R&D NESTER

13 NL set 2018

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EDITORIAL

Dear Reader,

How will energy markets change as we increase the amount of low marginal cost generators in the system? How can digitalization impact the energy networks? How can we quickly evaluate if rapidly developing technological solutions are mature for deployment? How can the networks and system operation be more flexible to adapt to the strong swings in supply and demand that can occur for different reasons? In the edition of our Newsletter we provide an overview of the work R&D Nester is performing in order to contribute to address those and other questions which are making the energy industry landscape one of the most dynamic today.

The way markets are designed to allow new forms and procedures for bids can influence the market dynamics, the players participation, hence liquidity, and market outcomes.

The integration of digital solutions in the network elements and network systems contribute to a more flexible, more efficient and more effective way for the network operators to manage and operate the energy networks.

Designing a network and system operation that can accommodate the flexibility needed to cope with the supply and demand variations resulting from time varying energy sources and from changing consumer behaviors requires the careful consideration of multiple new ingredients in the energy system such as storage or demand side management.

Developing and introducing into the power system ICT tools that can efficiently manage all this novel ingredients and coordinating them among the different market participants and responsible parties, namely TSOs and DSOs, requires researching multiple scenarios, alternatives and applying them to relevant use cases.

Wholesale and retail markets, values chain organization and coordination and corresponding regulations all have to be in line with these developments in order to continue guaranteeing a smooth evolution of the energy system.

We are sure that all these endeavors will contribute to a more informed decision making from the multiple agents in the industry and to a more sustainable, efficient and secure modern energy system.

Enjoy your reading!

Sincerely,

Nuno de Souza e Silva

Managing Director

HIGHLIGHTS

R&D NESTER PRESENTS “MARKET-BASED BIDDING STRATEGY FOR VARIABLE RENEWABLE GENERATION IN THE MIBEL” AT EUROPEAN ENERGY MARKETS 2018

The EEM18 - 15th International Conference on the European Energy Market was held from 27 to 29 June in Poland.

The EEM is a European Energy Market related topics conference with a long tradition starting in 2004. It started in Poland and was present in different countries along the years, including Portugal in 2008. The conference is an excellent opportunity to present researches, share ideas and discuss European market operation, its development and main challenges.



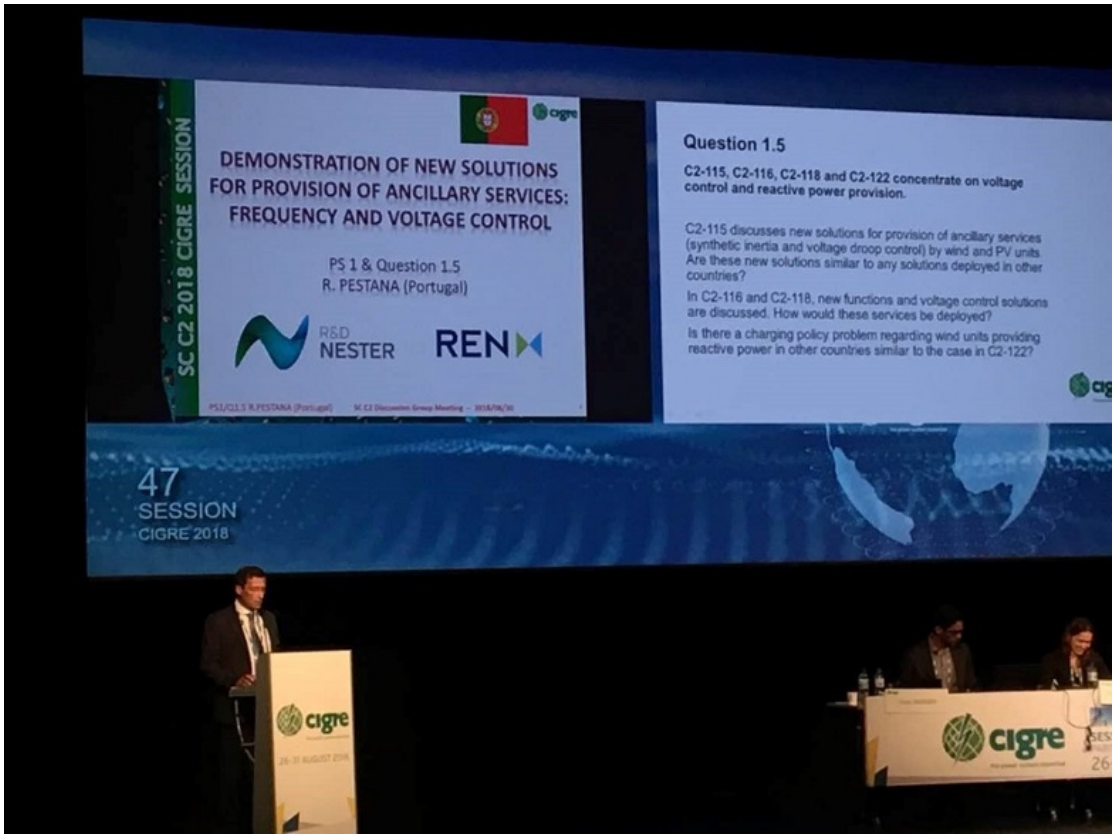
Each year several important players from the industry make presentations in the key-note speeches. This time, the conference counted with the presence of the director of the Florence School of Regulation, the Strategy Department Director of Lithuanian electricity transmission system operator (LITGRID), representatives of ABB and several professors from Poland Universities. Topics such EC rules of the winter package, the new European electricity market projects as XBID or MARI, the integration of the Baltic states in the Continental Europe synchronous area and HVDC connection equipment's were addressed.

