# Sustainable development and energy sector regulatory models

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## ABSTRACT

The need for the inclusion of sustainable development issues in regulatory decision making highlights the importance to expand or modify traditional regulation models frequently used in some segments of the energy sector. These models have indeed been criticised on grounds of their emphasis on cost and financial efficiency. Aspects like the security of supply and climate change are major concerns of policy makers and must be properly assessed and integrated in the regulatory environment. The European Energy Regulators are already aware of the need to expand traditional regulation, beyond pure financial analysis. However, the sustainability concept is still strongly related to the environmental dimension alone and with the internalization of these externalities on the cost functions to be used. This paper presents a comparative study of different regulatory models in three European countries (UK, Portugal and Spain), focusing on the inclusion of sustainable development concerns on these models. This review indicates that regulatory authorities recognize the importance of the integration of the social and environmental dimension along with the economic one, but the formal design of such an integrated model is still emerging.

## INTRODUCTION

In the last 20 years there has been a liberalization trend of the energy sector (e.g. electricity, gas) with the aim of promoting competition, improving efficiency, reducing costs, increasing investment levels and lowering prices to consumers/users of these services. However, the empirical evidence demonstrates that these objectives not always have been achieved, raising doubts about the efficiency of this process (see, for example, [1], [2], [3], and [4]).

As this type of industry is characterized, at least in some segments of the value chain (especially in transport and distribution), by natural monopolies it is fundamental preventing that utilities´ companies take advantage of their monopoly power, charging a price above marginal cost. For these reasons, the role of economic regulation of network industries becomes increasingly important. Thus, regulatory authorities need a regulatory model to support the decision-making process, in order to protect users of these services, to assure the financial viability of operators and to contribute to the development of these industries.

According to [5], essentially, two models of regulation can be found in the literature: the cost plus regulation and the incentive regulation. However, these models have been criticised on

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grounds of their emphasis on cost and financial efficiency. The need for the inclusion of sustainable development issues in regulatory models highlights the importance to expand or modify these models, so that social and environmental issues are recognized as important targets of regulation ([6] and [7]).

Given the shortcomings just outlined, there is the need to develop a new regulatory model for the energy sector that includes the several perspectives of analysis and ensures: an adequate rate of return for regulated companies; the promotion of efficiency and reduction of costs; and sustainable development. In fact, there are recent developments in the literature (e.g. [8], [6], and [7]), arguing that regulatory authorities should assumed sustainable development duties. As [7] pointed out, social and economic regulations must be considered to ensure fair treatment of customers who lack the protection that comes with competition and is justified for markets not reflecting externalities and with imperfect information. Moreover, [9] argue that there should be a linkage between a country's energy policy and regulatory objectives in order to promote sustainable energy systems.

The combination of different objectives poses important challenges and creates additional complexity to traditional regulatory models. To tackle this problem, regulatory models must go beyond the traditional weighted averages ([10] and [11]). The combination of participatory multi-criteria methods with benchmarking tools and econometric techniques is fundamental to ensure a sustainable but also practical performance measurement methodology. A previous task necessary to the development of this type of model, is to conduct a comparative analysis of the existing regulatory models on different countries to assess how sustainable development issues have been integrated (or dealt with) in those models. More precisely, how social, environmental and financial criteria are being taken into account in the decision-making process at the regulatory level. Therefore, this paper's goal is to show the main findings of this comparative study, undertaken for three countries: UK, Portugal and Spain.

The empirical analysis focused on the energy sector (namely, electricity and gas). The required technical and economic data were taken, mainly, from official reports published by regulators, from financial and environmental reports of companies and from statistical documents produced by official bodies (e.g. EER, OFGEM, ERSE, CNE).

The remainder of the paper is organised as follows. Section 2 presents a brief description of the literature on regulatory models and sustainable development issues. Section 3 describes the research methodology followed in the study. In Section 4 the findings obtained are shown. Finally, Section 5 draws the main conclusions and presents possible avenues of future work.

