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European Union legislation for demand-side management and public policies for demand response

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Abstract. Energy is now intrinsically linked to technological and social development, powering all such systems. The use of fossil fuels to supply the required energy is causing global environmental and health issues and is impacting on all life forms on the planet. Given the increasing energy use, anthropogenic greenhouse gas emissions are consequentially increasing. A critical and evolutionary way of thinking about the energy and resources demand management and supply is necessary because there is a clear concern about irreversible impacts on the world and a scarcity of the resources as well. At the same time, all the energy and resource use processes should be optimized to maximize the benefits, reduce the costs and promote stakeholders network, toward a circular economy. This could be the way to supply the demand without increasing the scarcity of the resources and to simultaneously achieve environmental benefits. At the same time, creating an educational grid is important to change the established paradigms, to promote critical thinking about the wasted resources and thinking holistically about overall consumption. This paradigm shift is changing the market, making it more competitive and reducing inefficiency by promoting the efficient use of resources. In the XXI century, legislation and public policies which consider sustainability approaches are constantly improving, trying to fix the pathways to avoid climate changes and achieve energy efficiency, but at the same time, the energy and resources demand still increasing to a no sustainable way to the social and environmental aspects.

Keywords: Demand Side Management, Demand Response, Energy Efficiency, Sustainability, Circular Economy, Public Policies.

1. Introduction

The World Wildlife Fund (WWF) in their Living Planet Report (LPR) from 2014, claims that if all the world lives like an average European, it 2.6 planets will be needed to sustain the demand. The world population growth, industrialization, and its continuous development are increasing in a non-sustainable way the energy consumption, inducing the irresponsible demand, therefore, the spread of greenhouse-gas emissions to the atmosphere. The humanity witnesses the shift from an industrial society to a society at risk [1].

The buildings in the European Union (EU) are responsible for large amounts of consumption from natural resources, energy, water, and generated wastes, being that society spends 90% of their whole time living in the indoor environment of the buildings [2]. In this sense, the current emplacement of the construction corporations throughout entirely buildings lifecycle, is not the most auspicious to bring off the sustainable development, since they are only focused on their own economic and oncoming progress, exploring continuous models of linear economy to achieve exclusively economic benefits deprived of thinking in the social and environmental aspects. Hereupon, the ecological industry addresses the flow of materials and energy resulting from anthropological activities, promoting bases to the development of closed cycle approaches and subsequently the reduction of environmental issues from the activities coming from the construction sector [3]. The concept of the Internet of Things (IoT) which can connect billions of devices, enabling sensors and monitoring of stakeholders, from manufacturers to governments and research labs, tracking is pathways. It can improve the efficiency with artificial intelligence by an automated demand, and connecting person to person, person to machine, machine to person and machine to machine [4].

This paper aims on the way to expose an explanatory and argumentative approach about building data in EU and Portugal and a critical constructivism way of thinking about the public policies directly or indirectly connected to buildings and the significance of this concepts to enlarge the Demand Side Management (DSM) to all the energy system in the future in a responsible way to the social and environmental effects, to help the future legislative procedures with the flexibility of steps to develop the policies related to all the building and construction environment, exploring diverse variables to ensure an holistic approach.

2. The energy efficiency in the building industry

In the search for greater energy efficiency in all the world, especially in the EU, buildings are one of the three most important sectors to consider. More well-organized construction procedures and use of buildings can accomplish substantial saves of resources and healthier environmental performances, reducing 42% of energy use, 35% of greenhouse-gas emissions, 50% of extracted materials and 30% of water consumption and generated wastes [5]. According to the Energy Efficiency Directive (EED, Directive 2012/27/EU), only 2% of the buildings are designed to promote the demand response from all the stakeholders throughout all the building lifecycle [6]. In the EU, 75% of the current buildings and 50% of the buildings built before 1975 will remain in use in 2050 [7]. To achieve the goal of almost all the buildings to be nearly Zero Energy Buildings (nZEB), and consequently, the decarbonization of the built environment in 2050, 97,5% of the buildings must be upgraded [8]. Thereby, the propagation and promotion of the nZEB concept, introduced through the Energy Performance of Buildings Directive (EPBD-recast, Directive 2010/31/EU), it is essential to assure the education of all the stakeholders and to enhance the sustainability of the built environment, making the nZEB integrant part of the existing infrastructures. Demand response is progressing slowly in the construction area, residential buildings and small and medium enterprises (SME). Therefore, seeing that further than 90% of the construction corporations are SME and residential buildings are a significant portion of the built environment, it is necessary to develop public policies which promote efficiency in a responsible manner and eradicate fuel poverty in the EU [7].