João Esteves, researcher at R&D Nester, presented the paper entitled "Market-based bidding strategy for variable renewable generation in the MIBEL", in the scope of "Renewable Integration Tools" project undertake by R&D Nester.

This work proposes a methodology for the assessment of the economic viability of wind and solar photovoltaic electricity generation participating in the Iberian Electricity Market (MIBEL) in equal terms with the remaining generators. This methodology is important in the point of view of a wind or solar power plant owner in order to: 1) Understand what kind of revenues it can be expected having no feed-in-tariffs and, 2) Elaborate on the bid strategy to make in the market in order to maximize the revenues.

More information at: http://www.eem18.eu/

R&D NESTER AT THE BI-ANNUAL CIGRÉ MEETING



R&D Nester (the energy research center from the Portuguese TSO REN and SGCC) will be presenting its work at the bi-annual CIGRÉ meeting 26-31 august 2018.

With mainly TSOs, utilities and DSOs, international influential decision makers and technology experts as its regular attendees, 3000+ international delegates and 8000+ participants from 93 countries, CIGRÉ is the international leading event for the Power Systems Industry.

R&D Nester succeeded to submit 3 publications to the exclusive list of accepted papers for the technical sessions, aiming at contributing to a more robust, sustainable and efficient power system.

Below is a short description of the work being presented, which results from the cooperation between R&D Nester, REN and CEPRI experts.

1)Demonstration of new solutions for provision of ancillary services: Frequency and Voltage control

Study Committee C2 - Power System Operation and Control

With the increasing penetration of wind and solar photovoltaic, the system operator may not rely on the remaining synchronous generators to guarantee the frequency and voltage control. These renewable sources of energy must take part in the frequency and voltage control in order to contribute to the electricity grid safety. In the scope of the project "Renewable Dispatch Tool", R&D Nester researched this topic leading to real frequency and voltage tests, on site and in factory environment. The goal of this paper is to show the tests results for wind and PV technology regarding frequency and voltage control tests. Regarding the frequency control tests, frequency-droop-control and inertia emulation tests were conducted for wind and two tests for solar (including the simulation of a real frequency incident in the European electricity grid). The simulation of the feature f-return was also addressed. In the voltage control tests, a test with a real wind farm was performed and a simulation test in factory environment was done for solar. The conclusions are that wind and solar can comply with the "voltage-droop-control" system service; they can also comply with the primary frequency control for over-frequency, by limiting the output power. For under-frequency control, only wind has demonstrated the capability to provide synthetic inertia. For solar PV, local storage might be required to fulfil this requirement. These new solutions will also require a new market design in which the system will have to pay for all system services.

2)The impact of shorter intraday market gate closure on regulation reserves

Study Committee C5 - Electricity Markets and Regulation

This work quantifies the variation of regulation reserve requirements by reducing the time span between gate closure of intraday markets and physical power delivery in Portugal. Intraday markets and regulation reserves are means of readjust the grid balancing against deviations from the day-ahead market schedule. While the first works ex-ante to the physical power delivery, the second is a real-time mechanism used by the System Operator to secure the energy supply and avoid the curtailment of wind and solar power generation.

The work reviews the new intraday market design in connection with the system services' market. Quantitative analysis identifies a significant increase in the activation of regulation reserves for real-time technical restrictions relief when the physical delivery is more than 7 hours away from the end of the intraday negotiation. This happens in two of the sessions of the intraday market. With the integration of the European continuous market model in the MIBEL intraday market design, it is expected these sessions will lose their weight in the system management.

3)Laboratorial assessment and scalability analysis of protection and automation functions supported by a smart substation process bus network

Study Committee B5 - Protection and Automation

As the IEC 61850 standard is increasingly being adopted as the communication and configuration standard by IED manufacturers, utilities are deploying more Process Bus networks in their substations. Despite all the advantages broadly analyzed in literature, these networks shall be carefully designed, in order to get the maximum benefit without compromising the current levels of reliability, dependability and security of Protection, Automation and Control (PAC) systems.

This paper presents a laboratorial assessment of a Process Bus network architecture suitable to be applied in transmission size substations. A testbed with physical, simulated and virtual IEDs and real-time simulation of Portuguese transmission system was used, where one Portuguese transmission substation was simulated and interacted with real IEDs installed in the testbed through hardware-in-the-loop (HIL) simulation.

For more information please see www.rdnester.com and http://www.cigre.org/Events/Session/Session-2018.

