R&D NESTER

26 NL jul 2024

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EDITORIAL

Dear Reader,

This edition of our Newsletter is long due! The good reason for that is the sheer amount of topics in which we are currently working in the context of the Energy Transition.

The best way to evidence that is the following list of aspects that this Newsletter covers. Bear with us while you read through the following summary bullets related to the projects in which we participate that are further expanded in the sections below:

- **Energy Communities**: see the prize our project **FlexUnity** received from the International Smart Grid Action Network (ISGAN), deploy novel services for managing energy communities and their integration in the electric power system
- **Architecture for a TSO-DSO-Customer Network for Europe**: review our European Project **OneNET**, where 70 European partners prepare large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation
- **Integration of off-shore wind in the grid**: check the results of our project **ARCWIN** on Adaptation and implementation of floating wind energy conversion technology for the Atlantic region
- **Big Data for Energy**: see the 12 large scale pilots of the European **BD4NRG** project, addressing big data management and decision-making challenges in the energy sector using state-of-the art data science and Artificial Intelligence techniques, and how some pilots are contributing to the increase of efficiency and reliability of the electricity network
- **Artificial Intelligence for Energy**: check how 8 European countries are using the **I-NERGY** European project aiming to support, develop and demonstrate innovative AI-as-a-Service (AIaaS) Energy Analytics Applications and Digital Twins services, including Short Term Net Load Forecasting Using Computational Intelligence Techniques
- **Protections** under high penetration of renewable energy sources: see our developed models to perform the assessment of potential problems on the behavior of protection functions due to the massive integration of wind sources in transmission networks
- **Electric Vehicles**: review our work on the project on the analysis on the distribution side planning of distributed Electric Vehicle Charging Stations (EVCS), Renewable Energy Sources (RES) and Battery Energy Storage Systems (BESS), on the deployment and sizing of EVCS clusters with RES and BESS from the network operator's perspective and promoter's perspective
- **Real-time simulation**: learn about news on real-time simulation with our participation in the annual event from OPAL-RT
- **Energy Management in Buildings**: get insights on the just started European project **WeForming** which is at the forefront of transforming energy management in buildings, focusing on seamless integration with the energy ecosystem and using buildings as efficient interoperable formers of clean energy ecosystems
- **Aggregation**: learn about our research on key technologies of distributed flexible resource aggregation and optimization for EU market operation and the development of appropriate models and modules for simulation in closed-loop with hardware in the loop (HIL) in order to validate the functions of developed technology
- **Data Spaces**: check the developments of the reference architecture for a European Energy Data

Space being developed (**ENERSHARE** project) that combines cloud security solutions with integrated digital security and global artificial intelligence and data exchange architectures

- **Next Generation Storage**: review the developments in the **New Generation Storage (NGS)** Project that aims to enhance the battery sector in Portugal, considering on its entire value chain
- **Digitalization of Energy System via IoT solutions**: learn about a novel Digital Framework being developed in the new European project **Hedge-IoT** which aims to deploy Internet of Things (IoT) assets at different levels of the energy system (from behind-the-meter, up to the TSO level), to add intelligence to the edge and cloud layers through advanced AI/ML tools and to bridge the cloud/ edge continuum introducing federated applications governed by advanced computational orchestration solutions
- **Digital Twins**: see how the European project **TwinEU - Digital Twin for Europe** is building a federated ecosystem of Digital Twin solutions (DT) by enabling new technologies to foster an advanced concept of DT while determining the conditions for interoperability, data and model exchanges through standard interfaces and open APIs to external actor

As you can see below, we also keep ourselves active in the standardization activities via participation in **IEC** subcommittee **SC 8A**: "Grid Integration of Renewable Energy Generation", and with dissemination activities such as the participation in Innogrid annual event and Lisbon Energy Summit & Exhibition, while maintain our state-of-the-art innovation processes as confirmed by our renewed certification on the NP447 Standard.

One of the most appreciated elements of our Newsletter is the technical dive in the "Technical Information" section. This time we feature the following items:

- Short Term Net Load Forecasting Using Computational Intelligence Techniques
- Short-circuit current (SCC) information exchange between DSO and TSO
- Separation between software and hardware substation protection, automation and control (PAC) systems.

As usual, reach to us if you're interested or want to contribute in any of the topics addressed below.

Don't forget to test your knowledge with our popular Quiz section, this time on European and Portuguese trivia.

Hope you find the reading!

Sincerely,

Nuno de Souza e Silva

Managing Director

HIGHLIGHTS

R&D NESTER RECOGNIZED FOR ITS WORK ON FLEXIBILITY AND ENERGY COMMUNITIES

FleXunity Project won the **ISGAN Award of Excellence 2023**, this year recognizing excellence in AI for Smart Grids.



R&D Nester led the work on balancing markets in **FleXunity Project**.

9th edition of ISGAN Awards of Excellence is sponsored by the **International Smart Grid Action Network (ISGAN)** in partnership with the **Global Smart Energy Federation (GSEF)**.

These awards recognize excellence in innovation, integration, and transformation of smart grid systems and policy.

The award attributed to the **FleXunity** project was received by the project coordinator, **Cleanwatts**, at the 14th CEM - Clean Energy Ministerial conference that was held in Goa, India, in July.

FleXunity project started in December 2019 and ended last month of May. Its main objective was to deploy novel services for managing energy communities and their integration in the electric power system, including their participation in the energy and ancillary services markets, enhanced by **Virtual Power Plant (VPP) technology** empowered with **AI algorithms** focused on optimizing the use of distributed renewables from the utility or community portfolio.

The innovative services developed in this project will enable new business models from managing multiple energy flexibility assets, enhancing the use of renewables and support energy security and climate change challenges.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870146.

More information:

FleXunity project website

FleXunity Project @ R&D Nester website

FleXunity Project LinkedIn Page

CEM14 website

ONENET GENERAL ASSEMBLY - THE LAST YEAR OF THE PROJECT

The General Assembly of **OneNet** Project was hosted by the Florence School of Regulation (EUI) in Florence, Italy.



OneNet (One Network for Europe) - "TSO-DSO-Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" is a unprecedented project being the largest project founded by Horizon 2020 in the topic of integration and cooperation TSO-DSO-Consumer, involving 70 partners from different countries, of which **REN** and **R&D Nester** are part.

The purpose of this project is to create a fully replicable and scalable architecture that allows the entire European electrical system to function as a unique system in which a variety of markets enable the universal participation of different stakeholders, regardless of their physical location - at all levels, from small consumers to large producers. This project lasts for 3 years and half (October 2020 to March 2024).



The meeting had 65 members of OneNet Project meeting in person in Florence, and 40 more joining online.

During 2 days meeting were discussed the achievements and complications from all the Work Packages (WPs), focusing mainly into the horizontal WPs and the missing inputs required from the demo pilots.





R&D Nester made part of the presentation related with the Western Cluster demo, where its developments related with the flexibility and operational planning use cases were announced to the audience.

The **ONENET** general assembly was also a great moment to cooperate actively and provide feedback to the colleagues responsible for the development of the ONENET Connector, that is the crucial element of the system that allows the connection of multiple stakeholders to an unique system in which a variety of markets enable their universal participation.

More information:

OneNet website

OneNet project video

OneNet Project @ R&D Nester website

FLOATING WIND ENERGY SOLUTIONS – FINAL RESULTS OF THE ARCWIND PROJECT

The final workshop and meeting of **ARCWIND** project was hosted by **IST - Instituto Superior Técnico**, in Lisbon.



ARCWIND Project - Adaptation and implementation of floating wind energy conversion technology for the Atlantic region, financed by **INTERREG Atlantic Area**, aims to contribute to drive the floating wind energy forward such that it can become a major contributor of green energy in the Atlantic Area. The project has contributed with developments in four concepts of floating wind turbines, the identification of possible locations for economically viable wind farms and the design of some wind farms, hoping that these studies can provide investors and funding agencies technical support for decisions.

This workshop was an opportunity to present the major achievements of the project. The following topics were presented:

- Presentation of the multicriteria methods developed to identify feasible areas for farm locations in the Atlantic Area implemented in a GIS system;
- Presentation of the four platforms adapted for a 10 MW turbine and tested in hydrodynamic laboratories, with the comparison of the numerical models with the experimental results;
- Presentation of the design of the farms in the Atlantic Area based on four floating wind turbine platforms;
- Presentation of the moorings designed for selected farms and the corresponding installation;
- Presentation of maintenance aspects that can be applied to offshore wind farms;
- Presentation of the study of the economic feasibility of the FOW farms in the selected areas.

The welcome and opening of this final event was made by the Professor Carlos Guedes Soares, from Instituto Superior Técnico, Project Leader of **ARCWIND project**, who presented the project overview.



One of the main novelties introduced by the project is not only the study of four different designs of floating wind farms, but also an innovative approach to determining the location of the wind farms based on the satellite images, estimating the wind speed and direction, and innovative mooring and installation logistics.

R&D Nester, as a part of the WP7, related to array design, installation logistics and maintenance planning, contributed to study of the impact in the electric grid, in order to analyze the effects of the offshore wind farm in the connection point, taking into consideration the wind farm's output characteristics (load profile) and based on real network data, using a nodal capacity calculation tool.

During the presentation discussing the maintenance planning of offshore wind arrays, the aspects of wind farm connection were presented by WP Leader, highlighting the maximum installed capacities of the wind farms in six specific areas identified within the project scope.

The **ARCWIND project**, financed by **INTERREG Atlantic Area**, aims to contribute to the development of floating wind solutions. Different areas of knowledge are addressed, including the analysis of potential of wind resource, design and testing of prototypes of floating wind platforms, network impact and economic viability studies.

More information:

ARCWIND Project @ R&D Nester website

Arcwind project website

2023 INNOGRID “BETWEEN URGENCY AND ENERGY TRANSITION: GETTING THE BALANCE RIGHT”

InnoGrid, organized by the European Distribution System Operators' Association (E.DSO) and the European Network of Transmission System Operators (ENTSO-E), was held last June in Brussels, Belgium. Sessions took place on 9 and 14 June.

This is an annual event for the last 12 years that approaches the European innovation in power networks.

This year's conference theme was **"Between urgency and energy transition: Getting the balance right"**. Basically, this topic was debated focusing on 2 questions:

- **How to advance on the energy transition while dealing with the energy crisis?**
- **How to speed up the development and uptake of new technology solutions to meet the 2030 climate objectives and at the same time coping with energy emergency measures?**





Key pillars on the discussion were **Electrification, Digitalization and Cooperation**. It was reinforced that "grids" are urgently needed to fulfill the EU Green Deal, the FitFor55 ambitions and the REPowerEU initiative.

The identified trilemma is still the same: a reliable, sustainable and affordable energy system!