## LITERATURE OVERVIEW

### Regulatory models

The current economic regulation issue gained importance in the context of the economic liberalisation process felt in several countries [12]. Economic regulation is needed because of the existence of market failures, and the most important ones are the following ([13], [14], and [15]). Firstly, externalities, i.e., actions taken by an individual (or firm) that influence others, either positively or negatively, without them having to pay or be compensated for those actions. The second form relates to problems of information asymmetry, where one agent has better information than other. For example, in the context of this study, the regulated firm has better information about is activities and costs than the regulatory authority. Finally, problems of competition, either motivated by behaviour of firms that lead them to obtain market power, or as

a result of technological constraints which lead to the existence of natural monopolies (in fact, industrial structures are determined by the technologies that characterize the respective industries).

Due to the natural monopoly character of some segments of the value chain of the energy sector (e.g. transmission/transport and distribution), regulatory authorities have a fundamental role in order to prevent market power abuses and to promote efficiency [12]. In fact, markets characterized by large economies of scale and a large proportion of fixed costs tend to evolve naturally to monopolies [14]. In other words, the formation of natural monopolies is facilitated by the existence of strong economies of scale and concomitant decreasing long-term marginal costs. Those are driven by four essential characteristics [16]: physical interconnection between the client and supplier, difficulty in storing the products, large variations in demand throughout the day, and the obligation to deliver the service. Therefore, the challenge for regulators is to ensure the most efficient price possible, in terms of resource allocation, while allowing companies to gain, at least, a fair return in order to remunerate their investments [17].

The difficulty of regulating natural monopolies arises from the fact that these companies exercise market power and cannot sell their goods and/or services at a price equal to marginal cost [18]. However, the issue of economic inefficiency emerge because the goal of efficient allocation of resources would lead the company to sell below their average costs, preventing the company of having economic viability. Given these two facts, the regulatory authority faces a difficult situation when trying to define the level and structure of prices. To [19], when defining regulatory models, regulators should take into account that these models should provide incentives to consumers to make their choices of consumption efficiently, and give regulated companies a sufficient return to cover the costs of providing its services.

The regulatory models found in the literature can be grouped into four categories: rate-of-return regulation, incentive regulation, yardstick regulation, and hybrid models of regulation.

Regulation by the rate-of-return, also known as cost-plus regulation, is a regulatory mechanism that ensures to the regulated company a return on invested capital for providing the service set [20]. The application of this type of regulation was a form of regulatory authorities round the problem of determining firms' marginal costs [5]. In this form of regulation, the regulated company is allowed to receive a fair return on their investments of capital, but cannot receive profits that go beyond that return, that is, the rate of return allowed is set previously [21]. So, the company can set their prices freely, provided that the income obtained is not higher than a fair rate of return. This form of regulation results from the compromise between achieving an efficient pricing and the ability of regulators to establish such prices.

This type of regulation has been subject to some criticism ([22], [21], [19], and [15]). Firstly, the regulated company can work inefficiently because it does not make investments based on the marginal costs of their inputs, but taking into account the return that these inputs will obtain within the regulatory process (this his known as the Averch and Johnson effect). On the other hand, the regulated firm is encouraged to expand into other regulated markets, even with losses in the long-run, which may discourage other companies to enter the market, even if they were more efficient. A second critic relates to the fact that, in this type of regulation, firms sell a quantity higher than what would be indicated by the equality between marginal cost and marginal revenue. Thus, companies tend to invest up to a point where they do not make a profit in order to the regulator enable them to obtain a higher return, charging higher prices for more inelastic demand. Finally, this form of regulation is difficult to implement, especially when the

regulated company supplies various markets, some being competitive and some others not. Thus, the regulated firm is tempted to include in the regulated market the assets that support its activities in both markets, upon distribution of costs for regulatory purposes. Therefore, consumers in regulated markets, by remunerating assets that are not related to the services obtained, are suffering an excessive cost that subsidizes the company in competitive markets and creates barriers to competition.