R&D NESTER PRESENTS WIND AND SOLAR FORECAST IN PORTUGAL AT THE 2018 ESIG FORECASTING WORKSHOP

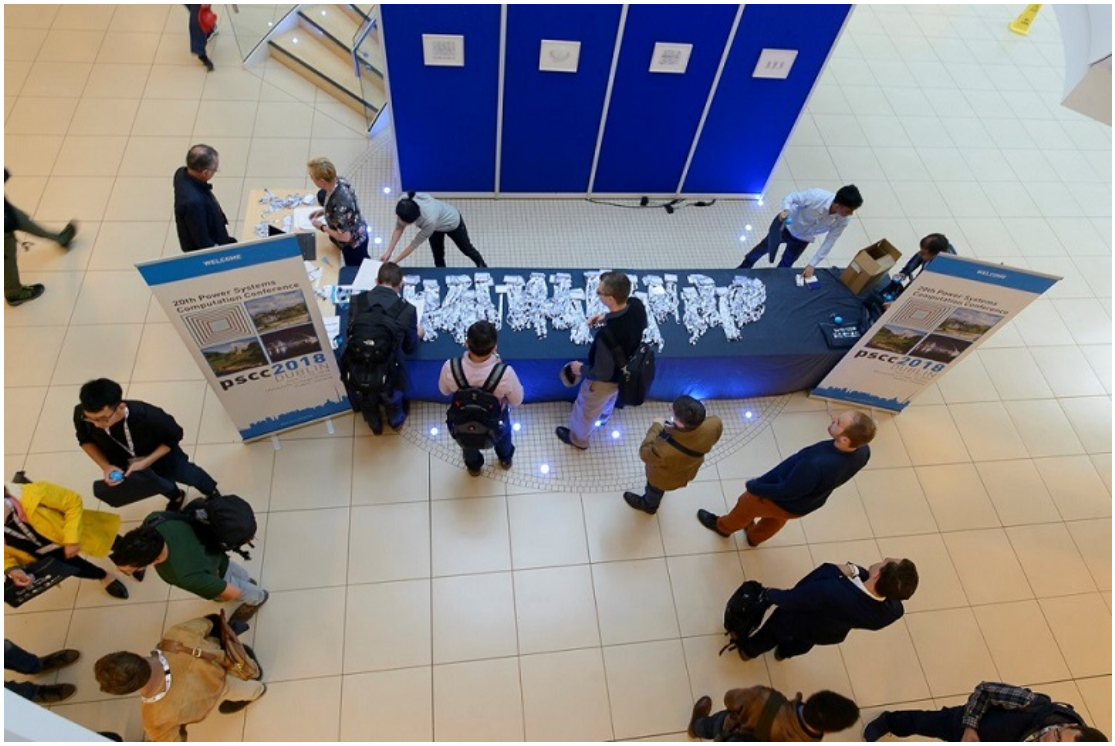
R&D Nester was present at the 2018 ESIG (Energy Systems Integration Group) Forecasting Workshop, held last June in St Paul, Minnesota.

The three-day event brought together experts from North America, Europe, and around the world to explore the state-of-the-art in wind, solar and distributed generation forecasting and meteorology application to electric power system planning and operations.

The presentation by R&D Nester was on Wind and Solar Forecasting in Portugal - Status and Prospects.

More information at: https://www.esig.energy/event/2018-forecasting-workshop/

R&D NESTER PRESENTS 'CO-SIMULATION FOR THE EVALUATION OF IEC 61850 BASED PROTECTION SCHEMES' AT POWER SYSTEMS COMPUTATION CONFERENCE 2018



The 20th session of the PSCC2018 - Power Systems Computation Conference was held in Dublin, last June.

The Power Systems Computation Conference (PSCC) has become one of the most outstanding events in the area. With a change of pace from meeting every 3 years to every 2, PSCC provides a truly international forum for the regular exchange of knowledge and experience on the latest developments in this area.

PSCC addresses theoretical developments and computational aspects with respect to power system applications from micro-grids to mega-grids. There is an emphasis on modelling and simulation for understanding a system of components, plant or actors, the interactions between them and their collective behavior, and methods to inform decision-making in power systems. Contributions might comment on the analytical techniques, modelling challenges and complex software engineering issues, or what the analyses say in respect of today's and the future's power system challenges. Thus, papers from utility and manufacturing industry engineers are just as welcome as those from academic researchers.

Researcher André Santos represented R&D Nester presenting ‘Co-Simulation for the Evaluation of IEC 61850 based Protection Schemes', in the scope of "Smart Substation Testing and Implementation" project undertaken by R&D Nester.

The work is expected to contribute greatly to capture the benefits of the digitalization of the power systems, namely by developing more efficient network solutions than the network operators can benefit from.

More information at: http://www.pscc2018.net/

R&D NESTER PRESENTS WEBINAR ON “NEW HIL TRENDS IN PROTECTION SYSTEMS”



R&D Nester attended the "New HIL (hardware in the loop) Trends in Protection Systems" webinar, promoted by OPAL-RT, which took place on 7 June.

Representing the Centre for Energy Research and Development of REN and State Grid was R&D Nester's researcher and REN's employee, Ricardo Cartaxo, who shared his experience in real-time simulation with the "HIL testing of Protection, Automation and Control (PAC) systems" presentation. The presentation sought to illustrate the advantages of using a Real-Time Power System Simulator (RTPSS) to test a PAC system. An RTPSS is designed to simulate a power system, enabling the execution of tests in closed loop (HIL).

In this test, the RTPSS can be used to simulate faults (short circuits) in the power grid, in order to evaluate the PAC system's performance. With the simulator's resources, it is also possible to automate tests using the TestView, enabling the convergence analysis of the test's results.

At the meeting, where awareness was raised to the trends in HIL simulation and testing in Protection Systems, there were presentations and live demos, seeking to show how these technologies can help companies reduce risks, costs and the total time required to identify faults in the power grid, enabling testing of complex protection systems and more efficient monitoring.