This edition reinforce that innovations continue to be needed at all levels, from the consumers premises to the control centers.

Implementation is the key word, as is removing the barriers that delay deployment of emerging solutions.

In summary, it became evident the urgent need for implementation of all type of efficient proven solutions, in a short timeframe and at a minimized cost.

For more information:

https://www.innogrid.eu/

BIG DATA FOR NEW GENERATION ENERGY - BD4NRG GATHER IN RIGA

BD4NRG Project (**"Big Data for New Generation Energy"**) had its plenary meeting in July, hosted in Riga, Latvia.

R&D Nester and **REN** integrate the project **BD4NRG - "Big Data for New Generation Energy"** under

the EU funded H2020 program. This project lasts for 3 years (January 2021 to December 2023).

The main goal of **BD4NRG** is to address big data management and decision-making challenges in the energy sector using state-of-the art data science and Artificial Intelligence techniques. This project will therefore unlock new solutions for this sector which have never been explored in the past, giving energy stakeholders the opportunity to improve their operations and economic returns.

From a technical standpoint, the BD4NRG ecosystem will make available a set of distributed data services, including big data processing and analytics tools as well as Machine Learning and other AI based models.

The technical solutions developed in the project will be validated through 12 large scale pilots across 10 countries.

R&D Nester, along with **REN**, is contributing with one of such pilots, focusing on the application of AI solutions to condition based monitoring and predictive maintenance for two classes of transmission system assets: overhead lines and circuit breakers. Currently,

R&D Nester and **REN** are working in the development of the required algorithms to execute these data related pilots.

The primary objective of the 5th Plenary Meeting in Riga was to ensure that each LSP (large-scale pilot) was progressing according to the pilot project schedule, and that follow-up action was taken in the case of any deviation from the defined objectives. Pilot project partners were invited to present the progress of each LSP. The current status of the LSP projects was discussed, as well as the steps necessary to reach the final evaluation cycle and expected results. Partners were encouraged to work closely together to overcome potential obstacles and thereby ensuring the success of the pilot project as a whole.

The **R&D Nester** presentation focused on two use cases related to LSP1 (Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance).

- The first use case concerns the development of a condition-based monitoring approach for circuit breakers using historical data from incident reports. The purpose is to assess the operational conditions of circuit breakers and identify potential correlations between faults and external causes.
- The second use case involves generating a semi-automatic maintenance plan for overhead lines using historical LiDAR data obtained from right-of-way corridors and transmission towers.

The development status of these two use cases was thoroughly discussed. The successful integration of the services into the projects was highlighted, and the availability of simulated data for validation was appreciated.

The presentation demonstrated R&D Nester's commitment to data-driven solutions for the predictive maintenance of critical energy assets, and highlighted the importance of these use cases for the advancement of their technological capabilities.







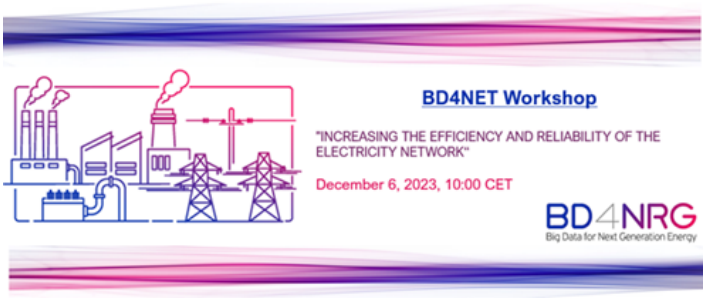
More information:

BD4NRG Website

BD4NRG Project @ R&D Nester website

BD4-NET WORKSHOP "INCREASING THE EFFICIENCY AND RELIABILITY OF THE ELECTRICITY NETWORK"

BD4NRG project workshop "INCREASING THE EFFICIENCY AND RELIABILITY OF THE ELECTRICITY NETWORK", was held online last December.



The ability to analyse and manage vast volumes of data is increasingly important in order to improve operational efficiency and the reliability of the electricity network.

Predictive analytics use the massive amounts of data available today and to inform realtime decisions that have a significantly positive impact on reliability and performance. In particular, predictive analytics provide early warning of equipment failure and abnormal operating conditions that may go unnoticed within the realm of traditional maintenance practices. Therefore, it can be used to minimize outages as well as improve equipment reliability and performance while avoiding potential failures.

The proposed "BD-4-NET" Large Scale Pilots (LSP) focus on predictive analytics that can forecast and increasing the efficiency and reliability of the electricity network.

During the workshop, **R&D Nester** presented the developments and results of the Large Scale Pilot named "Integrating off-grid Data with Condition-based Monitoring for Enhanced Predictive Asset Maintenance", developed in collaboration with **REN** and **UNINOVA**.

More information about this workshop here.

AGENDA

Time	Name	Presenter
10:00 - 10:05	Welcome and quick introduction	Nikos Dimitropoulos [NTUA]
10:05 - 10:10	BD4NRG Project Presentation	Nikos Dimitropoulos [NTUA]
10:10 - 10:20	BD4NRG Technical Solutions and Advancements	Nikos Bilidis [ED]
10:20 - 10:30	"BD-4-NET" Large Scale Pilots: Increasing the Efficiency and Reliability of the Electricity Network	Paride D'Ostilio [ASM]
10:30 - 11:00	Integrating off-grid Data with Condition based Monitoring for Enhanced Predictive Asset Maintenance	Nicolò Italiano [RDN]
11:00 - 11:15	Q&A	Nikos Bilidis [ED]

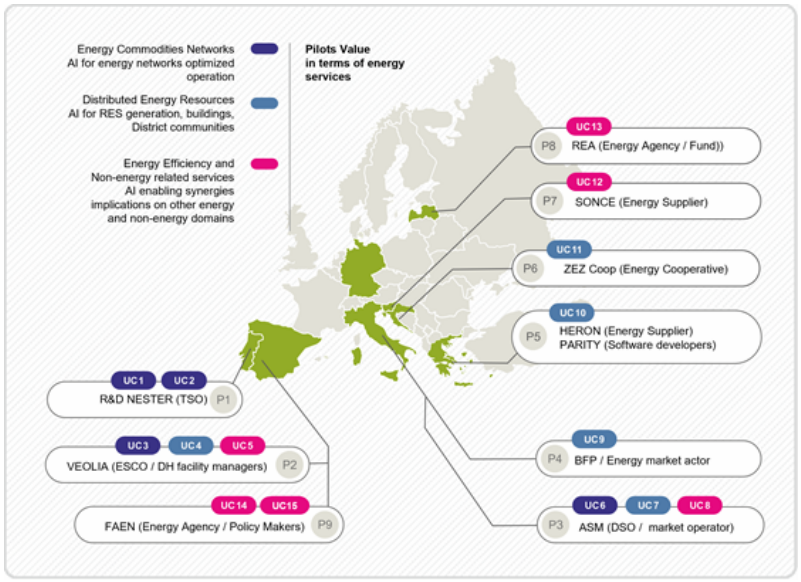
BD4NRG Website

BD4NRG Project @ R&D Nester website

R&D NESTER PRESENTED RESULTS OF THE PORTUGUESE PILOT FOCUSED ON AI FOR SUPPORT TO THE ELECTRIC SYSTEM MANAGEMENT (H2020 I-NERGY PROJECT)

On the 20th and 21st of September 2023, **R&D Nester** attended the 5th **I-NERGY** (**Artificial Intelligence for Next Generation Energy**) plenary meeting, held in Riga, Latvia. The assembly, which was the first physical plenary meeting of the European project, aimed to presents the main results of the demonstration pilots and of the other projects' components before the end of the project, foreseen in December 2023.

I-NERGY is an EU funded project aiming to support, develop and demonstrate innovative **AI-as-a-Service (AIaaS) Energy Analytics Applications** and **Digital Twins** services validated along 9 pilots across 8 countries. The services focus on three different sectors: **Energy Commodity Networks** (in which **R&D Nester** is involved), **Distributed Energy Resources**, and **Energy Efficiency**. The large geographical coverage of the demo sites, illustrated in the figure below, aims to support the EU-wide replicability and market take-up of **AI-driven solutions** in different socio-economical contexts to maximize the impact of **I-NERGY** services across Europe. **I-NERGY** pilot's approach permits to comprehensively test the analytics devised to cover the initially detected interests of relevant **Electrical Power & Energy Systems (EPES) stakeholders** within the energy value chain, covering their whole energy market: from the operation and maintenance to the society, as well as cross-cutting interests, such as policy making and research.



Under the scope of the project, **R&D Nester** has implemented a demonstration pilot in Portugal, focusing on the two following Use Cases (UCs):

UC1: AI for enhanced network assets predictive maintenance, integrating off-grid data with condition-based Monitoring;

UC2: AI for network loads and demand forecasting towards efficient operational planning.

UC1

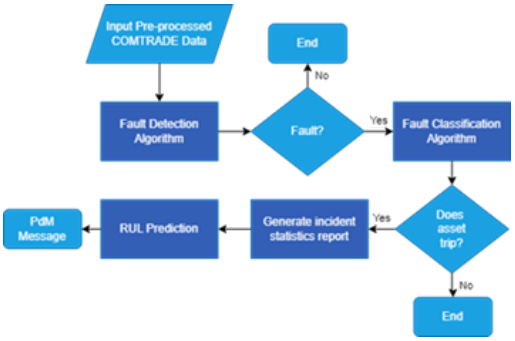
AI for enhanced network assets predictive maintenance, integrating off-grid condition-bases Monitoring

On top of presenting the current progress and results for both use cases, the meeting in Riga was an opportunity to showcase a live demo of one of the services developed for UC1, namely the Circuit Breaker Asset Management. **Nicolò Italiano**, an energy systems research engineer from R&D Nester, pitched a step-by-step demonstration on the functioning of the service, which is currently available as web-based application on the **AIoD Catalogue**, at the following LINK.



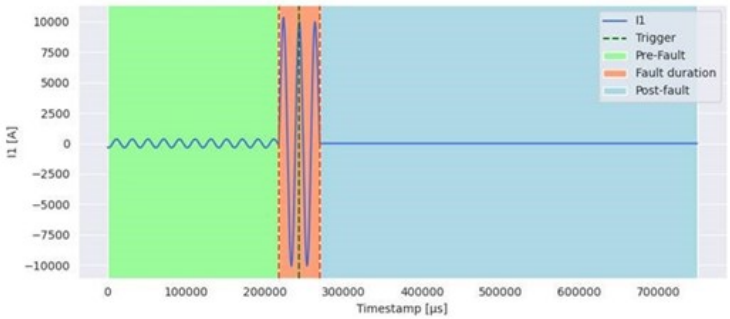
The service, which can be tested after requesting the credentials to **R&D Nester**, features a fully automated fault data processing, analysis, reporting system, and circuit breakers' Remaining Useful Life (RUL) estimation, for events occurring in any electrical system. Specifically, it includes the following submodules, depicted in the workflow below:

- **Fault detection**, which leverages signal processing techniques to detect whether an event is a fault or not;
- **Fault classification**, identifying the type of fault occurred (e.g. single-phase-to-ground, three-phase-to-ground), using Machine Learning (ML);
- **Incident reporting**, which extracts incident statistics that are key to assets management divisions of system operators;
- **RUL prediction**, predicting the Remaining Useful Life of a given circuit breaker, leveraging failure probability functions fitted on historical dataset of the events occurred, and identifying the corresponding maintenance recommendation.