Awareness of the limitations of this type of regulation led to the emergence of new regulatory proposals, with an emphasis on the incentive to improve production efficiency, allowing companies to save part of the gains [23]. This type of regulation, known as incentive regulation or price cap regulation, is characterized by the fact that the regulatory authority is concerned, primarily, with the fact that firms produce efficiently, ensuring a level of profit that allows them to cover their total costs, and this implies an *ex-ante* definition of the price level ([15], [21]).

In practice, this form of regulation is a contract between the regulator and the regulated company, in which the maximum price (or prices) that the company can charge in the regulated market is established ([24], [9]). These maximum prices are set by the regulator according to factors that are external to the regulated firm (for example, the revenues/ income levels of similar companies). This avoids the connection between the company's costs and the regulatory process. Assuming that the company aims to maximize its profit, it will have an incentive to reduce their costs, as happens to a company in a competitive market.

One of the critics of this form of regulation relates to the fact that an incorrect setting of prices could create serious inefficiencies in terms of resource allocation, especially if companies' costs are not taken into account. Hence, in assessing the effects of this form of regulation, there is a need to analyse the profitability of companies which, in turn, is based on its costs. Therefore, price cap regulation is applied with some adaptations in relation to its original formulation, as proposed by [25]. In a simplified form, this type of regulation consists in defining an automatically adjusted formula, during the period of price control, based on price variation and the expected growth in productivity. Thus, the company's bundle of prices grows at a slower rate than the price index that serves as a reference, taking into account their expected productivity gains. Therefore, these are transferred to consumers. The growth rate of sales prices allowed will be equal to CPI-X, where CPI is the consumer price index and X is the expected gain in productivity. During the period for which the parameter X is set, the company can keep all the benefits from the reduction on its costs until achieve what is called the potential decrease in those costs - the X-factor. Since this is a dynamic process, the existence of that period encourages the company to lower its costs. After this period, the regulator assesses the real level of a company's costs and compares it with the price level to determine the adjustment to be made, and this adjustment will be introduced in the new price level. At this stage, the X-factor is also re-evaluated.

A third model of regulation is called yardstick regulation. In this form of regulation, first proposed by [26], the price is established after comparing the cost level of the regulated company with other similar companies. This methodology allows the regulator to bring prices to the level of costs of an efficient company, by comparison with other companies [27]. In this form of regulation, company's prices are not related to its level of costs, but with the average costs of the compared companies [28]. This comparison allows determining the costs that are not controllable by the company, because they are external to the sector itself, which reduces the risk of the regulated company. If Z stands for the change in non-controllable costs, when considering

these in the regulatory process, the variation permitted in regulated prices will be equal to CPI-X+Z.

The main advantage of this form of regulation relates to the fact that it enables a better simulation of the competitive process than the more usual version of price cap regulation, given that the yardstick regulation compares the revenues/income of the regulated company with the performance of the industry (or similar companies) and not with the company's performance in the past, which could discourage the company to lower its costs ([29], [31]). However, this approach has as main drawback, by considering for regulatory purposes the no-controllable costs by the company, the fact that these may constitute a disincentive for the regulated company to neutralise the risks brought in with those costs.

The last form of regulation presented corresponds to what is known as the hybrid models of regulation. These models combine features of price cap regulation with features of the rate of return regulation. In other words, these hybrid models seek to combine the benefits of a regulation that encourages the reduction of costs with another one that controls the allocation of resources, by offering a variety of contracts ranging in a continuum between the price cap and rate of return [21]. Thus, the most efficient company will choose a fixed price based contract and a less efficient company will choose a contract based on the reimbursement of costs.

Among the various proposals that have emerged in this context, only for illustration purposes, the model known as revenue sharing model is briefly explained. In this model, the implementation of profit sharing implies the establishment of a maximum and a minimum value between which the company may retain all the profits it generates for a given price level established. If profits exceed the maximum amount allowed, a portion of those profits will be transferred for consumers through a price decline. If profits are lower than allowed, the company can increase its profits through a revision of prices.

**Sustainable development**

Energy use and availability are central issues in sustainable development. Energy is essential for economic development and for improving society’s living standards. However, political decisions regarding the use of sustainable energy must take into account social and environmental concerns.