R&D NESTER PUBLISHES PAPER ON DIGITALIZATION OF THE ENERGY SYSTEM IN IEEE JOURNAL



In the context of the work performed in Substation of the Future project, R&D Nester submitted the paper entitled "Characterization of Substation Process Bus network delays" to "IEEE Transactions on Industrial Informatics" journal in 2017. This paper has just been published in the last issue of this journal, corresponding to May 2018 (volume 14, issue 5).

The concepts of SmartGrids and digitalization of the energy system are extremely timely.

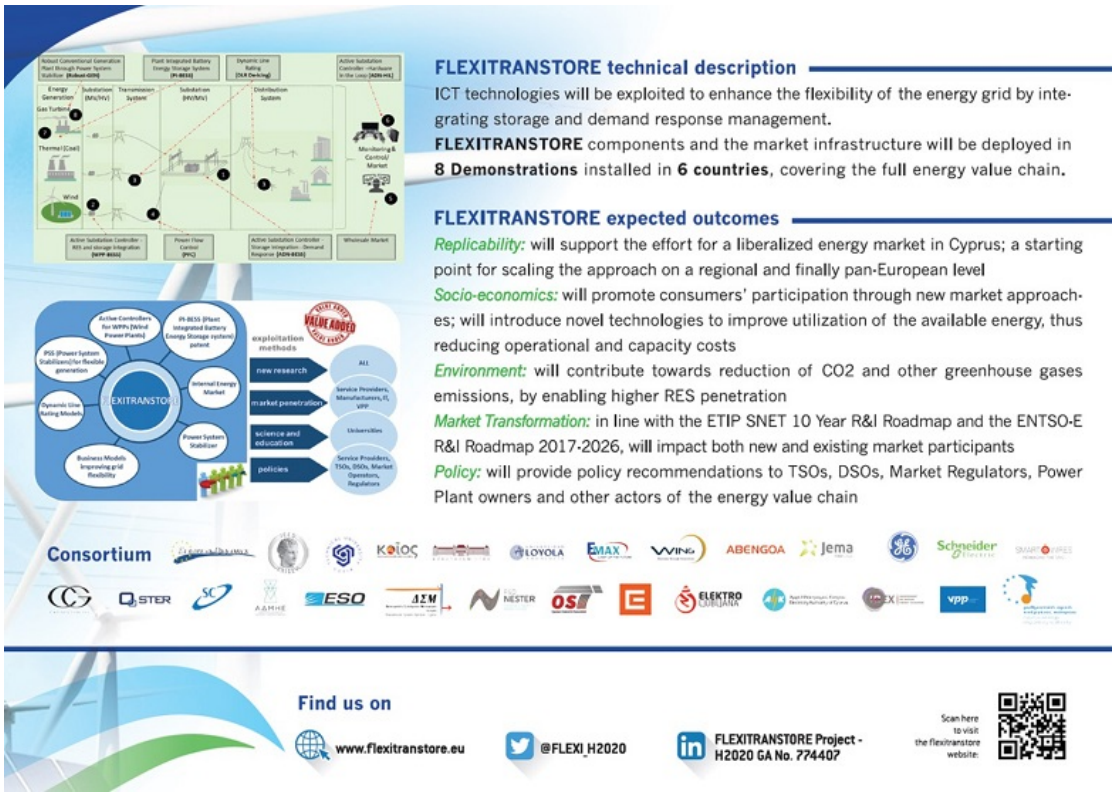
R&D Nester have been working on these topics, in particular in what concerns digitalization of substations and the design of more efficient substations.

The paper presents a study of characterization of network delays in an IEC 61850 process bus substation area network expected to exist in the future digital transmission substations. This network delays study was carried out both through theoretical analysis and simulations, considering the predicted traffic in the future process bus communication networks. Since crucial information for correct operation of protection, automation and control functions flows in these networks, they have high performance requirements, justifying the importance of these kind of studies.

The paper can be seen in IEEE Xplore digital library.

The "IEEE Transactions on Industrial Informatics" journal has high reputation in scientific community, having an Impact Factor of 6.764. It is placed in the top 20 ranking of the journals related to Computer Science & Electronics with highest Impact Factor.

R&D NESTER CONTRIBUTS TO INTRODUCE FLEXIBILITY IN THE EU POWER SYSTEM WITH THE H2020 FLEXITRANSTORE PROJECT



R&D Nester continues its contributions to H2020 FLEXITRANSTORE project on "An Integrated Platform for Increased FLEXIbility in smart TRANSmission grids with STORage Entities and large penetration of Renewable Energy Sources".

FLEXITRANSTORE project aims at developing a next generation of Flexible Energy Grid (FEG), which provides the technical basis to support the valorisation of flexibility services, enhancing the existing European Internal Energy Market (IEM). This FEG addresses the capability of a power system to maintain continuous service in the face of rapid and large swings in supply or demand, whatever the cause. Thus, a wholesale market infrastructure and new business models within this integrated FEG should be upgraded to network players, incentivize new ones to join, while demonstrating new business perspectives for cross border resources management and energy trading.

The strategic objectives of FLEXITRANSTORE are: to enhance and accelerate the integration of renewables into European energy systems and to increase cross border electricity flows across Europe. Flexibility is one of the keys to meeting these strategic objectives.

