MEDREG

STUDY VISIT TO ERSE

STUDY VISIT REPORT:

EXPLORING ENERGY STORAGE AND DEMAND MANAGEMENT

Empowering Mediterranean regulators for a common energy future

Renewables Working Group (RES WG)

Co-funded by the European Union

ABSTRACT

This document gives an overview on the topics that were discussed during the study visit on "Energy Storage and Demand Management" that took place in Lisbon, Portugal on the 4th and 5th of July 2022 and that was attended by speakers from the Portuguese regulator (ERSE), specialized in their fields and an array of representatives of energy regulators from different countries from the south shore of the Mediterranean region. The event was kindly hosted by the Portuguese regulator (ERSE).

ACKNOWLEDGMENTS

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DISCLAIMER

ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, bringing together 27 regulators from 22 countries, spanning the European Union, the Balkans and the MENA region.
Mediterranean regulators work together to promote greater harmonization of the regional energy markets and legislations, seeking progressive market integration in the Euro-Mediterranean basin. Through constant cooperation and information exchange among members, MEDREG aims at fostering consumers rights, energy efficiency, infrastructure investment and development, based on secure, safe, cost-effective, and environmentally sustainable energy systems. MEDREG acts as a platform providing information exchange and assistance to its members as well as capacity development activities through webinars, training sessions and workshops. The MEDREG Secretariat is located in Milan, Italy.
MEDREG wishes to thank in particular all the experts for their work in preparing the training and for sharing their knowledge.
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1
Introduction

Under its efforts to continuously support its South Shore members throughout the peer- to-peer sharing of experience and good practices, MEDREG, in cooperation with its members, considering their urgent needs and requirements, has identified the topic of "energy storage and demand management" as a cornerstone for the correct development of the grids as well as the legislation of the future.

The increasing share of renewable energy in the energy production mix puts a great strain on the existing electricity infrastructure. Renewable energy generation cannot be accurately predicted and can lead to severe fluctuations in generation while the demand can be approximated accurately and is currently hard to manipulate. This will lead to an imbalanced energy market. To mitigate this effect, the flexibility of the energy grid should be strengthened. Energy storage and demand side management will create a big market for flexibility and will therefore help further integrate renewable energy sources into the grid. Energy storage will inject the stored energy into the grid when solar and wind power are not enough to provide for the entire system and will be charged when power is ample in the grid, especially when wind and solar power are abundant. Demand side management will help flattening the demand curve by managing the demand at the end user's side, leading to consumption reduction when the peak demand is reached, and transferring the demand that is not essential to the low consumption hours.

Multiple facets can enter in both energy storage and demand side management. Energy storage can take several forms such as pumped storage, batteries, thermal salts and oils, compressed air, hydro dams and others. Demand side management consists of the operator having access to motivate consumers to change and adapt their level and pattern of electricity usage. In this case, the operator can implement a system that encourage consumers to use less energy when demand is higher and use more energy in times when cheaper renewable energy is plentiful on the grid. The management of both sides can lead to big opportunities for flexibility in the energy market and help alleviate the stress added by the RES on the grid.

In this framework, MEDREG organized a study visit for the representatives of the south shore regulators to the Portuguese regulator ERSE. The study visit highlighted the main questions and possible answers that characterize energy storage and demand side management in the national Portuguese energy sector, focusing on the role played by the regulator in implementing and monitoring it, also addressing the tariff structure options and methodologies for the management of energy storage and demand management. The discussion with ERSE's experts was complemented with a site visit to E-Redes, the main Portuguese DSO, to see and discuss the operation of the distributor, and a visit to the room where control of the grid and reports on the grid take place on an instantaneous basis.

The experts' mission took place in Lisbon, Portugal on the 4th and 5th of July 2022, during which the topics that were addressed are elaborated I the following report.