The most common definition of sustainable development is the one provided by the the Brundtland Report “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” [31]. In general, definitions of sustainable development focus on three main aspects: economic, environmental and social. As the World Bank [32] report states “Improving human well-being over time is a broader goal than increasing economic growth (..) social and environmental assets also affect human well-being directly”. Also [33] defines the concept of sustainable development as an attempt to combine concerns about environmental issues with socio-economic issues. [34], highlight the role of proper evaluation for sustainable development as an instrument to ensure and verify the integration of social, economic and environmental policies. This quest for integration makes the policymaking processes more complex and creates additional problems with the weighting of the different dimensions of sustainable development [35].

The thinking about social sustainability is not yet as advanced as for the other two pillars [32]. Until recently, sustainable development was perceived as an essentially environmental issue, concerning the integration of environmental concerns into economic decision-making [36]. For

example, for the particular case of the role of renewable energy sources (RES) to sustainable development, [37] support the view that much emphasis is being put on the environmental benefits while socioeconomic impacts have not received a comparable attention.

The three dimensions of sustainable development are intrinsically linked. As [38] recognises "Economies can only grow if they are not threatened by environmental catastrophe or social unrest. Environmental quality can only be protected if basic economic needs are fulfilled and individuals take responsibility for public goods. Finally, social development rests on economic growth as well as a healthy environment."

Under conditions of sustainable energy planning, the profitability of energy companies and the financial viability of energy projects become highly dependent on non-financial factors. The simultaneous assessment of economic, strategic, social, environmental and technical aspects is fundamental for making professionally correct investment decisions in any sector. However, it is particularly important for the energy sector, traditionally associated with large scale projects with strong and conflicting social impacts: on one hand, these projects are absolutely indispensable for the social welfare of the population but, on the other hand, they are frequently associated with environmental problems and have to deal with social opposition.

## RESEARCH PROBLEM

The integration of all sustainable development perspectives within a unique regulatory model is still not fully explored. Presently, energy regulatory models focus mainly on the economic perspective, aiming to promote competition and avoiding market power abuses and providing information on the technical and cost efficiency of the companies operating in the energy market. However, the integration of economic, environmental and social objectives is of paramount importance if sustainable development is to be pursuit. Ensuring a sustainable society for future generation rests, to a large extent, on designing and implementing sustainable energy system based on companies and regulatory models for the energy sector, regarded as cost-efficient, reliable, with a high quality of service, environmentally friendly and socially responsible.

It is argued, in this paper, that the responsibilities of the regulators should not be viewed in a narrow perspective. In fact, regulatory models should go beyond financial return maximisation, cost functions estimation and cost optimization. Therefore, a new regulatory approach is needed that encompasses economic issues as well as sustainable development concerns.

For that purpose, in the present paper a comparative study of different regulatory models for several European countries is presented, focusing on the energy sector, in order to assess how sustainable development issues are dealt with,. Special attention is given to UK, as a paradigm of the liberalization process in Europe, and to the Portuguese and Spanish regulatory systems. This analysis should be a valuable input to explore the possibility to explicitly include on the regulatory frameworks impacts related to the social and environmental dimensions of sustainability is explored.

The empirical analysis focused on the electricity sector, for the case of UK, Portugal and Spain. The required information was taken, mainly, from official reports published by regulators (e.g. EER, OFGEM, ERSE, CNE).

## FINDINGS

### The UK case

OFGEM is the Office of the Gas and Electricity Markets in UK. OFGEM duties include the protection of consumers, promotion of competition and regulation of gas and electricity networks. Besides these general duties, sustainable development considerations are also included on the general priority areas of this regulator, focusing both on: (1) the environmental dimension, mainly related to climate change and (2) the social dimension, strongly associated with the needs of vulnerable customers.