Moreover, the service proposes an automatic and prompt visualization of the events processed, plotting all current's and voltage's signals segmented into the different phases characterising the faults, as per the graph below. Finally, the web-based application includes an asset management database, in which all processed faults are stored and grouped by assets.

The database leverages a traffic light label system for fast and easy-to-read visualization of assets' status, with the colour depending on the predicted failure probability.

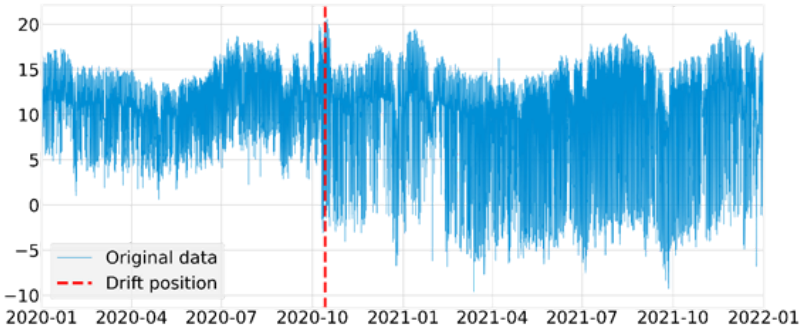


UC2

AI for network loads and demand forecasting towards efficient operational planning

The second use case is considering the forecasting of the Portuguese national load and of the net load of a specific TSO/DSO interface for the day-ahead operational planning. The most recent results presented in Riga concerns the Net Load Forecasting Model, applied to a specific case in which the net load is subject to a substantial change in the time-series pattern, occurring within a short timeframe.

This is commonly referred as concept drift, and is illustrated below:



Concept drift observed in the net load (y-axis), during a given time-period (x-axis)

Such events may occur for different reasons, among which, for instance, the installation of a new Photovoltaic (PV) power plant at the distribution level, self-consumption or Electric Vehicles (EV) chargers, in large-scale, or the connection of a new large-scale consumer. The first case could even lead to reverse power flows, represented by the negative values in the figure, which may be quite challenging to predict by a model that has always been trained exclusively upon positive values.

For this reason, it is critical to develop and use models that, in addition to feature high forecast accuracy, are also able to adapt to new patterns and changes in the data. Under the scope of **I-NERGY**, the

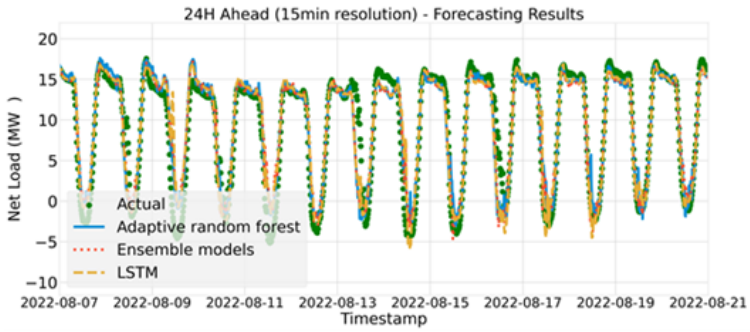
three approaches listed below have been considered:

- Long Short-Term Memory neural network-based model (LSTM);
- Ensemble models (XGB, DT, Lasso, SVR) based on Iterative Learning;
- Adaptive Random Forest based on incremental learning (Adaptive RF).

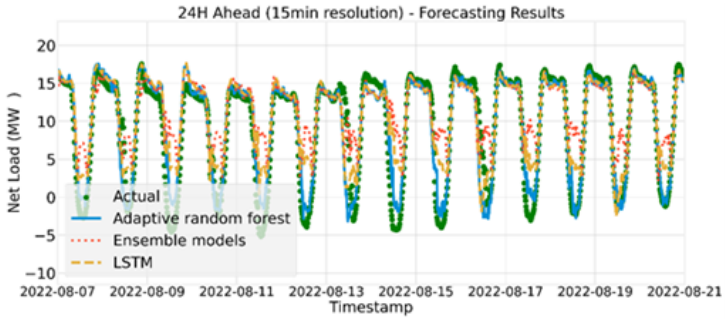
The three models were at first trained upon a large dataset that included significant drifts (Scenario 1), and then trained on a smaller dataset prior to the occurrence of the drifts (Scenario 2), with the aim to study the difference of the performance between the two cases. The second scenario was designed to analyse how the models react to new patterns and changes in the data that are not experienced during the training. The scenarios considered the same test dataset, which included one year that was not used for training the models.

The results showed that the Adaptive RF is the model that better adapts to the concept drifts, maintaining Normalised Root Mean Squared Error (NRMSE) of 8.6%, for both scenarios. The NRMSE corresponds to the ratio of the root mean squared error to the maximum of the absolute values within the test dataset. On the other hand, the ensemble model presents the worst performance, with an NRMSE of 9.1% in Scenario 1 and 14.1% in Scenario 2. The performance's drop from the first to the second scenario of the ensemble model indicates that it does not adapt well to new patterns unseen in the training dataset, contrary to the Adaptive RF. These results, described in detail in the scientific paper "Short term net load forecasting using computational intelligence techniques" presented at the 7th E-Mobility Power System Integration Symposium, in Copenhagen, highlights the importance of using adaptive forecasting techniques when facing net load time-series characterised by several concept drifts.

The figures below depicts the forecasting results of the three different models compared with the actual net load, for Scenario 1 and 2, respectively, and for a given timespan. Once again, it is possible to observe the Adaptive RF (in blue) is the model that better follows the actual net load patterns, especially for the second scenario.



Forecasting Results of Scenario 1



Forecasting Results of Scenario 2

For a full discussion on the results, please refer to "Laouali I., et al, SHORT TERM NET LOAD FORECASTING USING COMPUTATIONAL INTELLIGENCE TECHNIQUES, 7th E-Mobility Power System Integration Symposium, 2023", in which the dataset is described in detail, as well as the techniques used to prevent overfitting and the additional evaluation metrics considered.

For more information:

I-NERGY Project @ R&D Nester website
I-NERGY Project website

I-NERGY'S 2ND TECHNOLOGY TRANSFER PROGRAMME FINAL EVENT

I-NERGY's 2nd Technology Transfer Programme Final Event went Virtual last November.



I-NERGY, an EU funded innovation project around **Artificial Intelligence for Next Generation Energy** had the highly anticipated 2nd Technology Transfer Programme Final Event, held online, last November 21, 2023.

This engaging event ran for two and a half hours, featuring presentations from the champions of the 2nd open call who will showcase their projects in a concise 7-minute pitch.

Key event highlights included:

- Project Showcases: The champions of the 2nd open call took "center online stage", offering a brief but insightful 7-minute pitch about their innovative projects. Attendees will gained firsthand knowledge about groundbreaking technologies and solutions poised to shape the future of energy.
- Networking Opportunities: Participants had the chance to engage with like-minded individuals at the Q&A, fostering collaborations and partnerships in the pursuit of sustainable energy solutions.





More information about the project:

I-NERGY Project @ R&D Nester website

I-NERGY Project website

R&D NESTER PRESENTED SHORT TERM NET LOAD FORECASTING TOOL AT RENEWABLE ENERGY GRID INTEGRATION WEEK

R&D Nester was present in the **7th E-Mobility Power System Integration Symposium** held in Copenhagen, Denmark, on 25 September 2023.



The Renewable Energy Grid Integration Week, organized by the German energy consulting company Energynautics GmbH, provides an international forum to discuss project experiences, innovative ideas, and present results from ongoing research. It aims to stimulate interdisciplinary thinking between wind/solar/hydrogen/e-mobility energy and power transmission industries as well as universities and to identify subjects requiring more research efforts.

Benefits include the high technical level in considering challenges, solutions and trends and combining international project experience with networking between industry and academia. Presentations are held by invited speakers from companies and leading research institutes as well as by workshop participants selected through a call for papers.





In this 7th edition, **R&D Nester** presented a paper titled "**Short Term Net Load Forecasting Using Computational Intelligence Techniques**".

The content of the paper presented was produced as part of R&D Nester's participation in the **I-**

NERGY project founded by the European programme H2020. This initiative gathers 17 partners with the aim of supporting and developing new AI-based energy services and enhancing the service layer of the European AI on-demand platform (ai4europe.eu) in the energy sector.

The paper evaluates several forecasting methods, including an adaptive random forest method based on incremental learning incorporating a drift detector, a method based on a recurrent neural network using long short-term memory (LSTM), and a method based on an ensemble of models including decision trees (DT), support vector machines (SVM), extreme gradient boosting algorithms (XGBoost), and Lasso regressions.

The experiment was conducted using the net load data collected at the TSO-DSO interface in Portugal, where concept drift can be observed, possibly due to increasing integration of distributed energy resources behind the meter.

A series of experiments were conducted, exploring various scenarios, and an in-depth comparative analysis was then carried out.

For more information:

Renewable Energy Grid Integration Week website

I-NERGY Project website

I-NERGY Project @ R&D Nester website

BEHAVIOUR OF PROTECTION FUNCTIONS UNDER HIGH PENETRATION OF RENEWABLES – SIMULATION MODEL DEVELOPED BY R&D NESTER

R&D Nester project "**Prot4hiRES - Analysis of the impact of the high penetration of renewable sources on the performance of protection systems for transmission grids"** studies the potential negative impact of the high penetration of renewable sources in transmission grids on the performance of protection systems for these infrastructures, as these protections have been designed for grids supplied by conventional power stations, where synchronous generators are used. However, renewable sources use generators with interfaces based on power electronics, which characteristics differ from those of synchronous generators.

This project is being developed by **R&D Nester** in cooperation with **China Electric Power Research Institute (CEPRI)** and it aims to identify the potential problems resulting from the introduction of renewable sources on the protection functions and, using laboratory simulation, determine what changes are necessary to the current philosophies of parameterization and coordination of those functions. The final result will be a detailed specification for protection systems for transmission grids with a high penetration of renewable sources.

