with grid conditions and renewable availability.

C. Flexibility assessment methods

Our methodology considers EV charging flexibility in two main dimensions: time flexibility and power-specific flexibility. Time flexibility refers to the ability to shift the charging schedule without affecting the total energy delivered, while power-specific flexibility reflects the capacity to modulate charging power during a session. These flexibility aspects are quantified using two metrics.

Firstly, Idle Time, defined as the difference between Connected Time and Charging Time, this metric represents the window during which a vehicle remains connected but is not actively charging. High idle time indicates a greater opportunity for load shifting without impacting energy requirements.

$$\mathrm{T_{idle}} = t_{connected} - t_{charging} \qquad (1)$$

Secondly, Time-shift flexibility, expressed as (2) where t'_k is the total connection time (Connected Time) of charging event k and $t_{k,P}$ is the time required to deliver the same energy E_k at a specified charging rate P (i.e., $t_{k,P} = \frac{E_k}{P}$).

A $Flex_{shift}$ value of 1 indicates that the entire connection duration is required for charging at rate P; values above 1 reveal excess time that can potentially be shifted.

$$Flex_{shift,k,P} = \frac{t'_k}{t_{k,P}} \qquad (2)$$

Graphically, we represent these metrics using FlexBars. In a FlexBars, time is plotted on the horizontal axis-the full width representing the total duration of the charging event-while the vertical axis displays power up to the maximum available rate. The resulting rectangle indicates the total possible energy delivery, which typically exceeds the actual energy charged, thereby visually emphasizing the flexibility potential. By averaging FlexBars over all charging events within a defined period, we obtain a comprehensive view of the temporal and power-specific flexibility of a site or cluster of EV charging events.

This structured approach, combining data aggregation, statistical analysis, and graphical visualization, lays the foundation for robust clustering and flexibility assessments, ultimately supporting targeted strategies for load shifting or peak shaving.

CASE STUDY

This case study analyzes a dataset of 10,000 EV charging events from EVnetNL in the Netherlands, comprising 417,141 meter readings. This data provides detailed transaction and energy metrics, enabling a thorough analysis of charging behavior and flexibility potential.

Using K-means clustering on features such as Max Power, Charging Time, Connected Time, and Total Energy, five distinct EV charging user clusters were identified. These are visualized in the scatter matrix (Figure 1), revealing behavioral differences in session length, power use, and energy consumption. The temporal distribution of charging events (Figure 2) confirms that some clusters predominantly charge during daytime (public stations) while others peak overnight (residential charging).