2

Day 1

2.1. Introducing the Consumption Efficiency Promotion Plan PPEC (Ms. Liliana Ferreira)

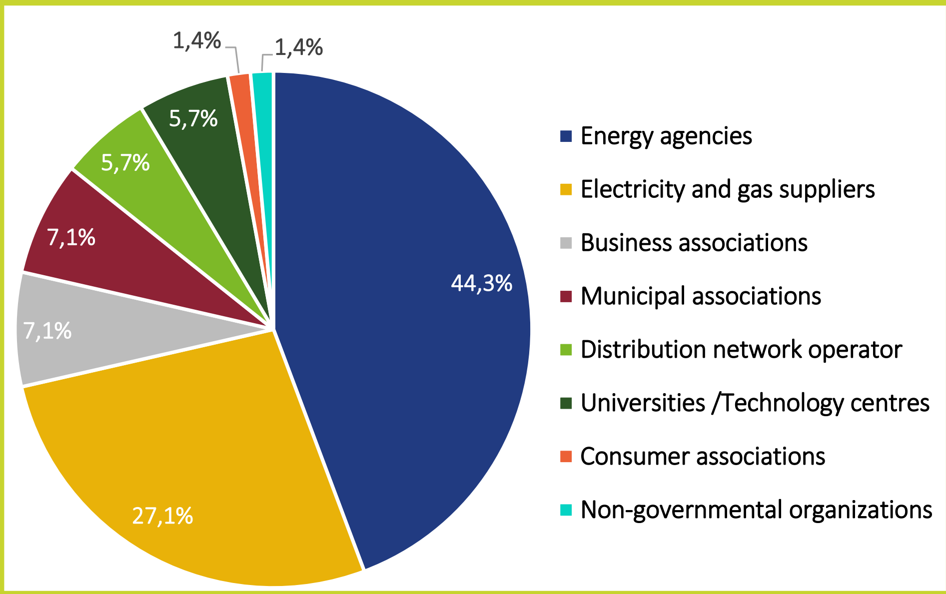
Three quarters of the gas emissions derive from the energy sector. So, it must be at the heart of the climate change solution. The energy transition should be technological and societal, and consumers have a crucial role in this transition. To reach the net-zero emissions target by 2050, energy efficiency should be doubled. In these efforts, Portugal has set a map towards carbon neutrality, where coal has been eliminated since 2021, and oil consumption will drop sharply by 2050. Oil will be replaced by natural gas in the transitory phase, and then by renewable energy.

The EU has set a plan known as “Fit for 55” which sets a goal of reducing the GHG emissions in the union by 55% by 2030 compared to 1995 levels. The “Fit for 55” package has under its objectives the revision of the energy efficiency directive. Energy efficiency presents benefits that can be grouped under 5 categories which are environmental sustainability, security of supply, energy system sustainability, economic development, and social development. Portugal has set a target for energy efficiency by 2030 to reach 35% reduction in primary energy consumption without considering non-energy uses.

Regulation can assist in promoting efficiency in energy consumption by defining tariffs that induce this efficiency. Tariffs should recover all the efficient costs associated to each activity, they should have several billing variables to convey accurate price signals to the consumers, and they should have price structures adherent to marginal or incremental costs. Other types of mechanisms should also be adopted because barriers and market failures can hinder economic agents from taking efficient decisions. While developing the regulations, it is important for the regulators to ensure that the regulatory incentives are closely aligned with the objective of energy efficiency, and that the regulation is friendly to innovative new service providers.

PPEC was established by ERSE in 2006 to support the implementation of measures that help improve efficiency in energy consumption. In 2021, PPEC became the Energy Consumption Efficiency Promotion Plan, promoting efficiency in electricity and gas consumption. The plan evaluates the measures based on their merit, taking into account the amount of savings that it generates. Applicants include a wide array of the stakeholders such as electricity and natural gas suppliers, TSOs and DSOs, energy agencies, consumer and business associations, NGOs, municipal associations, and research centers and higher education institutions. The 7th edition of PPEC has a budget of 23 million Euros and the applications are evaluated by ERSE and the Directorate General of Energy and Geology (DGEG). This version will be the first one to cover electricity and gas in the context of an integrated energy system. Measures will be implemented starting July 2022. Energy efficiency has been introduced on the agenda of a broad range of players, reaching 34 lead promoters and several other entities that are involved in the implementation of the selected projects. The PPEC covers both tangible and intangible measures. Tangible measures consist of the installation of equipment with a higher level of efficiency then the ones existing in the market, while intangible measures consist of trainings and education and focused information campaigns along with the energy audits.