In the scope of the developed work, R&D Nester Team already presented some results. The latest Paper produced in the scope of this project details the development of a simulation model of a Type IV wind turbine generator compliant with the requirements of the Portuguese Grid Code. For the validation of the model, it was introduced in a portion of a transmission grid where faults were simulated at the point of connection. This allowed to obtain measurements of current and voltage which were later compared to well-known methodologies of protection functions, namely, overcurrent and distance. Results show that current contributions from RES are considerably lower during faults as compared to traditional synchronous generators. It was also verified that the type of generator does not seem to affect distance protection behavior.

This paper entitled **"Assessment of potential problems on the behavior of protection functions due to the massive integration of wind sources in transmission networks"** was presented **at the 22nd edition of Wind & Solar Power System Integration Workshop**, which was held last September in Copenhagen, Denmark.



The Wind & Solar Power System Integration Workshop provides an international forum to discuss project experiences, innovative ideas, and present results from ongoing research. It aims to stimulate interdisciplinary thinking between wind/solar/hydrogen energy and power transmission industries as well as universities and to identify subjects requiring more research efforts. Benefits include the high technical level in considering challenges, solutions and trends and combining international project experience with networking between industry and academia. Presentations are held by invited speakers from companies and leading research institutes as well as by workshop participants selected through a call for papers.



For more information:

Prot4HiRES Project @ R&D Nester website

2023 Wind & Solar Integration Workshop website

DEPLOYMENT AND SIZING OF EV CHARGING STATIONS CLUSTERS

R&D Nester project **"FEVER - Analysis on the distribution side planning of distributed EVCS, RES and BESS"** aims to study the direct impact and the associated challenges that distribution grids are facing with the integration of EVs and EV Charging Stations (EVCS). The research topics include an analysis on the EV infrastructure development, integrating both distributed renewable energy resources and battery energy storage systems (BESS), from the distribution network perspective.

This project is developed by **R&D Nester** in cooperation with **China Electric Power Research Institute (CEPRI)**.

This project already developed a methodology for the determination of the location and dimensioning for a cluster containing Electric Vehicle Charging Stations (EVCS), Renewable Energy Sources (RES) and Battery Energy Storage System (BESS). The methodology aims to optimize system security from the network operator's point of view, while also considering potential location preferences from the EVCS promoter.

The siting process is carried out using a Nodal Load Allocation algorithm, which iteratively increases the load at each candidate bus to obtain the maximum admissible load. The BESS is dimensioned using the Evolutionary Particle Swarm Optimization (EPSO) method. In this paper the methodology and the tools were tested using PandaPower and through the simulation of a medium voltage network from Simbench dataset.

Similarly, the representative load and generation profiles used for the analysis are obtained through the use of clustering techniques from the whole year's net load from the Simbench dataset. The proposed methodology provides an effective tool for the problem associated with the determination of the location and dimensioning aggregated clusters of EVCS, RES and BESS, which can help network operators to

avoid overloads while maximizing local renewable energy integration.

As a result of this developed work, **R&D Nester** Team produced a paper titled **"Deployment and Sizing of EVCS Clusters with RES and BESS from the Network Operator's Perspective"**.



This paper was presented at **IEEE PES ISGT Europe 2023 (ISGT Europe 2023)** last October, in Grenoble, France.

This conference was organized by IEEE Power & Energy Society (PES) and Université Grenoble Alpes, France and this year theme was **"Powering solutions for decarbonized and resilient future smartgrids"**.



The IEEE PES ISGT Europe conference addresses power grid modernization and the applications for the wide use of information and communication technologies for more intelligent operation of electric power systems and integration of renewable and distributed energy resources.

This conference always feature keynotes, plenary sessions, panels, industry exhibits, paper and poster presentations by worldwide experts on smart grid and related technologies. Researchers, practitioners and students worldwide submit papers for consideration to be presented at the conference and to discuss the latest trends and emerging and innovative technologies for grid modernization.

For more information:

FEVER Project @ R&D Nester website

IEEE ISGT Europe 2023 (ieee-isgt-europe.org)

REAL-TIME SIMULATION - R&D NESTER AS KEYNOTE SPEAKER AND TECHNICAL VISIT HOST IN RT23'S OPAL-RT EVENT

R&D Nester owns a real-time power systems laboratory that is used in many of its national and international projects that is based on **OPAL-RT** solutions for real-time simulation.

OPAL-RT's 15th annual conference on real-time simulation was held in Lisbon, from November 13th to 16th.



RT23 featured a range of hands-on workshops, keynotes and technical sessions covering a wide range of topics including power systems, energy conversion, eMobility, and more.

Recently **R&D Nester** was the partner selected by **OPAL-RT** to showcase its most recent Success Story with the title "HIL Simulation for the Substation of the Future".

This nomination allows to discover how R&D Nester is shaping the future of power systems simulation and renewable energy management with the help of OPAL-RT's real-time solutions. **R&D Nester's** Real-Time Power Systems Simulator (RTPSS) Laboratory is providing a unique research and simulation infrastructure to analyze the behavior of different components of power systems.

Within the scope of this collaboration, and with the **OPAL-RT** event taking place this year in Lisbon, R&D Nester was involved in this event's agenda.

Nuno Souza e Silva, **Managing Director of R&D Nester,** was a keynote speaker on the 3rd day of the event, with the presentation entitled **"Real-Time power systems simulation - current uses and future challenges"**.



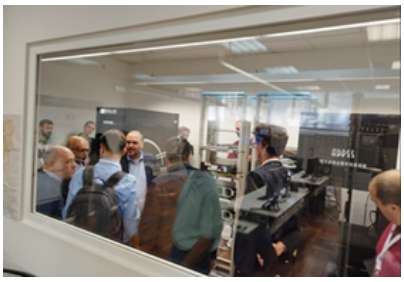


The last day of the event was dedicated to technical visits for the participants. **R&D Nester** received over 100 visitors in its Laboratory. During these visits, R&D Nester's team of researchers made presentations, demonstrations and examples of how the Laboratory works.











These technical visits allowed visitors to discover how R&D Nester is using OPAL-RT's real-time solutions in several projects in areas such as smart grids, renewable energy, energy markets, communication networks and interoperability. R&D Nester's Real-Time Power Systems Simulators (RTPSS) Laboratory provides a unique research and simulation infrastructure to analyze the behavior of different components of power systems.

For more information:

R&D NESTER
CREATING A SMART ENERGY FUTURE

OPAL-RT TECHNOLOGIES

RT23 - Real-Time Simulation Conference - OPAL-RT

RT23-agenda-18.10.23.pdf (opal-rt.com)

R&D Nester - LABORATORY (rdnester.com)

R&D Nester - R&D Nester LABORATORY - Creating a Smart Energy Future (2016) (rdnester.com)

RealTimePowerSystemsSimulationLaboratory (rdnester.com)

R&D NESTER AT THE FOREFRONT OF TRANSFORMING ENERGY MANAGEMENT IN BUILDINGS

The European project WeForming is at the forefront of transforming energy management in buildings, focusing on seamless integration with the energy ecosystem. Through groundbreaking solutions, this EU project addresses digital operation, management, and maintenance, along with efficient and interactive energy processing for Intelligent Grid-Forming Buildings (iGFBs).

WeForming - an acronym for **Buildings as Efficient Interoperable Formers of Clean Energy Ecosystems** - envisions a revolutionary approach to managing energy, one in which buildings are strategic players in supporting and forming the energy networks of the future. At the heart of WeForming's value proposition are iGFBs, actively participating in an interoperable energy ecosystem, including both energy networks and markets. These innovative buildings are designed to seamlessly integrate various energy sources, such as electrical, thermal, mechanical, and chemical energy. Their main goal is to optimize efficiency and self-sufficiency while prioritizing occupants' well-being, enhancing comfort, convenience and safety.

The ultimate mission of WeForming is to establish iGFBs as integral elements in shaping a secure, resilient, and carbon-free energy ecosystem. Over the next three years, the EU-funded project will develop and demonstrate a new generation of iGFBs that leverage advanced technologies and smart energy processing to innovate building energy operations, involving all the participants in the energy building value chain (consumers, aggregators, grid operators, etc.) in a common digital space. This approach will lead to increased multidirectional data flows, with the creation of new digital platforms and operational strategies. Artificial intelligence and machine learning will be key to WeForming's framework, ensuring automation and interactivity.

WeForming's methodology and digital solutions will be implemented and validated in six real-life demos across six countries. These use cases will target different systems, building types, consumer needs, economic conditions and climates, providing a comprehensive assessment and adaptability across different scenarios.

Comprising 30 partner entities from 10 countries, the WeForming project addresses the challenges of improving the interoperability between energy carriers, creating new roles and business models for buildings in energy markets, boosting buildings' physical interaction with energy networks, and fostering awareness and acceptance of iGFBs. This is a 3-year project starting in October 2023 and ending in September 2026.

The kick-off meeting for this project took place in Athens, Greece on the 17th and 18th of October, where **R&D Nester** team was represented. At this project kick-off meeting, the general context and administrative details were analyzed, including the analytical work plan and task schedules, milestones and expected results of the Working Packages.

R&D Nester is responsible for the **Working Package 6 "Evaluation and assessment, replication and scalability potential"** and has a strong contribution in the **Working Package 5 "WeForming Demonstration across technologies and scenarios"**.







Last November, a visit was made to the Portuguese Demonstrator *Palácio do Gelo Shopping*, in Viseu, a large shopping center with internal generation and energy storage systems.

This visit, allowed the 3 partners involved in the Portuguese Demonstrator, Movida, Builtrix and R&D Nester, to define the work plan for the coming months of cooperation.





The WeForming project is an innovation action funded by the European Union through the Horizon Europe Programme.

For more information:

WeForming Project website

WeForming LinkedIn page

WeForming project Twitter page

WeForming Project @ R&D Nester website

ENERGY DATA SPACES: CURRENT RESULTS OF THE EUROPEAN ENERSHARE PROJECT

The 4th Plenary Meeting of the European-funded project Horizon Europe **ENERSHARE** was held in beginning of October in Athens, Greece, hosted by one of the consortium partners, the Greek University NTUA, at the Amalia Hotel Athens.

ENERSHARE main objective is to facilitate the sharing of energy data. Since, in the energy sector, data sharing is lagging due to trust and privacy concerns, **ENERSHARE** will develop a reference architecture for a European Energy Data Space that combines cloud security solutions with integrated digital security and global artificial intelligence and data exchange architectures. It will carry out pilots and use cases. By enhancing interoperability, establishing trust and increasing the value of data building blocks, **ENERSHARE** will tailor solutions to the needs of the energy sector.