In Portugal, 93% of the buildings are residential buildings within which 87% are single-family houses, being this the most vulnerable to fuel poverty [9]. Since the end of the XX century, that the discussions about rehabilitation or demolition and posterior new construction have constantly increased, especially about the urban regeneration. The economic aspects tend to balance the benefits of rehabilitation, except in cases that the building has poor performance and the costs of the rehabilitation reach the costs of demolition and new construction [10].

2.1. European Union Directives and building efficiency for a circular built environment

To apply the challenge of sustainability is necessary a long-term perspective and integrate diverse elements. Energy is one of them. Thus, driving all the energy system in a sustainable way, are progressively raised up and being considerate in the legislation regarding the buildings.

Nevertheless, the incorporation of the legislative flexibility must be considered, given the continuous innovation development since the technologies are increasingly in the social life, allowed an integrated approach to the social and environmental challenges. Therefore, a whole set of procedures that allow a regenerative system, rethinking all the pathways to DSM, looking for the sustainability of the built environment, must be addressed with the aim of rethinking similarly the social and the environmental performance [11].

The buildings are one of the EU strategies for energy efficiency, being indirectly addressed in various Directives, as the ecological design, energy labeling, renewable energy sources, and energy efficiency. However, buildings are directly addressed in the Energy Performance of Buildings Directive (EPBD, Directive 2002/91/EC), reformulated through the Directive 2010/31/EU (EPBD-recast) in 2010, and most recently through the Directive (EU) 2018/844 of 30 May 2018. In 2002, emerge the EPBD, with the aim of improving the energy performance of buildings and reducing the energy demand, reducing the maximum value of the heat transfer coefficient, the thermal transmittance of the building envelope [12]. Through the continuous development, and in the absence of the requirement to report the results, some mishaps arose, such as lack of credibility from the certificates and consequently the low rate of buildings rehabilitation.

In 2010, the EPBD-recast reforming the EPBD, promoting the development of sustainable solutions and energy efficiency, considering the emissions cutback and energy demand. Therefore, increasing the use of energy from renewable sources, and considering the Kyoto Protocol and environmental purposes to 2020, as seen its importance improved based on the optimum cost method and obligation schemes to energy efficiency. The EPBD-recast also established, a benchmarking system, following the optimum cost method during the life cycle to support the member states to define the minimum requirements of energy performance and its continuous monitoring to rehabilitation and new constructions [13]. The EPBD-recast prelude the nZEB concept whereby a building with high energy performance, where the energy demand for heating and cooling is net or nearly zero, being suppressed from renewable energy sources.

Consequently, the nZEB became mandatory in the EU as from January 2019 to public buildings and, in January 2021 to all new buildings and considerable rehabilitation. Every EU member state it's up to define this concept, considering local variables and the minimum mandatory targets. Nevertheless, the development of this concept is still far from being a current reality, since more than half of the member states still in the beginning process of developing the national definition of nZEB (Figure 1) [14].

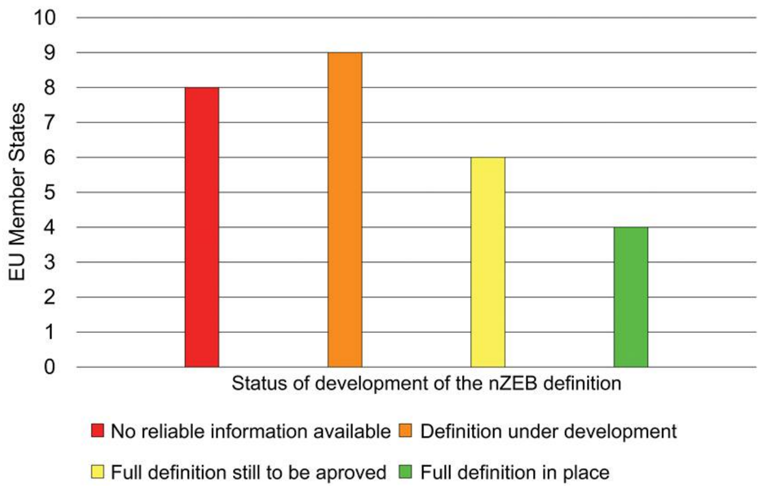

Figure 1. Development of the nZEB definition in the EU member states [14].