Figure 1. PPEC 7th edition candidates



The evaluation process of the PPEC is divided in multiple stages. The first one is related only to the tangible measures, where if these measures have a net present value or primary energy savings that are negative or null, they are automatically disqualified. After this, all measures are studied by ERSE and DGEG based on a scoring sheet. Both entities have the same weight in deciding the approval or rejection of the measure, and they tackle them based on the points of interest of the two entities.

As PPEC is a tender mechanism, it has the advantage of being able to choose the best measures with the highest benefit-cost ratio to be implemented. This program also enabled the level of co-financing to increase, leading to a higher involvement of all the stakeholders. This can be seen in the difference in financing types from the first PPEC to the 6th PPEC where the PPEC financed 85% of the costs in its first edition, and dropped to 56% in its 6th edition, with most of the rest of the financing being paid by the beneficiaries themselves. PPEC 2017-2018 has an expected accumulated savings of 1,289 GWh, roughly equivalent to the yearly consumption of 500,000 families. The previous six PPECs have cost 75 million Euros, but in return, they have generated 979 million Euros of savings which is more than 13 times the initial investment. In summary, PPEC is a success because it is a good initiative for the energy system and the environment, they provide good publicity for companies, and the consumers benefit from lower energy bills.

All in all, energy efficiency turns out to be far more cost-effective than other mechanisms to meet the environmental targets, to reduce energy supply costs, and to increase the security of supply. Especially in the current time, energy efficiency is assisting the energy bills low and cushion the price volatility of energy vectors that are continuously rising in price.

2.2. Self-Consumption, Demand Side Management, and Renewable Energy Communities (Ms. Patricia Lages)

Several plans in Europe have been elaborated to boost energy transition. The Clean Energy for all Europeans package is implemented through the European Union strategy to give EU consumers secure, sustainable, competitive, and affordable energy. After its adoption in 2019, this package aims at helping decarbonize the EU's energy system in line with the European Green Deal objectives. The European Green Deal in its turn, will assist Europe in becoming the first carbon neutral continent by becoming a modern and resource efficient economy, with 0-emissions by 2050 and with the economic growth decoupled from the resource use. The Fit for 55 package consists of a set of interconnected proposals to ensure fair, competitive, and green transition by 2030. The REPowerEU, is a plan that was adopted in 2022 after the growing conflicts in Europe and aims to reduce the dependency of the EU on Russian fossil fuels and push forward the green transition agenda. On the national front, Portugal has elaborated the Roadmap for Climate Neutrality 2050 which details how they will meet the Paris Agreement commitments and the energy union's objectives. The Portuguese National Energy and Climate Plan 2030 details the steps that will be taken by Portugal to reduce its emissions and increase the use of clean energy in its energy sources.

The EU directive 2018/2001, in its path to promote the use of renewable energy sources, defines the renewable self-consumers as a final customer who generates renewable electricity for his own consumption and may store or sell self-generated renewable electricity. The jointly acting renewables self-consumers refers to a group of at least two renewable self-consumers who are in the same multi-apartment block and that want to act jointly in the market. On the other hand, a Renewable Energy Community (REC) is an autonomous legal entity, based on voluntary participation controlled by shareholders or members of the community. This legal entity is located next to renewable energy projects owned and operated by them. The shareholders can be natural persons, Small and Medium Enterprises (SMEs), or local authorities including municipalities. The main purpose of the REC is to provide environmental, economic, and social community benefits for its members and the local area where it operates. In Portugal, the legal framework adopted in 2014 includes both renewable and non-renewable production units and regulates the behind-the-meter self-consumption. It was further bolstered by a legal framework adopted in 2019 that mentioned individual and collective self-consumption, energy sharing, energy netted in 15-minutes periods, smart metering, network access tariffs for the use of the public grid and set a framework for RECs. ERSE then developed a specific regulation for electricity self-consumption with specific rules for topics such as metering, commercial applications, and tariffs. Additionally, ERSE approved pilot-projects to serve as regulatory sandboxes. Under these different regimes of consumption, there is a need for smart metering systems and to clearly define the sharing rules. The number of self-consumers in Portugal is rising in a fast way going from 20,000 in the second quarter of 2020 to more than 90,000 in the first quarter of 2022 with a total production exceeding 500 GWh. Comparing the bills of traditional network access tariffs to the tariffs with self-consumption, it can be noticed that the tariffs are much lower than usual with some parts being overlooked as per the exemptions set in the legislations.