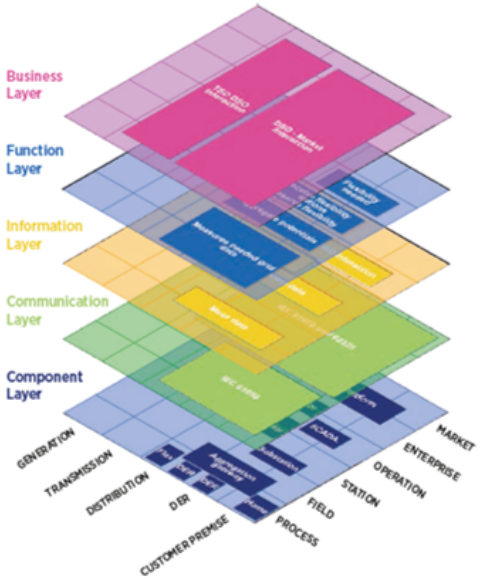
Follow the latest development in https://lnkd.in/dwuXdpR

R&D NESTER CONTRIBUTS TO TSO-DSO EFFICIENT INTEROPERABILITY WITH THE H2020 TDX-ASSIST PROJECT



This three year project started on the 1st October 2017 and aims to design and develop novel Information and Communication Technology (ICT) tools and techniques that facilitate scalable and secure information systems and data exchange between **Transmission System Operators (TSOs)** and **Distribution System Operators (DSOs)**.

The three novel aspects of ICT tools and techniques to be developed in TDX-ASSIST are: **scalability** – ability to deal with new users and increasingly larger volumes of information and data; **security** – protection against external threats and attacks; and **interoperability** – information exchange and communications based on existing and emerging international smart grid ICT standards. The Figure below depicts the scope of the project from the perspective of the **Smart Grid Architecture Model (SGAM)**.



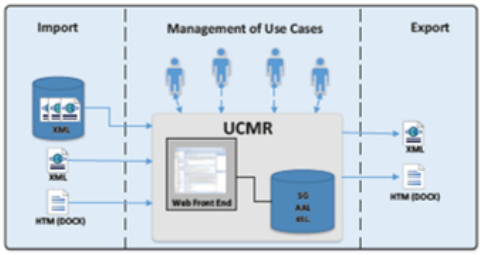
The project focuses on enhanced TSO-DSO interoperability. In this context, TDX-ASSIST will also consider DSO interaction with other market-participants (DSOs, Aggregators, Distributed Energy Resource Operators, Micro-grid Operators) and information or data access portals that enable business processes involving relevant actors in the electrical power sector.

Beyond state-of-the-art progress will be achieved as follows:

- Fully defined interface specifications for TSO-DSO information exchange interfaces based on Use Case analysis and IEC 61970/61968/62325 standards to support highly automated information exchange and network analysis.
- Fully defined interface specifications for information exchange between DSOs and market participants based on Use Case analysis and IEC 61850 and IEC 62325 standards to support highly automated information exchanges.
- Role-based access control that securely accommodates new data requirements and unbundling processes.
- A specified suite of ICT protocols and integration with the defined interfaces.
- Proof of Concept using field tests and demonstration with industry specification at both TSO and DSO levels.

This project addresses the further research and development needed to ensure that greater levels of TSO-DSO interoperability can be realized, and to also harmonise a wider range of standardisation activities that are presently underway or complete. Assessment of the final project activity will be used to quantify how scalability, security and interoperability combine to improve real power sector ICT processes. Targeted TRLs as specified in the project proposal will be linked to quantitative improvements in the sector's performance.

The planned Use Case Management Repository that will be used across project work packages is presented in the following figure:



R&D Nester continues its contributions to H2020 TDX_ASSIST project on "Coordination of Transmission and Distribution data eXchanges for renewables integration in the European marketplace through Advanced, Scalable and Secure ICT Systems and Tools (TDX-ASSIST)"

This project aims to design and develop novel Information and Communication Technology (ICT) tools and techniques that facilitate scalable and secure information systems and data exchange between Transmission System Operator (TSO) and Distribution System Operator (DSO).

The three novel aspects of ICT tools and techniques to be developed in the project are: scalability - ability to deal with new users and increasingly larger volumes of information and data; security - protection against external threats and attacks; and interoperability - information exchange and communications based on existing and emerging international smart grid ICT standards.

Check the 2-page 6-months brochure detailing the developments of the project: https://lnkd.in/g5mfSJd

TECHNICAL INFORMATION

R&D NESTER PROJECT GATHER INDUSTRY PARTNERS



R&D Nester laboratory, where testing platform was stablished

One of R&D Nester research areas is Smart Grids, that is, the digitization of the energy system, where ICT technologies play an increasingly important role. In the case of transmission and distribution substations, this digitization focuses on the so-called PAC system, that is, the protection, automation and control of the substation.

The current project ‘Smart Substation Testing and Implementation' is the continuation of the ‘Substation of the Future' project. The aim of both projects was to develop an architecture for a new generation of PAC systems, taking advantage of the increasing processing and integration capability of the electronic devices.

Another driver for these projects was the IEC 61850 international standard, which main goal is the interoperability between devices. This means that, contrary to what happen in the past, a PAC may include devices, such as protection relays, control units and SCADA systems, from different manufacturers.