With the same time reference, emerge in 2018 the most recently EPBD reformulation the Directive (EU) 2018/844, encompassing the long-term strategy (2050) considering the Paris Agreement signed by all EU member states. Thus, the member states have twenty months after entry into force this Directive, to transpose adopted provisions to national regulations and aims.

The main innovation of this Directive is the automation and monitoring systems, with the aim to accelerate the profitable rehabilitation of the buildings. These systems are composed of reading devices in real-time with features that are missing in the current devices. For this purpose, comes up an indicator of the suitability of the buildings for smart systems and their correlated technologies, for example, applying infrastructures to electric mobility, flexibility demand, and energy storage (heating, cooling, and electricity) [15]. Thus, the rehabilitation frameworks are supported and in the long-term strategies, rehabilitated buildings become closer to the nZEB concept.

To make feasible the ecological design grounding the concept of PassiveHaus, highlighting the use of local resources, building orientation considering the sun, and natural enlightenment and ventilation. Thus, embody efficient and mouldable openings and sustainable materials to reduce the energy demand, considering local weather conditions to achieve the sustainability of the built environment. Following the principle of energy efficiency first, comfort and functionality of the buildings are improved in a healthy and natural way to the stakeholders [16].

Thus, ensure that the interior building devices are relevant to change the user habits, being that even so almost of monitoring devices are inaccessible to the users and requires a manual reading. In that way, the main reason to develop support systems for the environmental performance of the buildings comes up with the incapacity of the member's states define how sustainable a building is. This issue also comes to the design teams that are responsible for the research and innovation in this context [17].

The energy performance of buildings it’s a reality to the future buildings, even though it required a long way to achieve the buildings decarbonization being necessary the support to rehabilitate the existing buildings. Notwithstanding, it is necessary to make a health check to all constructed buildings, to help the design teams to project rehabilitation in a responsible way and not only aesthetics. This health check procedure already been showing some good results in some countries in the EU, because like in the sector of electrical energy, the market prices in the real estate do not reflect the social and environmental costs of the resources consumption.

3. Demand Side Management (DSM)

The concept of DSM emerges in the XX century, in the '70s, after the first worldwide energy crisis, and it consists in decrease the peak of demand and energy consumption. The requirement to introduce automation and monitoring systems that promotes reliability during all the buildings lifecycle emerges as one of the priorities considering the social and technological development. Thereafter, the reduction of energy waste is related to the specific purpose of rethinking its end use.

Hereupon, emerge the possibility of new approaches, legislation, and public policies to shift the patterns of energy consumption, regarding further liberal markets through synergies and interconnectivity between monitoring, information, communication and automation technologies. The communication infrastructures are composed of sensors and smart devices that make viable support mechanisms for inherent activities. Thus, it was possible the effective management of the energy demand, with real-time evaluation and increasing flexibility for all the shareholders. Encouraged by dynamic prices, users manage their energy consumption in a responsible way, exploring energy storage technologies which increase the penetration of renewable energy sources into the grid. The infrastructures are built to suppress the maximum demand. However, there is a huge variance between the maximum and average demand, which consists of higher prices to generate energy and to their usage by the final users, as well as more energy wastes.

The DSM tools and methods allowing the adjustment of energy use promoting sustainability and the safety of energy flows [18]. Thereby, energy conservation and storage contribute to the flexibility in the systems planning and operation, keeping them stable during all the use periods adjusting demand and supply management [19]. On the other hand, the financial support for investments in energy efficiency in heating the indoor spaces and water are relatively higher than policies and support which promotes energy efficiency in electrical appliances [20]. While the industrial sector is widely conducted for economic reasons, when it comes to the residential sector these terms are not so linear, factors such as education and social and cultural norms generally prevail.

3.1. Efficiency, factors, and susceptibility

The DSM can also be approached as the introduction of the anthropological factor connected to the network which encourages a more sustainable way to the energy management and the supply network. Less energy use in the peak periods or moving the use periods are some good conducts that do not mean directly less use of energy but reduce the investments in the infrastructures to sustain the peak periods demand. On the other hand, the availability of energy from renewable sources is dependent on its source and season, gave the intermittency of this sources.

However, it is difficult to society to have a notion of the amount of energy required for different purposes, what in turn, makes difficult the modification of daily habits to decrease energy demand, demand response or investment in energy efficiency measures. While demand response programs tend to focus on reducing the demand in the peak periods or during specific periods, the energy efficiency measures are more comprehensive and focus on reducing overall energy use.