Demand-Side Management (DSM) is the act of planning and monitoring the activities and designing them in a way to motivate the consumer to change his patterns of electricity usage, including the timing and level of demand. DSM includes demand response and demand reduction. Tariffs can be used to control DSM by pricing peak hours at high prices and low demand hours at low prices, so the demand would shift from the peak hours to low demand hours. Some suppliers have electricity with indexed end-user prices where the contract varies in periods (e.g., monthly) based on average spot prices with losses and system costs accounted for. Dynamic end-user prices are still not offered in the Portuguese market, but they will be coming soon.

DSM and energy storage could help an average European household reach a rate of self-consumption of 65-75%, while without them it would be a maximum of 30%. With the advancement in smart technologies, connected appliances, sensors, and smart meters, it is easier to optimize the consumption and the operation of a PV-battery system and to interact with the grid and energy market.

Figure 2. Graph showing PV production and power demand with the possibility of load shifting (Interreg)

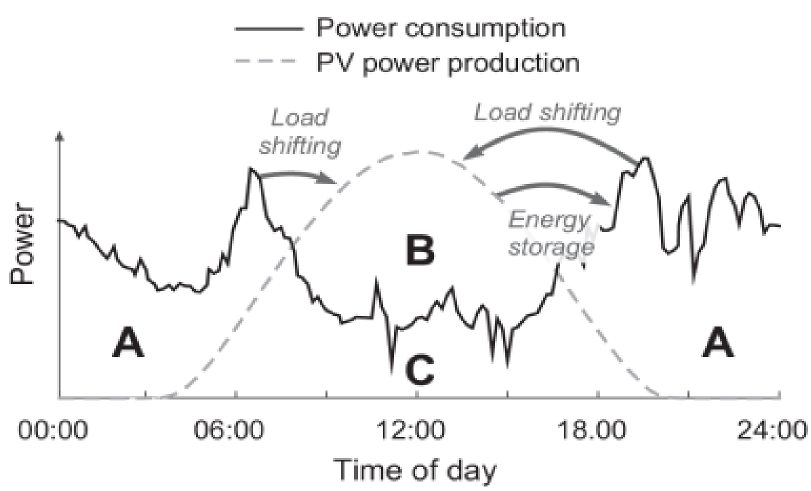


Figure 3 - Peak production and peak demand [6]

A = energy consumption, B = excess energy, C = self-consumption

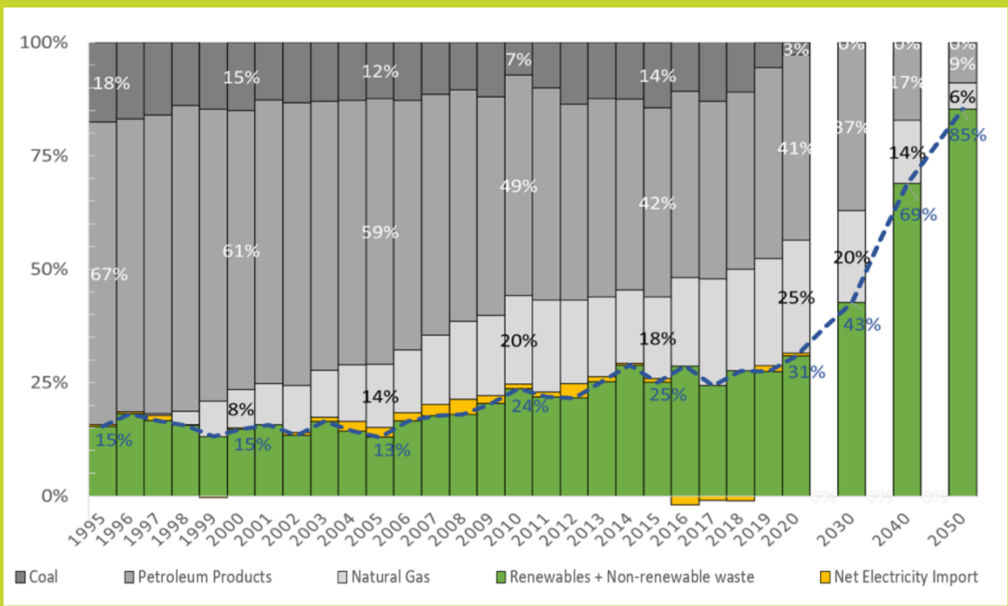
Self-consumption, DSM, and distributed renewable resources contribute to accelerate decarbonization, enhance the security of supply, and keep prices in an affordable range. Digitalization is essential for energy sharing and for activating the demand side. It is important for regulators to adapt the regulations in a way not to harm the advancement of these technologies.