The event held in October 2023 served to evaluate the status of the project, focusing on the developments of the last 6 months. The meeting was kicked-off by NTUA's Research Director Ntanos Christos, welcoming the Consortium and opening the discussions. All partners presented their parts, namely:

- Overview of the project & progress so far, by ENGINEERING (coordinator);
- Extended intra-energy and cross-sector Data Space interoperability building blocks, by TECNALIA;
- Data and Services marketplaces for data sharing value creation and energy compensation, by ENGINEERING;
- Cross-value chain AI-based data-driven services, by INESC TEC;
- Data Space and data sharing governance and business models, led and presented by **R&D Nester**;
- **ENERSHARE** real-life demonstration, by NTUA;
- Dissemination, communication and exploitation, by FIWARE and ENGIE.

The main outcomes resulting from the already published deliverables were presented, emphasizing the innovative design of data sharing incentive mechanisms, the connector's status and the 1st version of the MVP (Minimal Viable Product), as well as the different services that will be explored within the project's data space.



Group photo of the meeting with the ones attending physically

The meeting had also a couple of workshops dedicated to the MVP demo, project reference architecture and technical alignment and coordination led by TNO, RWTH and European Dynamics, respectively.

For more information:

ENERSHARE website

ENERSHARE @ R&D Nester website

"DER AGGREGATION AND OPTIMIZATION FOR MARKET INTEGRATION" – A DATA-DRIVEN APPROACH BY R&D NESTER

R&D Nester project "**Aggregation - Research on Key Technologies of Distributed Flexible Resource Aggregation and Optimization for EU Market Operation"** aims at characterise the aggregation of distributed energy resources, develop an aggregation terminal for distributed flexibility energy resources, and build an application of the aggregation of distributed energy resources in the European market, by developing appropriate models and modules for simulation in closed-loop with hardware in the loop (HIL) in order to validate the functions of the developed technology.

This project is developed by **R&D Nester** in cooperation with **China Electric Power Research Institute (CEPRI)**.

In the scope of this project, it was produced a data-driven approach to tackle the stochastic optimal power flow problem in an electric power system. The objective is to balance the operational costs and the risks of constraint violations in the network. The approach uses ambiguous distribution sets centered on a finite set of training data to account for uncertainties in the network. It leverages the Wasserstein metric to determine control policies that can withstand both the forecast errors and sampling errors present in the data set by quantifying the proximity between the empirical distributions and the actual unknown distribution. The goal is to support the reduction of over-voltage caused by high integration of renewable energy in the distribution network. This is useful for System Operators (T/DSO) to efficiently plan the grid operation, or for aggregators to draw operational strategies against penalties due to connection constraints' violation.

As a result of this developed work, R&D Nester Team presented a paper titled **"Improving renewable energy integration with distributionally robust stochastic optimal power flow"**.

This paper was presented **at the 22nd edition of Wind & Solar Power System Integration Workshop**, that was held last September in Copenhagen, Denmark.



The Wind & Solar Power System Integration Workshop provides an international forum to discuss project experiences, innovative ideas, and present results from ongoing research. It aims to stimulate interdisciplinary thinking between wind/solar/hydrogen energy and power transmission industries as well as universities and to identify subjects requiring more research efforts. Benefits include the high technical level in considering challenges, solutions and trends and combining international project experience with networking between industry and academia.
Presentations are held by invited speakers from companies and leading research institutes as well as by workshop participants selected through a call for papers.



For more information:

Aggregation Project @ R&D Nester website

2023 Wind & Solar Integration Workshop website

ELECTRIC VEHICLE CHARGING STATIONS PLANNING – IMPACT & CHALLENGES FOR BOTH NETWORK OPERATOR AND PROMOTER

R&D Nester project **"FEVER - Analysis on the distribution side planning of distributed EVCS, RES and BESS"** aims to study the direct impact and the associated challenges that distribution grids are

facing with the integration of EVs and EV Charging Stations (EVCS). The research topics include an analysis on the EV infrastructure development, integrating both distributed renewable energy resources and battery energy storage systems (BESS), from the distribution network perspective.

This project is developed by **R&D Nester** in cooperation with **China Electric Power Research Institute (CEPRI)**.

This project already developed a methodology for the determination of the location and dimensioning for a cluster containing Electric Vehicle Charging Stations (EVCS), Renewable Energy Sources (RES) and Battery Energy Storage System (BESS). The methodology aims to optimize system security from the network operator's point of view, while also considering potential location preferences from the EVCS promoter. The siting process is carried out using a Nodal Load Allocation algorithm, which iteratively increases the load at each candidate bus to obtain the maximum admissible load. The BESS is dimensioned using the Evolutionary Particle Swarm Optimization (EPSO) method.

As a result of this work, **R&D Nester** Team produced a paper titled **"Perspectives on Electric Vehicle Charging Station Planning in Distribution Networks: Promoter vs Network Operator"**, focused on the analysis of both perspectives with relation to the planning of EVCS in distribution grids.

In this paper the methodology and the tools were tested using PandaPower and the simulation of IEEE 30 Bus system integrated with a dataset based on public real data from the Portuguese DSO network comprising part of Lisbon's MV network. The proposed methodology provides an effective tool for the problem associated with the determination of the location and dimensioning aggregated clusters of EVCS, RES and BESS, which can help network operators and promoters to mitigate network stress while maximizing local renewable energy integration.

This paper was presented at **ICPE 2023 - The 4th International Conference on Power Engineering** last December, in Macau, China.



During the presentation of the paper in the on-line session, **R&D NESTER** was awarded with the **best presentation of the session**.

This conference is sponsored by IEEE, Macau University of Science and Technology, University of Electronic Science and Technology of China, Science and Engineering Institute, and IEEE Macau. As a core area of modern science, it finds applications in diverse fields, such as environmental, energy, aerospace, industrial, and transportation. The proceedings are available in IEEE Xplore, Scopus, EI Compendex and SCI.

For more information:

FEVER Project @ R&D Nester website

ICPE 2023 (ICPE 2023 (ICPE Conference website)

EMPOWERING THE ENERGY STORAGE SECTOR IN PORTUGAL – R&D NESTER AT THE 1ST PLENARY

MEETING OF THE NEW GENERATION STORAGE (NGS) PROJECT

The first Plenary Meeting of the **New Generation Storage (NGS)** Project was held at the **INL - International Iberian Nanotechnology Laboratory**, in Braga, on the 11th of December 2023.

The project will contribute to enhance the battery sector in Portugal, focusing on its entire value chain. The event was an opportunity to gather members of the NGS consortium to discuss several topics related to the battery sector, green mobility and the development of a battery value chain and ecosystem in Portugal. The main goal was to promote the exchange of ideas and experiences among the partners, fostering collective learning and growth of the NGS consortium.



The session included panel discussions and presentations for the seven pillars of the project, detailed below:

I. Valorisation and Advanced Refining, aiming to install a large refinery focused on sustainable refining and valorisation processes, in order to implement an innovative and improved industrial line for lithium processing, through a sustainable technology, based on membrane electrolysis.

II. Cell, Modules and Components, aiming to install and operate manufacturing lines of cells and modules, and develop new, safer and more sustainable electrodes, electrolytes and other components.

III. Battery Pack Assembly, focusing on the installation of three assembly lines for stationary batteries and batteries for the automotive industry. The goal is also to study the integration of cabling, connectors and coating, energy management systems and control electronics, as well as the design and development of the proposed product.

IV. Integration and Applications, related specifically to the connection of batteries to the grid for electricity network management, their use for different purposes (e.g. residential, commercial and industrial), and the integration of batteries in fast charging stations and in vehicles.

V. Recycling and Second Life, focusing on the recycling of battery materials and components, battery disassembly and second life batteries. The goal is to enable the re-use of recycled materials as new inputs of the value chain, creating a sustainable circular ecosystem.

VI. Training and Advanced Courses, a pillar transversal to the entire NGS project aiming to train human resources in the companies involved in the NGS, as well as providing highly specialized training

for future master's and doctoral students, promoting technical and university qualifications in companies.

VII. Technology Platform, aiming to develop and implement a Technology Platform, which will support the Portuguese industry in positioning itself as an important international player in the battery sector, supporting market innovation along the entire value chain.

R&D Nester is mainly involved in the **pillar IV "Integration and applications"**, by addressing the system and market integration of distributed storage within the Business Project **"Optimized distributed storage for energy communities"**.

This Business Project, designed in collaboration with **CleanWatts** and **Instituto Superior Engenharia do Porto (ISEP)**, aims at achieving the following specific objectives:

1. Development and validation under real world conditions of the integration of decentralised batteries in Energy Communities and, furthermore, in the national energy system and markets;

2. Management of distributed energy storage systems by a Virtual Power Plant (VPP) Management Platform;

3. Strengthen partners' positions in the Energy Storage and Energy Communities sectors, in Portugal and abroad.

The event in Braga presented a chance for in-person brainstorming and discussion among the three partners, in preparation to the next steps of the Business Project.
For more information:

NGS Project @ R&D Nester website

R&D NESTER IN HEDGE-IOT PROJECT TO DIGITIZE THE ENERGY SYSTEM VIA IOT SOLUTIONS

HEDGE-IoT project proposes a novel Digital Framework which aims to deploy Internet of Things (IoT) assets at different levels of the energy system (from behind-the-meter, up to the TSO level), to add intelligence to the edge and cloud layers through advanced AI/ML tools and to bridge the cloud/edge continuum introducing federated applications governed by advanced computational orchestration solutions.

The **HEDGE-IoT** project (full project name: **Holistic Approach towards Empowerment of the DiGitalization of the Energy Ecosystem through adoption of IoT solutions**) is co-funded by the European Union under Grant Agreement No. 101136216. The **HEDGE-IoT consortium**, consisting of **42 partner organizations** from **13 European countries**, has officially launched the HEDGE-IoT project during a **kick-off meeting held in Athens on January 24 & 25, 2024**, where R&D Nester team was represented.

Leading academic institutions, major energy players, utilities and energy exchange companies, technology suppliers, facility/infrastructure operators, legal and regulatory specialists, and SMEs supporting IT development and visibility are all part of the HEDGE-IoT consortium. The collaboration hopes to create **novel solutions**, advance **standards**, and influence the direction of **digital twins**, **smart energy**, and the **IoT** during the course of the project's 42-month duration. By utilizing IoT solutions, the HEDGE-IoT Framework will improve the energy systems' ability to host renewable energy sources (RES), unlock previously unrealized flexibility potential, and strengthen the grid's resilience to

the energy sector's digitalization and IoT standardization advancements.