Since the testing of interoperability was defined as one of the main issues of the project, it was decided to stablish a testing platform encompassing devices from a diverse range of manufacturers. Having this in mind, several manufacturers have been invited to participate, by means of partnerships, since the benefits are mutual. On one side, R&D Nester will have the devices (IEDs, intelligent electronic devices) to execute the tests and, on the other hand, the manufacturers will profit from the results of the testing, with the possibility to improve their products.

Currently, a testing platform corresponding to the PAC system of an existing and operational switching station of the Portuguese transmission grid is being configured. First, it will be tested at the laboratory, and then it will be placed at the mentioned station, to be compared with the existing PAC system.

This platform includes all devices that are expected to exist in a future substation. At the process level, that is, near to the switchgear, there are merging units, circuit breaker controllers and intelligent units for disconnector switches. At bay level (inside the relay houses) there are main units (for protection and control). These IEDs are from different manufacturers, namely SIEMENS, EFACEC, ABB, GE/ALSTOM and NARI, in order to assess interoperability issues.

At station (central) level, there is the local SCADA/HMI, provided by COPA-DATA and the gateway, also acting as HMI, from EFACEC. These devices have two innovative features in this project. First, the topological interlocking, that is, the authorization for the circuit breakers and disconnectors to operate, are accomplished via rules and not equations, as before. This means that no equations have to be developed for a new substation topology, just reconfiguration.

The other feature is the redundancy for servers (IEDs) with different data structure, allowing the use of, for instance, main units from two vendors, with no impact on the operation from the local and remote SCADA.

Finally, there is the remote SCADA (EFACEC) that communicates with the substation gateway via IEC 61850, contrary to the traditional T104.

The cooperation with industry partners allows an efficient and realistic approach towards the development of the future of power grids.

SOLAR ECLIPSE AND THE IMPACT IN SOLAR POWER

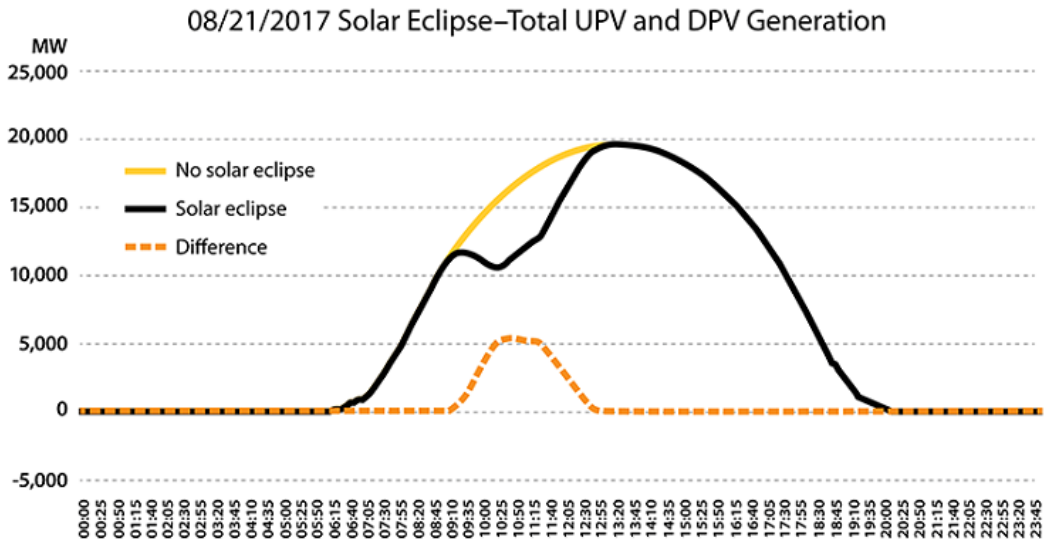
The solar eclipse phenomenon affects the amount of solar radiaton that reaches the solar panels, involving them in a cloudy similar effect. It cretes a shadow that highly affects the solar power output of the solar power plants.

As the solar power installed capacity increases, the impact on the operation of the power system also increases and must be taken into consideration. An example of this effect was verified in 2015 during the total solar eclipse (March 20), the eclipse started at 8:01 a.m. UTC in

the western part of Portugal and ended at 11:58 a.m. UTC in the eastern part of Romania[1].

In order to overcome and mitigate possible problems caused by the effect of the solar eclipse, a pre-event study should be conducted. Thus, before the 2015 total solar eclipse, the European Network of Transmission System Operators for Electricity (ENTSO-E) community produced an analysis to assess the operational impacts from the 2015 total solar eclipse and developed a plan to mitigate these impacts[2]. Some of the mitigation countermeasures were regarding the limitation of the power exchange between contries and the reliance on day-ahead solar power forecasts. Some Transmission System Operators (TSO) also increased the amount of primary, secondary, and tertiary control reserves.

Recently, on August 2017 another total solar eclipse occour. This one mainly affected the United States of America. In Portugal the solar eclipse started at 07:46 p.m, which had a small impact on solar power. In FIGURE 1 one can see the effect across Western Electric Coordinating Council (WECC), showing the significant impact (5,5 GW difference) of the solar eclipse in the solar power production, both at utility level (UPV) and distribution level (DPV).