2.3. Future of Energy Storage (Mr. Nuno Bairinhas)

Carbon neutrality by 2050 is the center of the European vision that has been developed with ambitious goals through multiple plans such as the European Green Deal, Fit for 55, the hydrogen and decarbonized gas market package along with other plans. European regulators are working to empower consumers for the energy transition. Three main axes are considered essential for decarbonization, and they are the integration of energy markets in the European dimension, decentralization and local flexibility, and the integration of energy vectors.

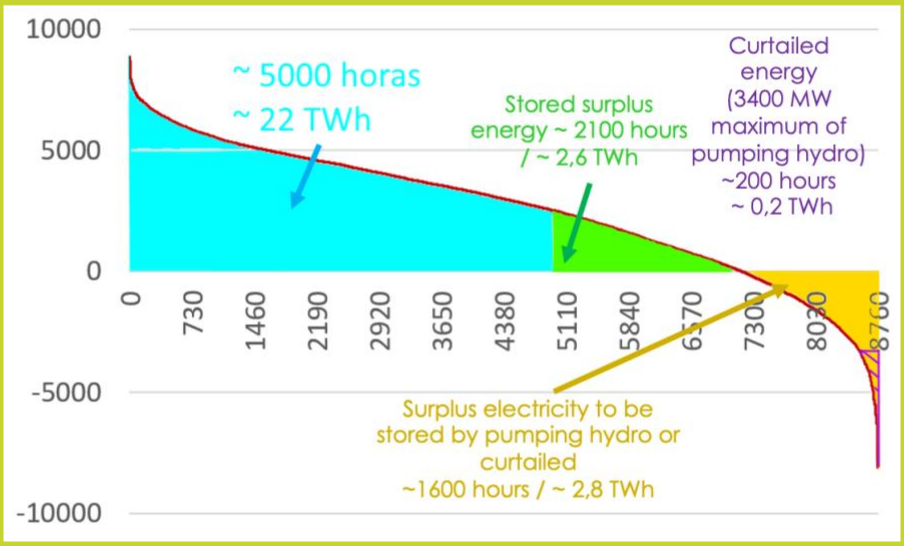
As mentioned before, Portugal has set a roadmap to reach a carbon neutral society by 2050. Currently the main contributors to GHG emissions are the energy sector, industrial sector, and the transport sector. As can be seen in the figure below, the renewables share of the primary energy consumption has been consistently increasing, reaching a total of 31% of the market in 2020. Renewable energy production is expected to grow to 85% by 2050. Energy efficiency will also rise by 40% reducing the consumption from 241 to 145 TWh/year by 2050. Energy dependence as well is expected to drop from 66% to 15% by 2050. Coal has been completely phased out of the Portuguese energy sector since 2021. Energy transition will be strongly connected to energy efficiency and to the electrification of the society.

Figure 3. Historical evolution and prediction of primary energy consumption in Portugal



One of the flexibility facets is the ability of the power system to mitigate fluctuation in supply and demand while maintaining its reliability. It is the modification of generation or consumption patterns in reaction to an external signal aiming to provide an alternative service within the energy system. It is expected to have a consumption of 58 TWh of energy in Portugal in 2030. Of this consumption, 36 TWh are expected to come from non-flexible generation systems like PV and wind. The figure below is a histogram representing the difference between power demand and the renewable generation in 2030. Without flexibility solutions, 2.8 TWh will be curtailed. Luckily, the available pumping hydro could help store 2.6 TWh while 0.2 TWh will have to be curtailed without further flexibility solutions. Hydro and natural gas will supply the remaining 22.3TWh needed in the Portuguese electricity system in 2030.