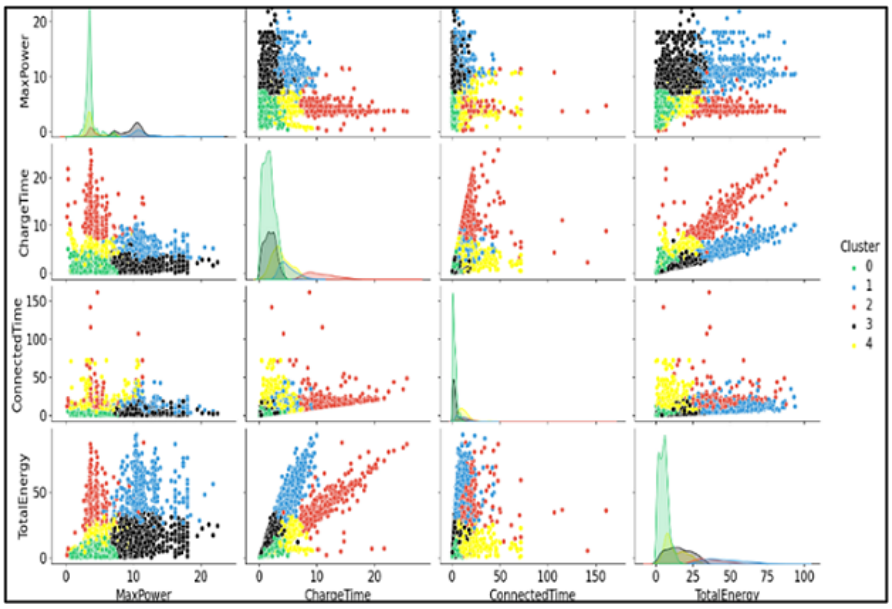


Figure 1 - Scatter matrix of the charging events dataset divided by 5 clusters

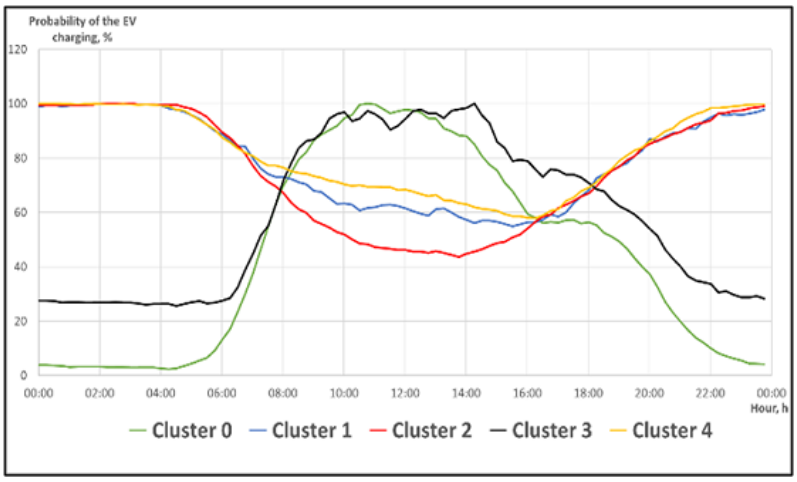


Figure 2 - Probability of the charging events occur at a certain hour for each clusters

Clusters differ widely in terms of idle time, which indicates flexibility for deferred charging. As shown in Figure 3, Clusters 2 and 4 exhibit the highest idle times, making them strong candidates for demand-side management. In contrast, Clusters 0 and 3 have short idle periods, reflecting optimized fast charging with limited flexibility.

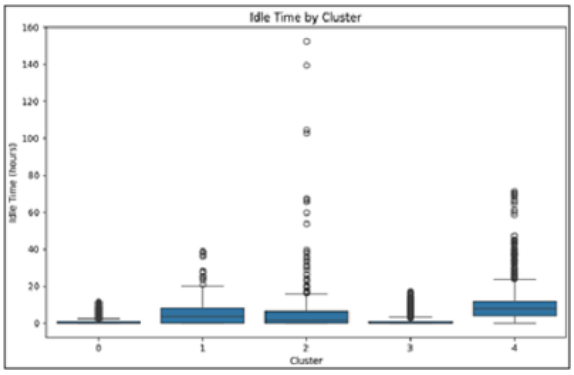


Figure 3 - Boxplot regarding Idle Time of each cluster

Table 1 summarizes the cluster characteristics and corresponding flexibility potential, while Figure 4 provides an example

of FlexBars visualization for Cluster 4, highlighting available temporal and power-related flexibility.

Cluster	Key Observations	Charging Flexibility	Class
0 (green)	Low ChargeTime and ConnectedTime. Low Power chargers	Low (already optimized)	Low Power Public (Opportunistic) / Commercial Areas
1 (blue)	High MaxPower (10-20 kW), balanced ChargeTime vs. ConnectedTime	Moderate (some users could optimize better)	High Power Household
2 (red)	Long-duration events. High ConnectedTime vs. ChargeTime, frequent excessive idle time	Highest (many users could optimize station turnover)	Low Power Household
3 (black)	Highest MaxPower, well-aligned ChargeTime and ConnectedTime	Low (optimized, minimal idle time)	High Power Public / Highways
4 (yellow)	Slow charging, low-moderate energy withdraw, high ConnectedTime	Moderate to High (long idle times can be optimized)	Low Power Household with PHEV or Fleet Charging

Table 1- Cluster classification summary table

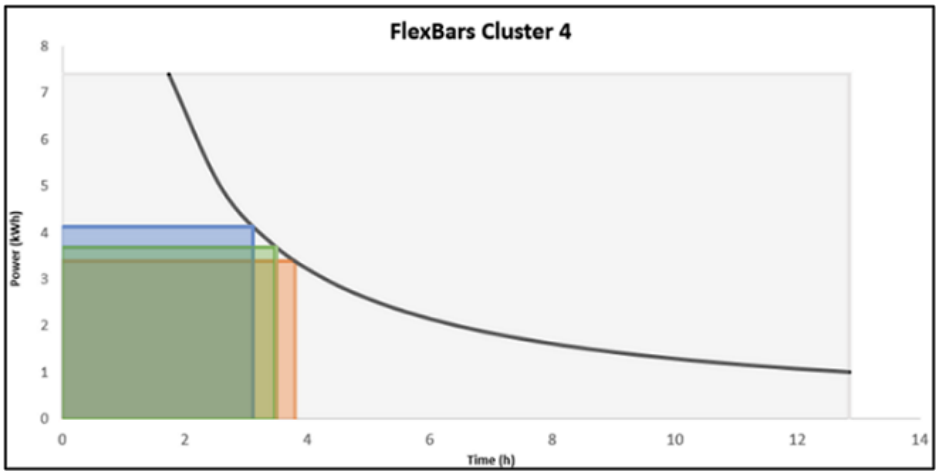


Figure 4 - Flexbars for cluster 4

The results show that household and fleet users with long connection times (Clusters 2 and 4) offer the greatest potential for smart charging and load shifting. Fast-charging users (Cluster 3) and opportunistic public charging users (Cluster 0) are already optimized with limited flexibility. Structured high-power users (Cluster 1) present moderate opportunities.