The Government support that some key aspects are essential for the achievement of a sustainable development system and as so, OFGEM is in charge of creating measures that will support this goal. According to [39] "The Government expects the Authority to look for opportunities, within its role and the scope of its powers, to facilitate the transition to a low carbon gas and electricity system in Great Britain". The document includes a proposal of measures to be supported by the Gas and Electricity Markets Authority, focusing on aspects such as:

- The improvement of the access to the electricity networks for new generation, including the identification of regulatory barriers to the achievement of RES targets.
- The ensuring of panning and preparatory work by network industries to better conciliate these plans with new generation capacity and to guarantee that network connection decisions can be made with clear knowledge of current and future network capability.
- The delivery of a regulatory regime for offshore electricity transmission.
- The secure of energy efficiency targets set by Government, ensuring the existence of appropriate incentives to the adoption of best practice energy efficiency measures along the energy value chain.
- The removal of unnecessary regulatory and market barriers to the economic deployment of low carbon and renewable distributed energy and heat technologies.
- The participation on the smart metering policy implementation, contributing this way to energy efficiency, to improve the operation of the energy supply markets, and to enable more advanced forms of dynamic demand management.
- The ensuring that consumers on low incomes are able to benefit from competitive markets, promoting the transparency in charging, the provision of information on comparative charges for different payment methods and the removal of unnecessary barriers to switching.
- The use of Impact Assessments to inform its regulatory decision-making, ensuring that social, environmental and economic factors are taken into account,

Taking into account these sustainability assignments, OFGEM is developing measures including sustainability indicators reporting, new regulatory models or the implementation of a social action strategy. Some of these measures are addressed below, with the aim of giving a brief overview of how this Authority is proceeding to address the sustainability goal for the energy sector.

OFGEM publishes regularly the progress of the energy sector towards sustainable development objectives, based on a set of sustainability indicators able to be measured quantitatively and grouped into five themes: Managing the transition to a low carbon economy; Eradicating fuel poverty and protecting vulnerable customers; Promote energy saving; Ensuring a secure and reliable gas and electricity supply; Supporting improvement in all aspects of the environment.

In line with the sustainable development duties, a proposal for the electricity distribution price control was also published [40]. The document addresses the economic efficiency and incentives and obligations on the distribution network operators to play a greater role in delivering social and environmental benefits. The proposal sets the capital allowance to these companies and assigns this value to investments related to both environmental and social sustainability, such as [40]:

-Environmental sustainability: working with others to develop technological and commercial agreements that will be able to accommodate in the grid the requirements brought by electric vehicles or microgeneration, and reduction of losses on the distribution grid.
- Social sustainability: improving interruptions performance, revising the interruptions incentive scheme to reflect better customers' willingness to pay for further service improvements, improving communication with worst-served customers, and assistance for vulnerable customers, introducing a new incentive based upon a broad measure of customer satisfaction.

On 2010, OFGEM published a document to implement a new regulatory framework, known as the RIIO model (revenue = incentives+innovation+outputs), addressing the challenges and opportunities to network companies operate on a sustainable, low carbon energy sector. This new framework is intended to encourage network companies to better understand the new and changing needs of consumers, to invest in new capital assets and new operating solutions, to undertake more technical and commercial innovation, to promote long term planning, to deliver economic and efficient network services, to develop new commercial relationships with users of the network and end consumers [41]. RIIO is a performance based model and intends to impose financial punishment to inefficient network companies and to create financial incentives to more efficient companies. An handbook was also published detailing the ‘how’ the RIIO model works in practice [42].

The social action strategy presents four main key themes involving OFGEM on the securing of compliance with regulatory obligations and effective monitoring and reporting of companies; on encouraging best practice among energy suppliers, using research to identify effective ways to address fuel poverty and help vulnerable customers; on influencing the debate about measures to help tackle fuel poverty, working with other stakeholders; and on informing consumers about ways to lower their energy bills. A document is published yearly providing an overview of the progress throughout and setting out the programme for next years (see [43] for example).

**The Portuguese Case**

In Portugal, the regulatory activity of the energy sector is committed to ERSE (Energy Sector Regulatory Authority). In the course of its activities, ERSE has as its mission[1]: "to appropriately protect the interests of consumers with regard to prices, service quality, access to information and the security of supply; to foster efficient competition, particularly in the context of building the internal energy market, thus guaranteeing economic and financial balance to the regulated companies within the framework of appropriate and efficient management; to encourage efficient energy use and protection of the environment; and also to arbitrate and resolve disputes, encouraging the settlement of disputes outside of the courts".