Within **HEDGE-IoT** project R&D Nester's responsibilities will be mainly related to the activities of **WP2 "Stakeholders Requirements and System Specification"**, **WP3 "Technological Enablers Specification, Design and Development"** and **WP5 "Demonstration across Technologies and Scenarios"**, in the latter, more specifically in the Portuguese demo together with other Portuguese partners: CEVE (DSO), REN (TSO), INESCTEC, SONAE group and Elergone which will collaborate in the implementation and demonstration of the **"Living lab for Interoperable AI-based Energy Services"**.





Follow HEDGE-IoT on social media LinkedIn, Twitter and YouTube and be the first to know about any project-related news.

HEDGE-IoT website is available at www.hedgeiot.eu.

For more information:

HEDGE-IoT Project @ R&D Nester website

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

The project **TwinEU - Digital Twin for Europe** aims to build a federated ecosystem of Digital Twin solutions (DT) by enabling new technologies to foster an advanced concept of DT while determining the conditions for interoperability, data and model exchanges through standard interfaces and open APIs to external actors.

This 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 goal.

The Kick-off meeting for this project took place on the 15th and 16th of January in Brussels, where the **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.



For more information:

https://twineu.net/

TWIN-EU PROJECT @ R&D Nester 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 HOSTED THE IEC SUBCOMMITTEE WORKING GROUP

Founded in 1906, the IEC (International Electrotechnical Commission) is the world's leading organization for the preparation and publication of international standards for all electrical, electronic and related

technologies.

IEC is divided into TCs (technical committees) and SCs (subcommittees), which integrate several WGs (working groups).
R&D Nester hosted the last meeting of the subcommittee SC 8A: "Grid Integration of Renewable Energy Generation" that was held last February.

This event was a joint meeting of two working groups that belong to the SC8A:

- **WG6** - Connection of Renewable Energy with HVDC System
- **WG7** - Integrating distributed PV into DC systems and use cases.

R&D Nester is represented in the WG6 with the nomination of its Managing Director, Nuno Souza e Silva, as member.

These 3-day meeting was held in a hybrid format, welcoming members of different nationalities in the face to face meeting in Lisbon, Portugal, and through the online zoom conference.





The event had a rich and busy agenda for these 3 days of work. The groups addressed several points scheduled on the respective agendas, including technical reports, proposals for new projects, technical presentations, progress and discussion of IEC technical standards.





More information, consult R&D Nester website and the IEC pages of the Study Committees and Working Groups:

IEC website

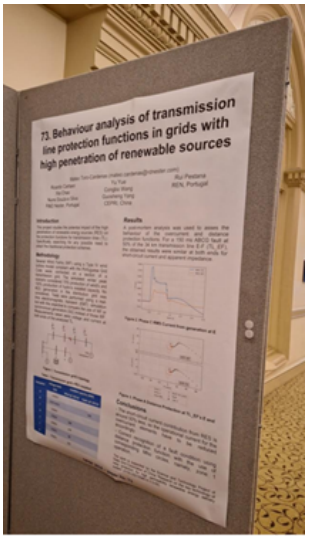
R&D Nester website

HIGH PENETRATION OF RENEWABLE SOURCES – PUBLICATION ON THE BEHAVIOR OF PROTECTION FUNCTIONS

The high penetration of renewable sources in transmission grids may have a negative impact on the performance of protection systems for these infrastructures, as these protections have been designed for grids supplied by conventional power stations, where synchronous generators are used. However, renewable sources use generators with interfaces based on power electronics, which characteristics differ from those of synchronous generators. This is the core of **Prot4HiRES**, the R&D Nester project that aims to identify the potential problems resulting from the introduction of renewable sources on the protection functions and, using laboratory simulation, determine what changes are necessary to the current philosophies of parameterization and coordination of those functions. The final result will be a detailed specification for protection systems for transmission grids with a high penetration of renewable sources.

This project is developed by **R&D Nester** in cooperation with **China Electric Power Research Institute (CEPRI)**.

As a result of this work, R&D Nester Team produced a poster that share the content produced in the Paper titled "**Methodology For The Assessment Of The Behavior Of Protection Functions In Transmission Grids With High Penetration Of Renewable Sources**".



This paper presents an assessment of the potential impact of the high penetration of renewable energy sources (RES) on the protection functions for transmission lines. The performed analysis was done on a simulation model of part of a transmission grid with wind farms (WFs) connected to various substations. A dynamic model was used for the wind generators, including fault-ride-though capability and reactive power contribution during faults.

R&D Nester presented this paper in the last edition of DPSP conference.

DPSP - Developments in Power System Protection International Conference is already in its 17th edition. This year edition was held in Manchester, UK, last month of March.

This is one of the only conferences dedicated to power system protection. It features leading voices in the sector, peer-reviewed technical presentations, a tutorial on protecting the evolving grid, networking opportunities and technical visit to the High Voltage Lab and Real-Time Digital Simulator facilities.



For more information:
DPSP 2024 conference website
Prot4HiRES Project @ R&D Nester website

R&D NESTER PARTICIPATES IN AN EXHIBITION ON THE FUTURE OF THE EUROPEAN ENERGY SECTOR

R&D NESTER and F6S Innovation were present at the **Lisbon Energy Summit & Exhibition 2024** representing the European projects **HEDGE-IoT** and **WeForming**. This event was held in FIL - Feira Internacional de Lisboa, last 27-29 May.

LISBON ENERGY SUMMIT & EXHIBITION 2025 | 2-4 JUNE 2025 LISBON | PORTUGAL

HEDGE-IoT is an ambitious EU-funded initiative within the Horizon Europe framework, dedicated to revolutionizing the energy landscape with innovative IoT solutions. HEDGE-IoT aims to lead the charge by deploying cutting-edge IoT assets and advanced AI/ML tools across energy systems, enhancing resilience and unlocking untapped flexibility potential.

WeForming involves various aspects to drive innovation and collaboration with the focus on energy optimization through Intelligent Grid-Forming Buildings (iGFBs). The project facilitates the integration of all the players across various sectors and geographical regions via standardized data interoperability and Advanced Building Management Systems. The project also promotes the creation of collaborative business models and policy recommendations through co-creation activities with both internal and external participants.



During the even it was possible for visitors to get to know these and other European initiatives focused on developing and demonstrating innovative energy solutions!

To discover more about R&D Nester initiatives and to explore the path towards energy efficiency:

HEDGE-IoT

https://hedgeiot.eu/

WeForming
Empowering Buildings. Energizing the Future.
https://weforming.eu/

R&D NESTER: SUCCESSFUL TRANSITION OF RDI CERTIFICATION TO THE NEW STANDARD NP447: 2021

The external audit conducted on the RDI management system implemented at R&D Nester took place over two consecutive days (January 18 and 19) and resulted in the approval of the transition of RDI Certification to the new version of the **NP4457 Standard: 2021**.

We highlight that no non-Conformities were identified, only Opportunities of Improvement that the organization may or may not choose to implement.

The audit covered all the requirements of the standard, with a focus on Project Management, Monitoring, Management Review, Information Management, and Results Valuation.

This achievement is the result of intensive work by all R&D Nester employees in aligning the Innovation Management System with the new and more demanding requirements. We receive this recognition with great satisfaction, reflecting the importance we attach to Innovation in this organization.

This certification is relevant not only for R&D Nester but also for its partners and shareholders, confirming that R&D Nester carries out its work in accordance with the best management practices.

For more information about **R&D Nester's RDI Certification**, please visit our website www.rdnester.com.

TECHNICAL INFORMATION

SHORT TERM NET LOAD FORECASTING USING COMPUTATIONAL INTELLIGENCE TECHNIQUES

In the scope of the European programme H2020 "**I-NERGY project**", R&D Nester developed a short-term net load-forecasting tool. The experiment was conducted using the net load data collected at the TSO-DSO interface in Portugal, where concept drift i.e., sudden and large changes in the energy flow pattern can be observed, possibly due to increasing integration of distributed energy resources behind the meter. Figure 1 presents an example of drift detected in the net load data.

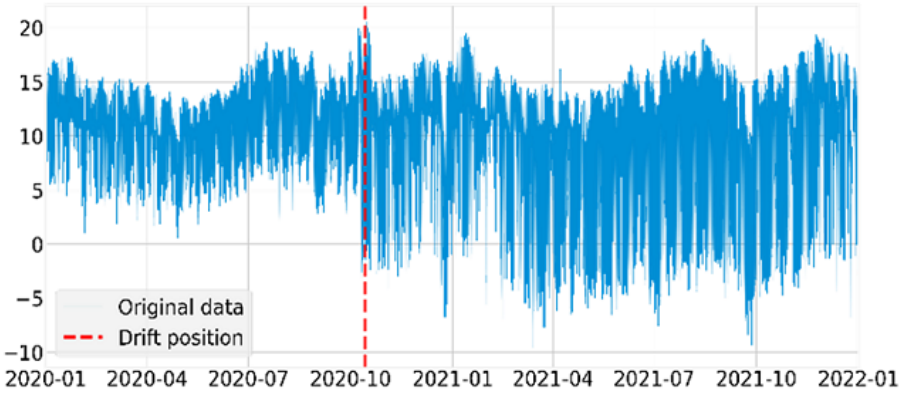


Fig 1: Drift detected by CUSUM in the net load data

The system evaluates several forecasting methods, including an adaptive random forest method based on incremental learning incorporating a drift detector, a method based on a recurrent neural network using long short-term memory (LSTM), and a method based on an ensemble of models including decision trees (DT), support vector machines (SVM), extreme gradient boosting algorithms (XGBoost), and Lasso regressions. Figure 2 shows the forecasting process.

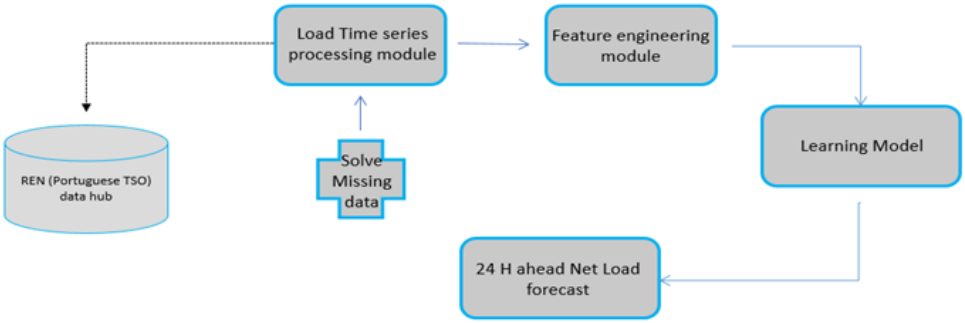


Fig 2: Forecasting process

The adaptive random forest approach is based on incremental learning and incorporates a set of algorithms to detect and adapt to drifts without re-training the models, thus reducing adaptation time while improving the performance of net load forecasts. Figure 3 presents the incremental learning approach.