Figure 4. Residual load histogram for Portugal in 2030



Lots of technologies that could store energy are available such as mechanical storage (pumped hydro storage PHS, compressed air energy storage CAES, flywheels…), electrical storage (supercapacitors, superconducting magnetic energy storage SMES…), electrochemical storage (classic and flow batteries…), chemical storage (hydrogen, synthetic fuels, methanol…), and thermal storage (Latent and sensible heat storage, thermochemical storage…). These technologies are at different maturity stages where the efficiency, cost, and application type could have a very wide range. However, this wide range helps them act under a mixed variety of circumstances such as generation and bulk storage support services, transmission and distribution infrastructure support, ancillary services, and customer energy management. In Portugal, pumped hydro storage is the most relevant storage technology with over 3 GW of installed capacity while battery storage consists of 3 installations with a capacity surpassing 500 KW. Future projects include the erection of a 1158 MW PHS project called Tamega Electricity Production System, and which is supposed to be commissioned in 2023. An additional storage capacity of 880 MW is also planned in Gouvaes. The horizon also includes several projects for batteries, variable renewable energy sources with storage, household applications such as PV coupled with battery systems, and power to gas projects with hydrogen being an important part of this plan.

Cooperation between TSOs and DSOs will be crucial for the operation of the system and the regulation framework should be technologically indifferent and non-discriminatory and should well define the different parameters in the power system.

2.4. The Role of EV in Coupling DSM and Energy Storage (Mr. José Bigares)

DSM is a method to manage congestion in the power system by changing consumption patterns. It can be also seen as flexibility and can be enforced through implicit and explicit measures. The implicit measures are built based on the consumers' reaction to price signals which push these consumers to adapt their behavior by increasing energy efficiency and automation in their quarters. The explicit measures are committed and dispatchable flexibility that can be traded, and to which consumers receive direct payments. Energy efficiency measures can be promoted through time of use tariff, critical peak pricing, and real time pricing. Demand-Response measures consist of direct load control, capacity market programs, emergency demand-response programs, interruptible or curtailment services, and ancillary services. DSM is essential to balance generation and demand due to unforeseen changes in consumption and generation patterns (e.g., lack of power from renewable sources).

Several technologies can assist with DSM and their contribution can vary from instantaneous to long term action. These technologies have different maturity levels and consist of industrial demand response providing reserves, aggregators providing demand side flexibility, smart charging EVs, electrolysers providing reserves, electric water heaters, district heating, and hydrogen. Ancillary services aim at preserving the different parameters of the power system and consist mainly of frequency containment reserves, automatic frequency restoration reserve, and manual frequency restoration reserve. These services are traded on multiple platforms in Portugal. They are provided by large consumers by increasing or decreasing his consumption, or independent aggregators. Entities that are qualified to provide these services should be balance responsible parties (BRP) or have a contracted BRP.

An aggregator is a service provider that may or not be a supplier, and operates directly or indirectly, a group of consumption, generation, or storage facilities in a way to trade flexibility. It should be a registered entity that has a separate accounting from the rest of the activities in the national electric system. A last resort aggregation is obliged to buy electricity from the entities who cannot sell energy to the system such as self-consumers and RES generators and it must be licensed. Aggregation requires a regulatory framework that allows aggregators to participate in the market, and it needs an advanced metering infrastructure and advanced forecasting tools and techniques.

EVs are storage units that are highly controllable. When aggregated, EVs may provide the potential to contribute to the reliability of energy systems by providing ancillary services. They can be programmed to avoid charging during peak demand. In the long term, they may help postponing investments in power plants built to respond to peak demand. They can send back some of their energy to the grid and they can act as active filters to the grid by compensating harmonic distortions in distribution grids or reactive power.