As can be seen in FIGURE 1, the impact of the solar eclipse is considerable and can have impact on the power system if is not expected and if measures to mitigate it were not previoulsy taken. To understand the level of impact of the solar eclipse, this phenomenon should be included in the solar power forecast algorithms. In this way, is possible to estimate the level of impact in the solar power during the event. This is relevant for day-ahead forecasts closer to the event but also for lon term forecasts.

Regarding Portugal mainland region, in 2015 the total solar eclipse had a 66.95% coverage of Sun while in 2017, the total solar eclipse only had a 18.62% coverage of Sun[3] . The next total solar eclipse will occour in June 2021 with a Sun coverage of abou 7%. The next big total solar eclipse is going to occur in August 2026 with an impressive Sun coverage of about 95%.

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[1]National Renewable Energy Laboratory (NREL), "Solar Eclipse Report, Evaluating the Impact of the 2017 Solar Eclipse on U.S. Western Interconnection Operations", April 2018

[2]ENTSO-E, Regional Group Continental Europe and Synchronous Area Great Britain, "Solar Eclipse 2015 - Impact Analysis", 19 February 2015

[3]**Information available online at:** https://www.timeanddate.com/eclipse/

ENERGY STORAGE SYSTEMS AND ISOLATED POWER SYSTEMS

With the growth in energy demand that has occurred in the last decades accompanied by the increasing of renewable energy penetration and decentralized generation, the biggest challenge to the electrical networks is to meet this development in a safe, economical and sustainable way.

For the special case of isolated power systems, for instance islands, is often interesting to invest in renewables energies because of the typical great potential of solar and wind resources. The increasing introduction of renewables in the network, and especially in isolated networks, creates operational challenges in these grids. The safe and stable operation of electrical systems is influenced, in the island networks, by the reduced inertia proper of those systems due to the reduced number of conventional synchronous machines in service and consequent shortage of spinning reserve. These characteristics, together with the lack of interconnections, limit the assistance in the primary frequency regulation. Additionally, the stochastic and unstable nature of renewable production due to the variability of renewable sources such as wind speed or solar irradiance decrease the power quality. Also, the renewable facilities don't contribute to the total inertia of the system.

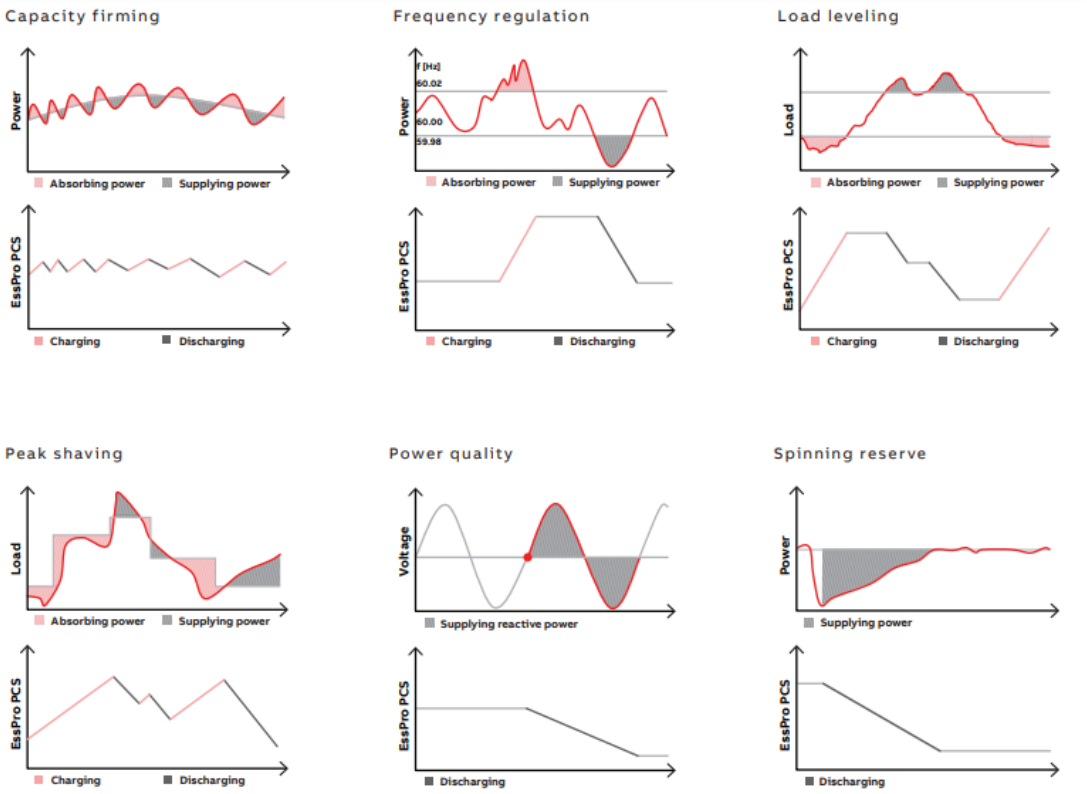
With this paradigm shift, the Energy Storage Systems (ESSs) are currently facing great developments in technical and commercial point of view. The benefits of energy storage systems are clear in terms of increasing the renewable penetration and by mitigating the operational problems that arise from it, mostly exploiting the capabilities of power electronics. In this context of the isolated power systems, different ESSs can be implemented, supporting the operation stability in terms of frequency or voltage control, increasing in this way the quality of service.