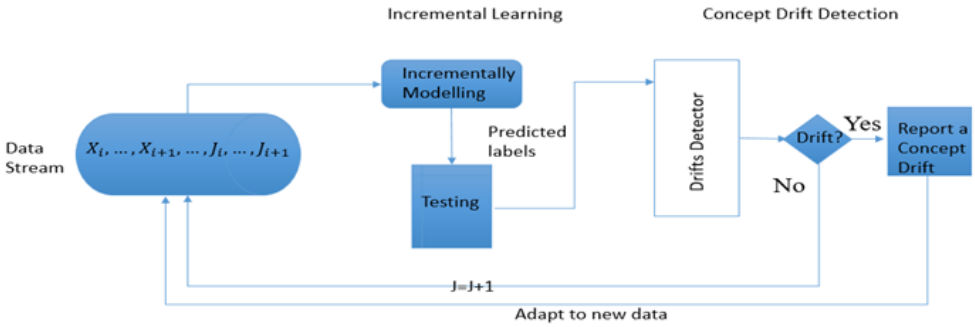


Fig 3: Incremental learning approach

The study examined two scenarios. In the first scenario, the models were trained using a large training set (January 2019 to December 2021 with a 15 minutes resolution) that included significant drifts (Figure 4), while in the second scenario, the models were trained (January 2019 to July 2020 with a 15 minutes resolution) prior to the occurrence of the drifts (Figure 5). Figure 4 shows an example of the actual net load curves versus the forecasts of the three models evaluated in the first scenario. Figure 5 compares the actual net load curves with the forecasts of the three models in the second scenario.

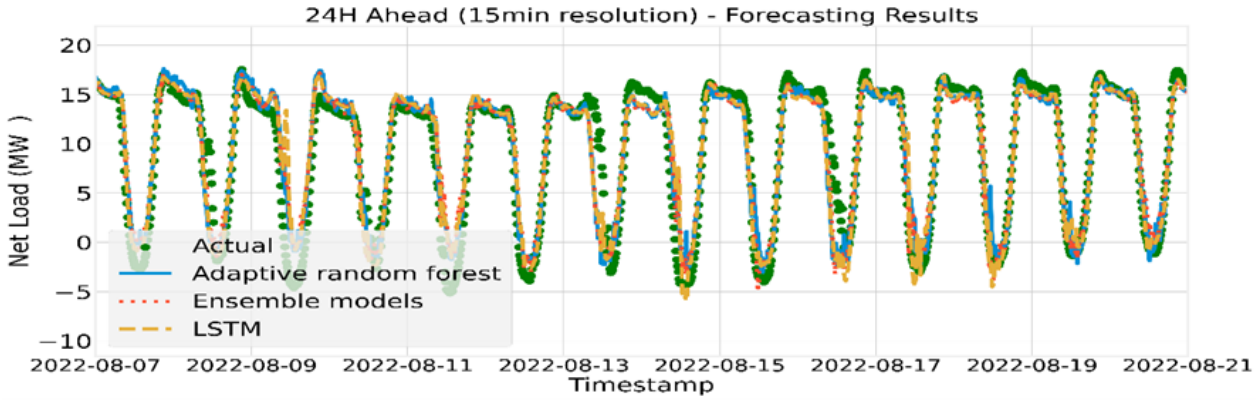


Fig 4: Forecasting results for scenario 1

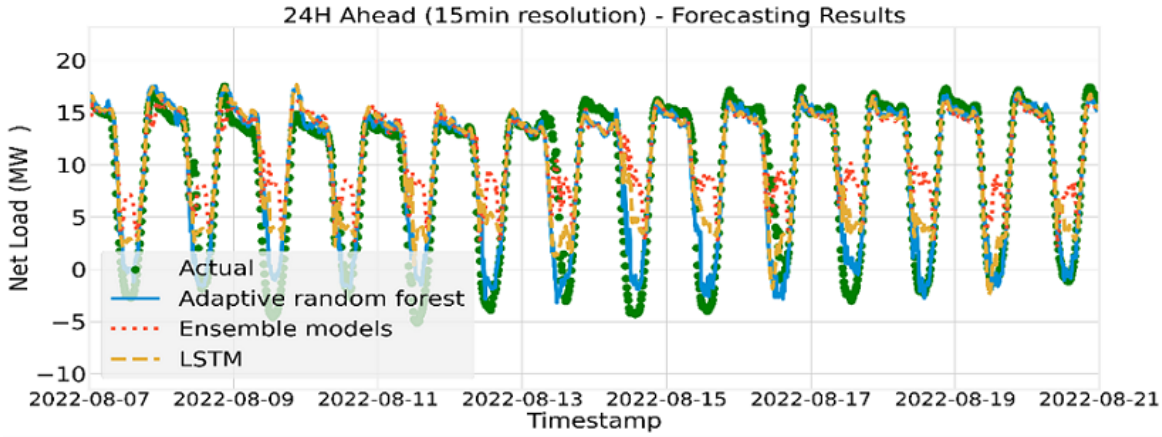


Fig 5: Forecasting results for scenario 2

The results highlight the impact of concept drift on the performance of the forecasting models. In both scenarios, the adaptive random forest proved to be the best performing method, demonstrating its ability to effectively manage changes in the data and maintain stable performance. LSTM also showed some resilience to concept drift, but to a lesser extent. The model ensemble showed the weakest performance, suggesting that combining several models without adaptation mechanisms may be less suitable for dealing with concept drift.

SHORT-CIRCUIT CURRENTS (SCC) INFORMATION EXCHANGE BETWEEN DSO AND TSO

In the field of electrical power system operation, short-circuit current (SCC) stands as a critical parameter to supervise for ensuring network safety. With the growing penetration of distributed energy resources (DERs), SCC monitoring has become increasingly crucial due to the dynamic and complex nature of DER contributions to fault currents. It is crucial to frequently and periodically monitor SCC, ideally every 24 hours and with high granularity (e.g., 30 minutes).

In the scope of ONENET project, R&D NESTER with the collaboration of the Portuguese TSO (REN) and DSO (E-REDES) developed a short-circuit computation methodology to calculate the complete short-circuit current in the TSO/DSO interface nodes (extra high voltage/high voltage (EHV/HV) substations).

The created methodology and information exchange procedures designed could be used for operational planning purposes, considering the active contributions to the SCC from both transmission and distribution networks.

A TSO-DSO coordination procedure is presented to obtain the day-ahead SCC forecast. In the end, it is possible to see the results obtained from one real case in order to demonstrate and validate the

proposed procedures.

Coordination between SOs is required since there is no way for the TSO to know about the assets connected to its interconnected DSO. Similarly, the DSO does not have the information needed to determine the short-circuit contribution from the transmission network. The main reasons for this coordination are:

i) Accurate dimensioning of substation equipment;

ii) Correct settings of substation and lines protection, automation and control systems;

iii) Equipment purchase/cost optimization.

In Portugal, the TSO (REN) uses 31.5 kA for HV circuit breakers, while the DSO (E-REDES) uses 25 kA rating for their circuit breakers. The TSO has only visibility of the contributions coming from the EHV/HV transformer upwards. The overall SCC value depends on the SCCs originating from the active contributions in the transmission and distribution networks, which are not readily available for DSOs and TSOs, respectively. In these cases, cooperation between the TSOs and neighbor DSOs is necessary to properly assess the SCC values and keep the substations, transformers and lines operating safely.

In order to both system operators (SOs) have access to a more accurate forecast of the expected SCC in the TSO/DSO interface (EHV/HV transformer) the information exchange procedures presented in Figure 1 were implemented. To allow the communication and exchange of data between both parties, a data exchange platform (DEP) was developed, one for the TSO (TDEP), another for the DSO (DDEP), which is a cloud system that serves as a gateway between the internal systems and tools of the TSO and DSO with other possible external entities. The SCC results are transferred in XML format, following the data model presented in Table 1.

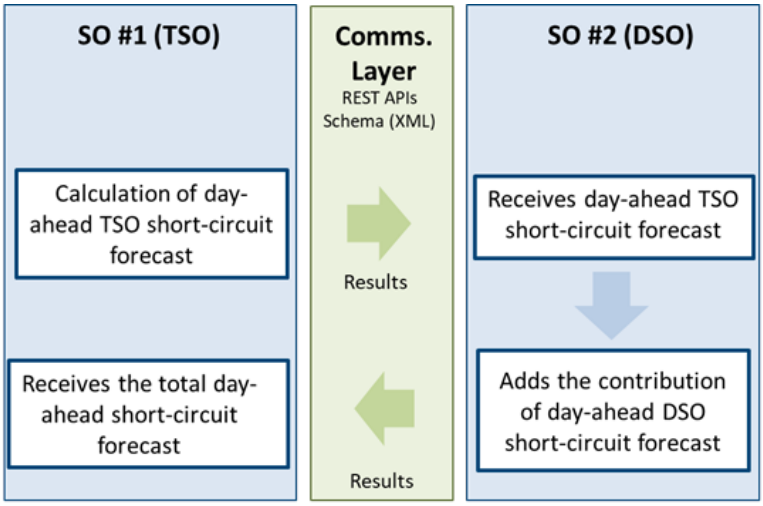


Figure 1 - SCC sequence diagram for information exchange between TSO and DSO

Field	Sub-field 1	Sub-field 2	Type	Description
Sender	-	-	(int) (**Required**)	0 -> DSO 1 -> TSO
Time of creation	-	-	(str date-time) (**Required**)	
Start time of data	-	-	(str date-time) (**Required**)	
End time of data	-	-	(string date-time) (**Required**)	
Start Time Array	Start time (of Forecast)	-	(str date-time) (**Required**)	
	Bus ID array	BusID	(string) (**Required**)	
		Contribution from EHV network (TSO)	(number float) (**Required**)	[kA]
		Contribution from HV network (TSO)	(number float) (**Required**)	[kA]
		Contribution from active HV network (DSO)	(number float) (**Required**)	[A]

Table 1 - SCC XML data model

To obtain the day-ahead SCC forecast in the interface, the TSO firstly computes the SCC only considering the contributions from its grid, calculated considering the expected generation profile from the wholesale market results. Then, these values are exchanged with the DSO to compute the final SCC value for each EHV/HV substation, by adding the contribution from the expected generation profile at the distribution level. The process finishes when both operators reach the final value, which include both SCC contributions in the TSO-DSO interface.

Next, the demonstration result from a real PT demonstration is presented. The automatic sequence-fault calculation method was used, focusing only on transient three-phase symmetrical short-circuit. The data exchanged has a timespan of 24 hours, a granularity of 30 minutes and is refreshed every 24 hours.