Nowadays, there are some issues that make difficult to users to improve their energy demand, considering the price variations offered by the electricity markets [21]. The demand response models appear thus with the purpose to help the operators of individual systems identify and implement incentive programs to responsible demand [22]. Thus, the risks associated with non-rational and unpredictable behavior are considerably reduced since the users become more aware of their demand and energy consumption. Thereby, decisions are improved, and the energy efficiency opportunities are easier to identify by all stakeholders throughout all the energy management process. The motivational guides, user awareness, support infrastructures, and user's behavior are the most effective ways to the DSM development [23].

Therefore, the most important step is in to acquire reliability of users to join DSM programs. Thus, the need for an information stimulus, to reshaped legislation and public policies to integrate them into society knowledge with transparency, equity, and social and environmental sustainability is extremely important to foster effective public actions. Demand response can be spread based on the price of tariffs and incentives for the users in the residential sector. It is addressed considering the typical applications in the residential buildings to minimize the energy costs and maximize benefits [24]. The European Environmental Agency report from 2013, argues that in the optimization of the interfaces between the legislation elaboration and the human behaviors is the key to reach sustainable energy consumption and reduce the demand, distinguishing the user's behaviors and use practices [25].

On the other hand, the scientific literature argues that is the use practices by themselves which should be the subject of careful analysis because these tend to block the use in progressive and intensive patterns since they cover a wide range of factors and stakeholders. Thus, optimizing the connections between behaviors and energy efficiency measures is extremely important, since there is clear evidence which suggests that technical measures only have a low impact and require a higher cost of implementation if carried out without programs designed to encourage behavioral changes [26]. Political decision-makers and all the responsible society to implement energy efficiency measures, are essentially focus only in the instruments and not with the interconnections between them and the social behaviors, practices, and patterns of consumption that should be improved.

4. Case Study - InovGrid

Technologies and services provide smart solutions to energy customers that give control to the stakeholders to optimize their energy utilization, for building energy efficiency solutions. Furthermore, industrialized construction procedures will be a win-win scenario for a sustainable development, modeling, and prediction [27].

Applying efficient solutions like building and subsystems control and efficient lighting promotes solutions which make use of artificial intelligence by smart meters and monitoring enabled by computerized technologies. Hence, the grid, the building, and its inhabitants make use of data analysis, sharing the necessary information, facilitating real-time synchronization and promoting stability [28].

The “InovGrid” (Figure 2) is a project from the corporation “Energias de Portugal” (EDP), to the Smart Grids development [29]. The main aims are to increase energy efficiency, reducing costs and simultaneously growth the operative effectiveness, with the availability of the incorporation of decentralization and liberalization of the energy generation, and encourage the users to develop new energy amenities. The integration with the Smart Buildings, allow DSM features across monitoring and automation devices, that deliver user interfaces to the diverse stakeholders throughout all the energy generation, distribution and use procedures.