According to the understanding of ERSE "supervision of markets is an important aspect of the development of energy markets, particularly in a context of liberalization of the production and commercialisation activities, which requires an enhanced attention to the practices in the

[1] This subsection was written based on information available at ERSE website (www.erse.pt).

markets. Simultaneously, there is the need to assure the conditions that allow to replicate the benefits of competition to markets and consumers, and raises the need for close, effective and adaptive monitoring, given the current and future context of energy markets".

In this context, it is particularly relevant ERSE's role as regulator of the Portuguese energy sector. Put it simply, it can be said that two forms of regulation are used in the Portuguese electricity sector: the price cap regulation, applied to the activity of electricity distribution, and the rate of return regulation, which has been applied to the electricity transmission activity. The regulatory period is three years, and ERSE has to prepare the Tariffs Regulation Document. This sets the tariff structure, the allowed revenues for regulated companies, the procedures for setting, modify and disclosure of tariffs, as well as the obligations regarding the provision of information by companies. In defining tariffs and revenues, several factors are taken into account, including: the regulatory stability and transparency, market efficiency and confidence of the agents, the need to reflect the cost of providing the various services, and the right structure of marginal costs.

In what regards how sustainable development issues have been framed in the existing regulatory models, it is expressly foreseen, in the Portuguese Tariffs Regulation proposed for the 2012-12 regulation period, the "Contribution to the improvement of environmental conditions, allowing, in particular, greater transparency in the use of renewable and indigenous energy as well as the planning and management of energy resources". To accomplish these objectives, in the same document, the following regulatory instruments are foreseen:

- Incentives to promote environmental performance, embodied in the Plan for the Promotion of Environmental Performance (PPDA).
- Incentives to reduce energy losses. The reference level of losses is established, for each year of regulation, taking into account the goals set in the National Plan on Climate Change (PNAC).
- Incentives to improve quality of service, which aims to promote the continuity of electricity supply.
- Promotion of efficiency in electricity consumption, which aims to improve efficiency in electricity consumption. This incentive is embodied in the Plan for Promoting Efficiency in Consumption (PPEC).
- Incentives for optimizing the management of contracts for electricity.
- Incentives for optimal management of $CO_2$ allowances.
- Incentives for the availability of the transmission network, which aims to promote its reliability as a key component for quality of service associated with the performance of the transmission.

In the following paragraphs, a more detailed description of the incentives for the promotion of environmental performance (PPDA) and the promotion of efficiency in electricity consumption is provided.

According to ERSE, Plans for Promotion of Environmental Performance (PPDA) are regulatory tools to promote improved environmental performance of regulated companies operating in the electricity sector. The existence of these incentives is intended to ensure that economic regulation, to which companies are subject, does not have perverse effects in its environmental performance. ERSE also notes that PPDA can also function as a communication tool, helping to organize and highlight the activities of a particular company in improving its environmental performance.

ERSE notes that this concern is more important for companies subject to regulation by a price cap, which incentive companies to improve its business efficiency and allow them to appropriate part of this efficiency gains. As a result of this incentive for increased efficiency, companies could be tempted to reduce its investment in upgrading of networks or in maintenance costs with consequences on service quality or environmental performance. Hence, to minimize or prevent such behaviours PPDA are adopted. Even in activities regulated by the rate of return, ERSE argues that the PPDA has the advantage of allowing companies to make a prior assessment of the costs of environmental protection, thus foreseeing the need to be included in tariffs calculation.

In summary, with the adoption of PPDA is intended to achieve the following main objectives. Firstly, to minimize the effects that can be induced by certain types of economic regulation so that, together with cost reduction, companies are encouraged to take steps to improve their environmental performance. Second, provide an understanding between the company and the regulator on the exercise of corporate social responsibility on the environment. Finally, assist companies in environmental communication.