Figure 2 shows the SCC values on a certain day from November 2022 for a substation at the 60 kV TSO-DSO interface bus and the respective PDIRT (1) maximum SCC value. In 5 periods during the presented day, the total SCC surpasses the maximum value from PDIRT (at 10:00, 11:00, 12:00, 13:00 and 16:30). The maximum SCC occurs at 11:00, correspondent to 14.63 kA which is less than 1 % above the maximum value from PDIRT (14.5 kA). Nevertheless, this value is far from the short-circuit ratings of the TSO and DSO circuit breakers (31.5 kA and 25 kA, respectively).

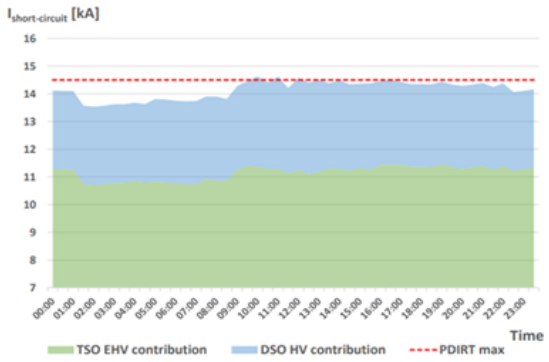


Figure 2- SCC results for a Portuguese EHV/HV substation

The DSO network's lowest contribution to short-circuit current (SCC), amounting to 20% or 2.83 kA, occurs at 23:30 during the off-peak period (22:30 to 04:30). This is attributed to the reduced demand and minimal solar power generation during off-peak hours. Conversely, the DSO's SCC contribution peaks at 13:00, reaching 22.96% or 3.33 kA, due to the increased solar generation during peak sun hours. The highest absolute value of the DSO's SCC, 3.34 kA, also occurs at noon. The computed SCC values remain significantly below the circuit breakers' ratings, indicating that the current TSO and DSO circuit breakers safeguard grid assets without the need for special operational measures to control SCC.

This analysis highlights the significance of incorporating DSO SCC contributions into TSO-DSO interface calculations. Neglecting the DSO's active contribution would lead to an underestimation of the maximum SCC forecast value. The presented coordination process for exchanging SCC contributions between system operators at the TSO-DSO interface enhances the reliability of total SCC values for operational planning. This enables operational teams to forecast day-ahead SCC values with greater accuracy, preventing unexpected SCC spikes at the TSO-DSO interface caused by unseen generation. While the combined SCC contributions remain within circuit breaker ratings, the surpassing of PDIRT maximum values underscores the importance of considering both contributions for asset planning purposes.

(1) *Plano de Desenvolvimento e Investimento da Rede Nacional de Transporte*

SEPARATION BETWEEN HARDWARE AND SOFTWARE IN SUBSTATION PROTECTION, AUTOMATION AND CONTROL (PAC) SYSTEMS

Nowadays, the functions executed by the protection, automation and control (PAC) system of electrical substations are executed by intelligent electronic devices (IEDs) installed in the substations.

These IEDs are sold by the manufacturers together with the respective software that implements the required functions. It is not possible to add ore software produced by the user or by any other company into an IED.

However, the IEC 61850 communication standard, that makes available interoperability between devices from different manufacturers, is changing this paradigm, opening the possibility to a separation between software and hardware.

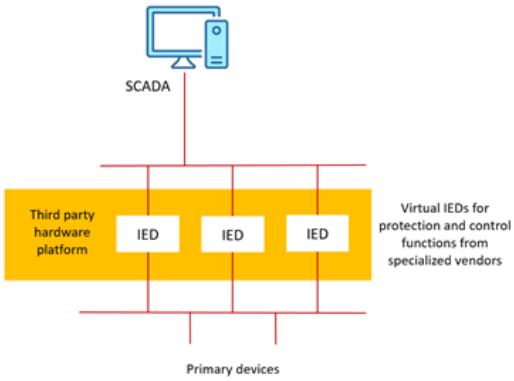
This issue was studied by the Working Group B5.60 of CIGRE (International Council on Large Electric Systems), which published the brochure 'Protection, Automation and Control Architectures with Functionality Independent of Hardware'.

In this document, several new architectures for the PAC system are proposed, considering hardware independent from software application for PAC functions, namely based on a Centralized Protection and Control (CPC) to provide the hardware independence.

In this solution, there is a centralized hardware platform by substation or by voltage level of the substation that contains virtual IEDs (software only) for all bays of the substation or voltage level. This software may be bought to different manufacturers or even be developed by the final user.

By separating hardware and software in the PAC system, the utilities will gain flexibility and take the most of the IEC 61850 standard.

The market is also moving in this direction, with some available solutions for the virtualization of IEDs.



To know more:

https://www.e-cigre.org/publications/detail/891-protection-automation-and-control-architectures-with-functionality-independent-of-hardware.html

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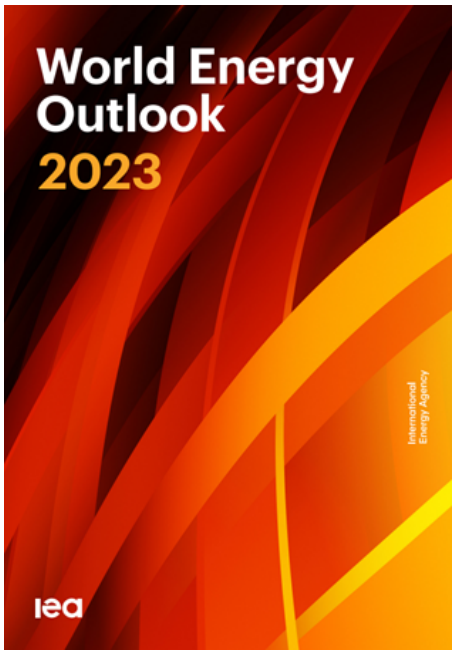
LITERATURE REVIEW

IEA - International Energy Agency - World Energy Outlook 2023 - Out/2023

The *World Energy Outlook 2023* provides in-depth analysis and strategic insights into every aspect of the global energy system. Against a backdrop of geopolitical tensions and fragile energy markets, this year's report explores how structural shifts in economies and in energy use are shifting the way that the world meets rising demand for energy.

This *Outlook* assesses the evolving nature of energy security fifty years after the foundation of the IEA. It also examines what needs to happen at the COP28 climate conference in Dubai to keep the door open for the 1.5 °C goal. And, as it does every year, the *Outlook* examines the implications of today's energy trends in key areas including investment, trade flows, electrification and energy access.

This flagship publication of the International Energy Agency is the energy world's most authoritative source of analysis and projections. Published each year since 1998, its objective data and dispassionate analysis provide critical insights into global energy supply and demand in different scenarios and the implications for energy security, climate change goals and economic development.



Link for Publication

IEA - International Energy Agency - Overcoming the Energy Trilemma: Secure and Inclusive Transitions - Dec/2023

Actions by governments in the Group of Seven (G7) can play a vital role in advancing inclusive, secure and sustainable energy transitions worldwide and addressing the climate crisis. In 2023, the International Energy Agency (IEA) was invited by G7 Leaders at the Hiroshima Summit to develop advice on how to address the triple challenges of energy security, climate change and rising geopolitical risks.

Building on the climate and energy outcomes of Japan's G7 Presidency in 2023, this IEA report responds to this mandate by setting out energy security and climate actions aligned with a pathway to limiting global warming to 1.5 °C.

Diversity is a key watchword: diverse energy sources and supplies, diverse clean energy supply chains, including manufacturing and critical minerals. This report offers guidance on the implementation of global commitments and outlines opportunities for building bridges between advanced and emerging economies across the G7, G20 and COP processes, notably on clean energy investment and finance.



Link for Publication

EVENTS

25 -30 Aug 2024

PARIS, FRANCE

CIGRÉ SESSION 2024

10 -12 Sep 2024

TORINO, ITALY

SEST 2024 - 7TH INTERNATIONAL CONFERENCE ON SMART ENERGY SYSTEMS AND TECHNOLOGIES

21 -22 Sep 2024

BRUSSELS, BELGIUM

FLEXCON 2024

8 -11 Oct 2024

HELSINKI, FINLAND

23RD WIND & SOLAR INTEGRATION WORKSHOP

14 -17 Oct 2024

DUBROVNIK, CROATIA

ISGT EUROPE 2024

3 -6 Nov 2024

ATHENS, GREECE

MED POWER 2024 - 14TH MEDITERRANEAN CONFERENCE ON POWER GENERATION TRANSMISSION, DISTRIBUTION AND ENERGY CONVERSION

14 -15 Oct 2024

LISBON, PORTUGAL

CHARGE - POWERING ENERGY BRANDS - CONFERENCE & AWARDS

QUIZ

1) WHICH EUROPEAN COUNTRY IS THE LARGEST NET EXPORTER OF ELECTRICITY?

- A) Sweden
- B) France
- C) Spain
- D) Norway

2) WHAT IS THE MAIN COMPONENT OF ELECTRICITY GENERATION IN EUROPE AS OF 2022?

- A) Nuclear power
- B) Coal
- C) Wind energy
- D) Natural gas

3) IN WHICH YEAR DID PORTUGAL FIRST ACHIEVED 100% RENEWABLE ENERGY CONSUMPTION FOR A PERIOD OF 107 HOURS (FOUR CONSECUTIVE DAYS)?

- A) 2015
- B) 2016
- C) 2019
- D) 2021

4) WHAT IS THE ROLE OF THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS (ACER)?

- A) Enforcing energy conservation measures
- B) Regulating electricity prices
- C) Promoting renewable energy projects
- D) Enhancing cooperation between national energy regulators

5) IN WHICH YEAR DID PORTUGAL OFFICIALLY END COAL-FIRED POWER GENERATION?

- A) 2018
- B) 2020
- C) 2021
- D) 2023

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

1. Answer: A) Sweden
2. Answer: A) Nuclear power
3. Answer: B) 2016
4. Answer: D) Enhancing cooperation between national energy regulators
5. Answer: C) 2021

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

Europe

- European Network of Transmission System Operators for Electricity (ENTSO-E)
- The European Wind Energy Association (EWEA)

ON RESEARCH, DEVELOPMENT AND INNOVATION

Portugal

- Portugal 2020
- Portal da Inovação
- Agência Nacional de Inovação (ANI)
- COTEC Portugal
- Portugal in Europe Research and Innovation Network (PERIN)
- Agência para o Desenvolvimento e Coesão (AdC)
- Direção-Geral de Estatísticas da Educação e Ciência (DGEEC)

Europe

- BRIDGE (H2020)
- European Energy Research Alliance (EERA)

- The Alliance for the Internet of Things Innovation (AIOTI)
- JRC Publications - Joint Research Centre - Smart Electricity and Interoperability
- The European Commission's Priorities
- A Europe fit for the digital age | 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

Rest of World

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

- 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

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

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