There is a wide range of different ESSs that are suitable for different applications based on their technical characteristics. Three of the main applications of energy storage utilities are power quality, regulation and time/load shifting services, and according to the desired role in power management strategy, the adequate ESSs should be chosen. For improving the power quality in weak grids with a high penetration of renewables, where the occurrence of spikes, voltages dips and harmonic signals in bus voltages and load currents arise frequently, an ESSs with a fast response ratio and high energy density like a flywheel or a battery should be used. The same kind of ESSs is suitable for regulation services, as frequency support to deal with the imbalance between generation and consumption, where a significant amount of energy is needed in a short period, for example.

For energy management services (time/load shifting), a different type of ESSs is advisable. In this kind of services, the main purpose is to

manage the energy that is produced from the renewable power plants, store it and use it when it is more beneficial in a technical and economic perspective. For example, is useful to shift the non-peak renewable production to the peak utility demand period, by storing the energy in an ESS. For this applications, the EESs should be a long-term storage and scalable to have more capacity power, as a pump hydroelectric storage or a battery.

In the figure below, it is possible to check the operation of an ESS in diverse services from primary frequency regulation to spinning reserve.



As presented, the ESSs are capable to provide several services and they will become increasingly more usual and important in the electricity networks, mainly for the less robust as the isolated power systems where they could be a fundamental asset in the stable, efficient and economic operation of the grid.

EVENTS

24 -28 Sep 2018

BRUSSELS, BELGIUM

EU PVSEC 2018

25 -27 Sep 2018

LONDON, UK

GRID ANALYTICS EUROPE 2018

10 -12 Oct 2018

LIMASSOL, CYPRUS

EUROMED MARITIME, OIL & GAS, 2018

16 -18 Oct 2018

BERLIN, GERMANY

IEC61850 GLOBAL 2018

17 -19 Oct 2018

STOCKHOLM,SWEDEN

17TH WIND INTEGRATION WORKSHOP

6 -8 Nov 2018

VIENNA, AUSTRIA

EUROPEAN UTILITY WEEK

28 -30 Nov 2018

AMSTERDAM, NETHERLANDS

EUROPEAN POWER STRATEGY & SYSTEMS SUMMIT & POWER PROJECT FINANCING AND NEW TECHNOLOGIES FORUM

19 -20 Mar 2019

TUCSON, ARIZONA

2019 SPRING INDUSTRY CONFERENCE

LINKS

Some useful links:
ON RESEARCH, DEVELOPMENT AND INNOVATION

Portugal:

- Portugal 2020
- Programa Operacional Competitividade e Internacionalização (COMPETE 2020)
- Agência Nacional de Inovação
- COTEC Portugal

Europe:

- Energy Research Center of the Netherlands (ECN)
- European Energy Research Alliance (EERA)
- Horizon 2020
- Nordic Energy Research
- JRC Publications - Joint Research Centre - Smart Electricity and Interoperability
- ETIP SNET - European Technology and Innovation Platform Smart Networks for Energy Transition

Rest of the World:

- American Energy Innovation Council (AEIC)
- China Electric Power Research Institute (CEPRI)
- Electric power research institute (EPRI)

OTHER ORGANIZATIONS

Portugal:

- Laboratório Nacional de Energia e Geologia (LNEG)
- Polo de Competitividade e Tecnologia da Energia (EnergyIn)
- Associação de Energias Renováveis (APREN)

Europe:

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

Rest of the World:

- CIGRE - International Council on Large Electric Systems

QUIZ

1) WHAT IS THE TOTAL INSTALLED ENERGY STORAGE BASE IN EUROPE (EXCLUDING PUMP HYDRO)?

- ○ a. 500 MW
- ○ b. 1,6 GWh
- ○ c. 3,2 GWh
- ○ d. 5 GWh

2) WHAT WAS THE AVERAGE DAILY MARKET PRICE (EUR/MWH) OF ELECTRICITY IN PORTUGAL (MIBEL PT) IN 2016?

- ○ a. 39,4
- ○ b. 41,9
- ○ c. 50,4
- ○ d. 52,5

3) WHAT WAS THE AVERAGE DAILY MARKET PRICE (EUR/MWH) OF ELECTRICITY IN PORTUGAL (MIBEL PT) IN 2017?

- ○ a. 39,4
- ○ b. 41,9
- ○ c. 50,4
- ○ d. 52,5

4) HIGH SPEED FLYWHEELS CAN SPIN UP TO:

- ○ a. 25,000 rpm
- ○ b. 12,000 rpm
- ○ c. 38,000 rpm
- ○ d. 60,000 rpm

5) BY THE END OF 2017, THE RENEWABLE'S TOTAL INSTALLED CAPACITY IN THE WORLD REACHED:

- ○ a. 989 GW
- ○ b. 2,179 GW
- ○ c. 1,589 GW
- ○ d. 3,585 GW

6) BETWEEN 2016 AND 2017 THE RENEWABLE INSTALLED CAPACITY IN EUROPE INCREASED BY:

- ○ a. 5%
- ○ b. 7%
- ○ c. 10%
- ○ d. 3%

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

Answers of the Quiz

1. Answer: b. 1,6 GWh
2. Answer: a. 39,4
3. Answer: d. 52,5
4. Answer: d. 60,000 rpm
5. Answer: b. 2,179 GW
6. Answer: a. 5%

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