Overall, the findings highlight how differentiated charging behaviors can inform targeted demand-response programs and improve renewable integration into the grid.

LITERATURE REVIEW

World Energy Council – Jun 2025 - 2025 Global Energy Scenarios Comparison Review

The 2025 Global Energy Scenarios Comparison Review is not just a survey of futures methods and studies - it is a strategic lens into the unfolding realities of global energy for human development - i.e., energy additions and transitions.

In a world shaped by compounding crises and rising fragmentation, scenario comparisons help leaders reveal and challenge assumptions, explore new possibilities and stress-test priorities under deep uncertainty.

This review synthesizes insights from 13 leading global energy futures studies, highlighting areas of convergence, divergence, and emerging blind spots. It goes beyond comparing models and methods to expose six key insights that matter now for making energy transitions happen.



LINK FOR PUBLICATION

World Energy Council - Mar 2025 - WORLD ENERGY ISSUES MONITOR 2025

Energy transitions around the globe are increasingly dynamic, emergent, and self-organising - much like the flocking of birds. Each bird reacts to its neighbours and surroundings, creating evolving formations that may look different from one moment to the next yet remain guided by the same basic rules. Energy transitions follow the same patterns, with a few unifying drivers - like climate concerns, technology advances, and social imperatives - shaping countless local variations, depending on political, economic, and cultural conditions.

The 2025 World Energy Issues Monitor serves as our lens into these patterns. It shows what factors drive energy transitions, how regions and groups respond differently, and where shared insights can help us nudge the global energy sector onto more human-centred, resilient, and inclusive pathways. Decarbonising our energy systems has yet to truly begin. And, at a time when the international landscape is growing more fragmented - with multiple poles of influence and competing agendas - understanding these regional differences is both urgent and essential to start the process of net-zero and beyond.



LINK FOR PUBLICATION

EVENTS

29 -30 Oct 2025

CAPARICA, PORTUGAL

CONFMET 2025 - CONFERÊNCIA NACIONAL DE METROLOGIA

18 -19 Nov 2025

BILBAO, SPAIN

ENLIT EUROPE 2025

8 -9 Dec 2025

FRANKFURT, GERMANY

2ND ANNUAL SMART GRIDS EUROPE

20 -23 Apr 2026

JOHANNESBURG, SOUTH AFRICA

PAC WORLD AFRICA CONFERENCE 2026

13 -14 Apr 2026

FRANKFURT, GERMANY

6TH EV CHARGING EUROPE 2026

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

QUIZ

1) WHICH TYPE OF RENEWABLE ENERGY TECHNOLOGY PRODUCED MORE ENERGY IN PORTUGAL IN 2024?

- A) Solar
- B) Wind
- C) Hydro
- D) Biomass

2) HOW MANY INTERCONNECTIONS DOES PORTUGAL AND SPAIN HAVE?

- A) 4
- B) 5
- C) 6
- D) 7

3) WHICH COMMUNICATION PROTOCOL OR STANDARD IS NOT ASSOCIATED TO ELECTRIC VEHICLES AND THEIR ASSOCIATED INFRASTRUCTURE?

- A) IEC 62325
- B) IEC 61850
- C) OCPP
- D) ISO 15118

4) WHAT IS THE NAME OF THE EVENT DEFINED AS THE TOTAL LOSS OF ELECTRICAL POWER, OFTEN UNEXPECTED, IN A CONSIDERABLE BIG AREA (CITY OR COUNTRY)?

- A) ZeroPower
- B) Blackout
- C) Critical Problem
- D) E-mergency

5) FROM THE LIST, WHICH SERVICE IS IMPLEMENTED IN R&D NESTER'S RESERVES ENERGY MARKET SIMULATOR?

- A) Replacement Reserves (RR)
- C) Automatic Frequency Restoration Reserve (aFRR)
- B) Manual Frequency Restoration Reserve (mFRR)
- D) All of the above. They are all implemented in R&D Nester's Energy Market Simulator

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

1. Answer: C) Hydro
2. Answer: C) 6
3. Answer: A) IEC 62325
4. Answer: B) Blackout
5. Answer: D) All of the above. They are all implemented in R&D Nester's Energy Market Simulator

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)

ON RESEARCH, DEVELOPMENT AND INNOVATION

Portugal

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

.

Europe

- BRIDGE (H2020)

- 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)
- 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

- 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)

Rest of World

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

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