An average car drives around 10,000 kilometers per year. Considering a consumption of 25 kWh/100Km, the yearly electric consumption of 1 EV would be around 2.5 MWh, almost doubling the average domestic consumption. This would require a capacity of 3 kW/EV if they were charged over night for 8 hours, and a capacity of 75 kW/EV for fast charging (20 minutes). The table below summarizes the Portuguese case and the needed additional capacity if a certain amount of EVs were added to the Portuguese scenario while considering the charging of EVs taking place in off-peak hours, once every three days, and considering a national yearly consumption of 50 TWh and an off-peak consumption of 4 GWh.

Table 1. Required capacity to charge EVs and their percentages of annual and valley hours consumption

Number of EVs	Yearly Consumption of the EVs (GWh/Year)	Percentage of Annual Electric Consumption	Maximum Capacity Needed (MW)	Percentage of consumption in Valley Hours
10,000	25	0.05%	10	0.25%
100,000	250	0.5%	100	2.5%
500,000	1,250	2.5%	500	12.5%

When connected to a single phase, EV charging may cause imbalance in the voltage phases, as well as significant harmonics and super-harmonics in the system. Currently in Portugal, there is one charger for every 23 EVs, while in the EU it's 13 EVs/charger. To reach the recommended 10 EVs/charger, Portuguese average growth for chargers should increase by 52%. The expected growth of the EV fleet in Portugal is up to 68% of all cars by 2030.

Smart meters play an important role in demand-response, but by themselves, they only measure the electricity consumption. They should be integrated in smart grids to unlock further services that could help tackling flexibility products. Many pilot projects are being tested internationally for demand response initiatives. In Portugal, these projects are the regulation reserve market which consists of a regulatory sandbox including industrial clients with a minimum of 1 MW installed capacity that are participating in demand response programs, and another for electric mobility vehicle-to-grid (V2G) in Açores which includes 10 vehicles with V2G capacity that have consumed a total of 198 MWh and injected in the grid a total of 109 MWh.

3

Day 2

3.1. Study Visit to E-Redes

E-Redes is the main Portuguese DSO and one the largest DSOs in Europe. It has 6.4 million customers connected to the distribution network, distributes 45 TWh of energy using around 230,000 kms of distribution lines and 70,000 transformer stations. It is the 6th largest European DSO in terms of number of customers and the third largest amongst private players.

Since 2002, E-Redes has assisted in the evolvement of the overall quality services of the distribution network, reducing the interruption time from 420 minutes to 50 minutes in 2021 (88% reduction). It has been taking significant steps in the large adoption of digital tools increasing in a sustained way its digital maturity.

Nowadays, DSOs are facing lots of challenges especially with the rise of topics such as decarbonization, decentralization, and digitalization. These challenges include the integration of distributed energy generation, the increase in the number of electric vehicles, the electrification of demand, the development of new energy markets and services, and the growth of customer connections. Facing these challenges, E-Redes is developing new capabilities as distribution system operator and market facilitator. It is also deploying smart grids to enable efficient energy and information management and leveraging digital and innovative solutions across the sectors from customer services to network operation.