In practical terms, the PPDA of a company is composed of a set of measures to be implemented, over a given regulatory period, and only voluntary measures can be considered (i.e. measures which shall not be required by law). For each measure, the following elements have to be included: objective; description of actions to be taken; estimated costs; description of expected environmental benefits; performance indicators; and efficiency indicators. The costs of PPDA are included in the tariffs of use of infrastructure.

The PPDA began to be implemented since 2002. According to ERSE, it is estimated, for the period 2002-2008, that the impact in terms of tariffs to be borne by domestic customers is around 10 cents per month (or about 0.5% of the electricity bill). On the other hand, it is estimated that the weight of PPDA in the cost structure in the production of electricity is 1.6%. As for the amount of investment approved, and considering, as example, the PPDAs of 2008-2009 and 2009-2011, one can see that for the former the investment reached an amount of one million euros, while for the latter an amount of twenty-two million euros. Also, as example, these investments have been directed to the following measures, in descending order of importance: landscaping; corridors lines; protection of birds; electromagnetic fields; and environmental management.

A second regulatory instrument adopted by ERSE is the Plan for Promoting Energy Efficiency in Electricity Consumption (PPEC). Indeed, given the importance that energy plays in the growth and development of a country, an aspect that deserves attention is the impact that energy consumption might have on environmental destruction and degradation of quality of life.

According to ERSE, the electricity sector accounted for about 28% of the energy sector $CO_2$ emissions, in 2007, making it imperative the design and implementation of solutions that minimize environmental impact, particularly through the use of renewable energy sources, the use of cleaner fuels, and management of consumption.

Although developments in regulation and liberalization of electricity markets has led to greater efficiency in the supply side of energy, ERSE stresses that, as regards the demand side, there remain many barriers to increased efficiency in energy consumption, namely regarding the participation of energy companies in energy efficiency activities. More specifically, ERSE highlights that the existence of barriers to the adoption of more efficient equipment and consumption habits by consumers and the existence of environmental externalities not reflected in prices, justifies the implementation of measures to promote efficiency in consumption. As examples of these market barriers to efficiency in the consumption, ERSE highlights: an extended payback period on investment; the difference between supply prices and the short-run marginal costs; environmental externalities; lack of information and the associated transaction costs; misalignment of interests between sectors' agents; and financial constraints of consumers.

Given these constraints, ERSE adopted the Plan for Promoting Efficiency in Consumption (PPEC) of electricity, which has as its primary objective, to financially support initiatives that promote efficiency and reduce consumption of electricity in different consumer segments. These initiatives can be implemented by different agents or organizations, such as: suppliers of electricity; operators of transport networks and energy distribution; organizations that promote and protect the interests of electricity consumers; business associations; associations of municipalities; energy agencies; and institutions of higher education and research centres.

To have an idea of the importance of the initiatives undertaken in the context of PPECs, some data on applications to PPEC 2011-2012 and the results of applying the PPEC 2007, provided by ERSE, are presented. With regard to PPEC 2011-12, one hundred and sixty-five measures presented by forty-eight promoters were presented, totalling 58 million euros. This amount represented nearly the triple of the budget available. Of those applications, fifty seven measures have been approved and are being implemented by 20 promoters. It is expected that the social benefits achieved by the implementation of those measures are much higher than the costs. In fact, ERSE estimates that the beneficial effects of the measures implemented will extend until 2032, representing about 2,244 GWh of cumulative avoided consumption, which corresponds to the annual consumption of about 750,000 families.

Regarding the results obtained with the application of PPEC 2007, whose measures were implemented during the years 2007-2009, a summary of the main conclusions presented at a seminar organized by ERSE in February 2011, are presented. Thus, it was found that, overall, the objectives that were intended to achieve with PPEC 2007 were successfully achieved, since it was possible to double the expected savings and the avoided emissions of $CO_2$, at a cost lower than expected at around 7%. It is expected that, with all measures undertaken, by 2023, the consumption of 770 GWh of electricity will be avoided, which corresponds to the annual consumption of about 257,000 households, and 285,000 tons of $CO_2$ emissions, which is equivalent to those issued for about 127,000 cars in circulation for a year. Thus, it was concluded that the 2007 PPEC allowed benefits of 74 million euros, seven times higher than the 10 million euros invested.