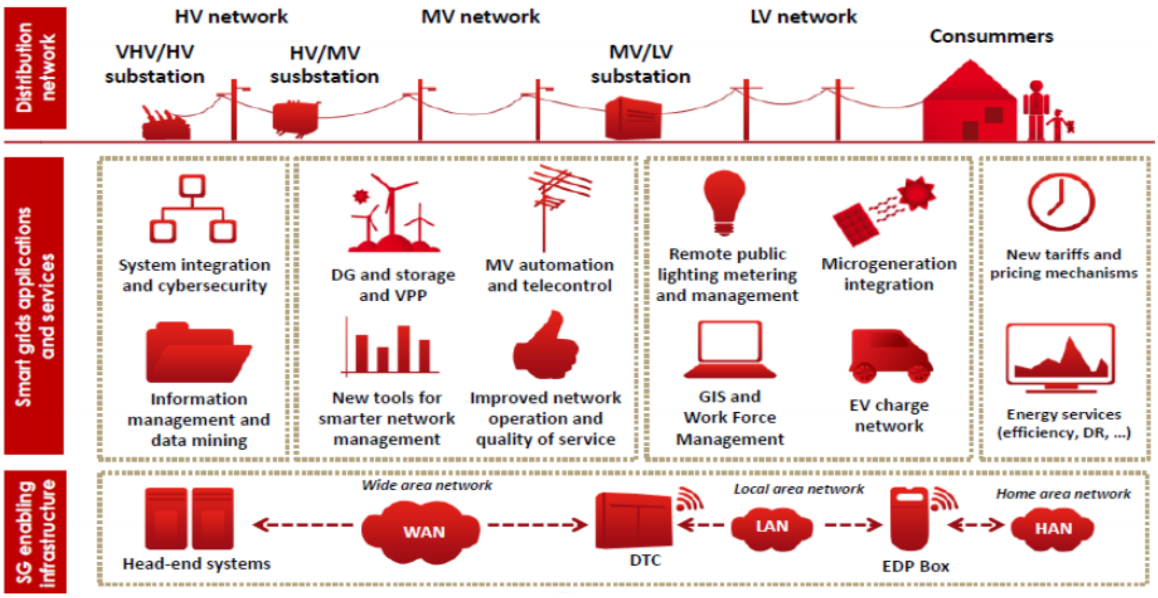

Figure 2. The InovGrid project, Smart Grid infrastructure [29].

These devices providing real-time information and management tools which reply to the grid signals, as well as allowing remote control by users. Furthermore, the monitoring devices allow data analysis, boosting the grid automation and new market solutions. The electric vehicles charging network energy flow is monitored by the “InovGrid” platform, allowing the flexibility of electric mobility management. The pilot project of the “InovGrid”, nominated “InovCity” was applied in the municipality of Évora, encompassing 30 thousand users. However, it is available in various regions encompassing 150 thousand users.

The “InovGrid” was supported by the European Fund to Regional Development in a consortium with public-private partnerships driven by the Portuguese law decree 363/2007 about energy microgeneration. The pilot project outcomes in Évora reach 30% of operational effectiveness gains, 15% fewer wastes which mean 45% energy efficiency gains [29]. One of the adopted measures was the public lighting systems in an efficient way.

5. Conclusions

Put forward innovation of how buildings and your stakeholders should cooperate in energy and resources transformation and use throughout all the building life cycle, rethinking all the pathways, insert the final customer in the top of the priorities pyramid which should contemplate the free and competitive market in the EU to offer support mechanisms to support an innovative ecosystem. The inefficiency in the final use drives to irrational tariffs and inadequate incentive policies, thus raising the need to shape synergies between research programs and innovation with the legislation and public policies.

A resilient environment, society, and economy, through responsible and sustainable demand management, promote an efficient supply, creating healthy ecosystems and ensures the sustainability of planet Earth and natural resources. Therefore, it is essential to foster research into dynamic and disruptive methods that advocate a set of ideas that encourage the promotion of voluntary and sustainable behavior by all building stakeholders, by promoting energy efficiency. Ensuring producer responsibility, as well as the development of educational information networks and the sharing of experiences among diverse stakeholders, are the greatest conducts to accomplish the sustainability of the built environment.

The consortiums between society, universities and enterprises should be improved so that the sources of knowledge do not focus exclusively on companies, to the society and enterprises not only left to manage by economic interests and think with the same importance in the social and environmental aspects. The introduction of the demand response in the electricity markets and building industry may reduce the economic and legislative barriers that prevent user's awareness of their energy demand. Monitoring and data analysis of the residential buildings alongside economic, social and environmental benefits to all the stakeholders. Thus, the requirement for new policies that adjust investments to DSM (energy efficiency, demand response and integration of energy from renewable sources), legislation and public policies should be put forward and sustained by search and research, innovation, communication and dialogue and not by economic lobbies that are willing to do everything to continue their linear economies that allow unsustainable profits. Didactic development in construction is essential seeing that legislation does not ensure the excellence of works.

Thus, DSM can improve monitoring not only new constructions but also support the rehabilitation plans of the built environment, reducing the fuel poverty, environmentally responsible, socially fair and economically feasible. The dissemination of the concept of the Smart Building with the integration of monitoring and automation technologies as well as new construction methods and processes are fundamental ways to support the EPBD review to put forward energy and resources demand response to assure that the correct indicators will be used not only for new buildings but also to rehabilitation.

The legislative evolution should optimize the reformulation processes to allow attain sustainability in a responsible way, since, energy efficiency became a business opportunity to the building industry. Thus, considering normative evolution and the current paradigm of the companies involved in the building's lifecycle and the entire real estate stock, it is necessary to develop new approaches to integrate various technologies and innovative processes which demonstrate high social and environmental performance. The circularity of these concepts promotes the sustainability of all energy networks, contributing to the growth of buildings with zero emissions, and can start an astonishing flexibility and temporal management of the legal regime for urban rehabilitation, contributing to the urban resilience to natural disasters and climate change.

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