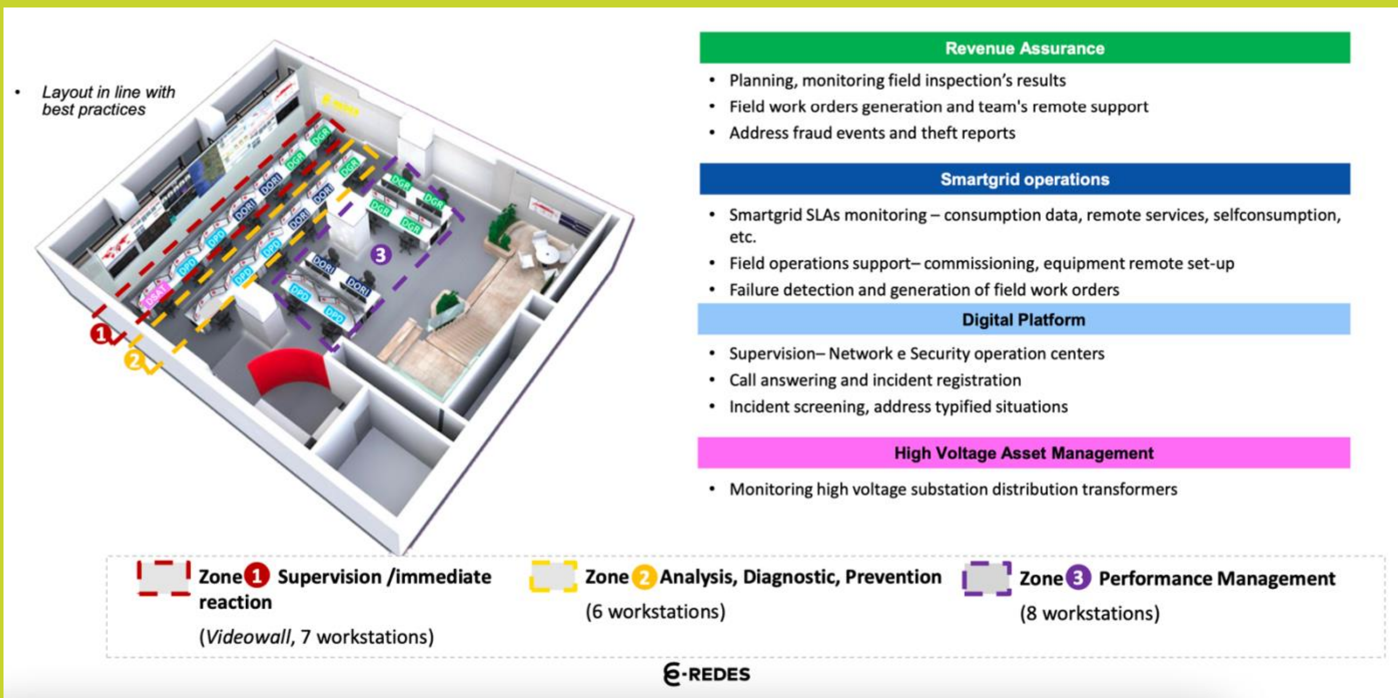
The main challenges that E-Redes will be facing in the coming years are categorized under four main pillars. The first one being facilitating the energy transition where they commit to be promoters of the energy transition as they have already deployed more than 4 million smart meters, connected 1,500 renewable distribution generation projects, and served 21.4 GWh for electric mobility. The second challenge is to renew the network as it includes many aging assets especially that Portugal has a high percentage of aerial network (80% of the network) which exposes it to extreme weather conditions. This task will need high investment volumes and financing options. The third challenge is to attract and retain talent which is considered a problem due to the fierce level of international competition for talent in the fields that are needed (STEM profiles) where employability rates are close to 100%. The last challenge is to proactively manage the unpredictable such as the rising prices of raw material, the low liquidity of the Portuguese market, and the possible disruption in the integrated management of HV/MV/LV concessions.

The smart grid is complex and requires important changes both at the technological level and at the organizational level because everything must be connected to a central IT communications unit that will be handling the problems that present themselves. Since 2019, new smart grids regulations were approved, and it was necessary to set-up an adjustment program to ensure full compliance, even though E-Redes was already at a high level of alignment with these regulations. The smart grid campaign aimed at delivering the best experience to the consumer by informing him on time, by being flexible, and by listening to the complaints and improving the process. 900 employees were involved in the campaign with the aim to reach 3,000 installations per day. Five main criteria governed the deployment of the smart grid and they consisted of geographical balance, service providers workload balance, operations efficiency, network densification, and fraud reduction. The campaign will strongly increase its activity in the coming two years to complete the infrastructure by the end of 2024. Due to the roll out of the smart grid, the volume of collected data and remote operations on the grid has been growing continuously. Every single day, more than 400 million data records are collected detailing all the parameters of the system.

Many challenges lie ahead of the development of smart grids such as the scarcity of material and qualified labor (unstable supply chains and high competition) and the services and data management opportunities that are always evolving very rapidly.

At the end of the lecture, E-Redes representatives took the participants in a tour to the supervision center which layout can be seen below detailing the areas and responsibility of each department. Three zones can be clearly detailed one for supervision and immediate reaction, the second for analysis, diagnostic, and prevention, and the third for performance management.

Figure 5. Layout of the supervision center



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