In addition to these two regulatory instruments, ERSE has adopted two other tools that seek to emphasize the importance of awareness about the impacts of energy consumption on sustainable development. One relates to the labelling rules of electricity and the other with the disclosure of information, by ERSE, on the impacts of energy production/consumption in terms of climate change.

With the first tool, ERSE wants to achieve two objectives. On the one hand, to inform consumers about the product they are consuming, making the consumer more aware, especially, about the primary energy resources that are used to produce electricity and about the environmental impacts associated with the supply. This makes the customer more responsible for its consumption choice. On the other hand, to allow differentiation between retailers, promoting competition in the retail market. Thus, there are legal provisions establishing the obligation of all electricity traders to include in bills information about the origin of electricity purchased and sold to its customers and the environmental impacts associated with providing their electricity.

The second tool (disclosure of environmental impacts of the electrical system, particularly with regard to climate change) resulted from the realisation by ERSE of a high interest, by several agents, on information about greenhouse gas emissions gases. Thus, ERSE makes available on its website information collected on the national electricity system and its emissions of carbon dioxide ($CO_2$).

### The Spanish Case

The National Energy Commission (CNE) is the regulatory body for the energy systems in Spain. Its objectives are "to monitor efficient responsibility in the energy systems and operational objectivity and transparency, to the benefit of all those individuals who work in these systems as well as consumers" (www.cne.es). The functions of CNE include, among others, the defining regulation to execute legal frameworks for the energy sector, presenting proposals in the field of energy planning, tariffs and payment terms, monitoring the energy markets to ensure free competition and resolving conflicts.

The 2009 CNE plan defines the main tasks and actions to be taken on short and medium term, some of them clearly related to the sustainability requirements of the energy sector, namely ensuring of quality and security of the energy supply, contributing to the rational use of energy, promoting participatory processes involving stakeholders and informing and protecting consumers.

Concerning the environmental dimension, the action of CNE is strongly supported by the regulation and Spanish legal framework, creating, for example, cost incentives to electricity distribution and supply companies, developing programs to promote better energy services and energy efficiency among consumers. As for the transportation and distribution network, the installation procedures must ensure the adequate environment protection and an environmental impact evaluation must be performed addressing the main environmental and socio-economic impacts.

## CONCLUSION

Ensuring a sustainable society for future generations rests, to a large extent, on designing and implementing a sustainable energy sector. This work aimed to analyse the inclusion of sustainability concerns on the regulatory frameworks of the energy sector. The research addressed, in particular, the cases of UK, Portugal, and Spain.

The results put in evidence that much of the sustainability issues are still largely focused on the environmental dimension. However, the need to expand the concept beyond the ecological concerns and fully recognise and to integrate the social dimensions of sustainability, is also now generally accepted by regulatory authorities. Some examples of these cross countries social concerns are: ensuring universal access to the electricity service, based on fair tariffs; protecting vulnerable consumers; and promoting participatory process and involvement of stakeholders.

As for the environmental dimension, the intention to promote friendly environmental practices among regulated companies is underlined by all the regulatory authorities. Tools and actions have been already implemented by imposing regulatory obligations to companies or by creating new frameworks and regulatory models, ensuring financial incentives to more sustainable companies. The environmental component has been assessed by regulated companies' reports, justifying their measures and allowing for the inclusion of the environmental costs on the regulated tariffs. However, a formal cost-benefit analysis is not yet a common practice and the non-financial or non-quantitative dimensions of the environmental and social objectives are recognised as more difficult to include in the regulatory process.

Although recognising the major challenges associated with the integration of economic and sustainable development issues in a unique regulatory model, the future work aims to explore an innovative regulatory framework for the energy sector which would simplify the regulatory decision making process . This new regulatory model should aim to result in an instrument for a sustainable regulatory policy, which means the integration of three objectives of sustainable development: economic growth, environmental sustainability and social responsibility.

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