



## Article

# Exploring the Critical Barriers to the Implementation of Renewable Technologies in Existing University Buildings

Joaquín Fuentes-del-Burgo <sup>1,\*</sup>, Elena Navarro-Astor <sup>2</sup>, Nuno M. M. Ramos <sup>3,\*</sup>  and João Poças Martins <sup>4,\*</sup> <sup>1</sup> Escuela Politécnica de Cuenca, Universidad de Castilla-La Mancha, 16071 Cuenca, Spain<sup>2</sup> Escuela Técnica Superior de Ingeniería de Edificación, Universitat Politècnica de València, 46022 Valencia, Spain; enavarro@omp.upv.es<sup>3</sup> CONSTRUCT-LFC, Faculty of Engineering (FEUP), University of Porto, 4200-465 Porto, Portugal<sup>4</sup> CONSTRUCT-GEQUALTEC, Faculty of Engineering (FEUP), University of Porto, 4200-465 Porto, Portugal

\* Correspondence: Joaquin.fuentes@uclm.es (J.F.-d.-B.); nmmr@fe.up.pt (N.M.M.R.); jppm@fe.up.pt (J.P.M.)

**Abstract:** For more than a decade, the European Union has been implementing an ambitious energy policy focused on reducing CO<sub>2</sub> emissions, increasing the use of renewable energy and improving energy efficiency. This paper investigates the factors that hinder the application of renewable energy technologies (RETs) in existing university buildings in Spain and Portugal. Following a qualitative methodology, 33 technicians working in the infrastructure management offices of 24 universities have been interviewed. The factors identified have been classified into economic-financial, administrative and legislative barriers, architectural, urban planning, technological, networking, social acceptance, institutional and others. It is concluded that there have not been sufficient economic incentives to carry out RETs projects in this type of building. Conditioning factors can act individually or jointly, generating a greater effect. Most participants consider that there are no social acceptance barriers. Knowledge of these determinants can facilitate actions that help implement this technology on university campuses in both countries.

**Keywords:** barriers; energy efficiency; renewable energy technologies; university building; energy performance of buildings directive (EPDB)



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## 1. Introduction

About 40% of the world's final energy is consumed in the building sector [1–3], while in the European Union (EU) it accounts for 40% of final energy and 36% of total CO<sub>2</sub> emissions from its Member States [4,5]. In view of these data, policies have been designed to promote energy saving measures that improve the energy efficiency of existing buildings [5,6].

The EU has made great efforts to meet the objectives set out in the EPDB Directive 2010/31/EU [4,7], turning energy and climate policy into cornerstones of EU policy [8].

Although it is essential to achieve the objectives set out in the Energy Performance of Buildings Directive (EPBD) Directive [4], the size of a country's real estate is much larger than that of new buildings [2,9,10]. In fact, existing buildings cover around 75% to 85% of the building stock today and in the next fifty years [11]. In addition, a many of the existing buildings consume more energy than the new ones as they do not comply with the energy requirements established in the new regulations based on the EPBD directives [12].

Publicly owned buildings represent a significant percentage of the real estate surface, around 12% in the case of the EU [4,13]. According to Bertone et al. [14], most public buildings were designed and built without taking energy consumption into account, therefore generating a significant impact on social, environmental and economic sustainability [2].

With this background, improving the energy efficiency of existing public administration is an important step towards reducing their environmental impact [2]. In Europe, there is a growing concern and awareness of using sustainable construction strategies, measures and solutions in buildings, both new and renovated [15].

Europe's public buildings include a large number of university buildings for classrooms, laboratories, offices, sports halls, university residences, etc., with high energy consumption for diverse purposes such as lighting, heating, ventilation, air conditioning and for the operation of the equipment [16–18]. Moreover, university campuses are usually large facilities, with a relevant impact on local energy consumption in the cities in which they are located. On the other hand, they are occupied and visited by large numbers of people, so any sustainability-related measures adopted in these buildings can increase the population's awareness of these issues and affect their own decisions towards implementing energy-efficient solutions elsewhere. Thus, adopting renewable technologies in university buildings can produce direct and indirect effects on the sustainability of cities, as promoted by UNSDG 11, and on the sustainability of other facilities, as promoted by UNSDG 9 [19].

Reducing energy consumption by installing RETs could be considered an energy-saving measure [20–23]. The use of these technologies in existing buildings could offset their energy balance, reducing the emission of CO<sub>2</sub> and other polluting gases, thus helping to achieve the European directives' objectives and reducing their environmental impact [9,24–26].

Within the framework of the Europe 2020 Strategy [27], whose objectives have been expanded with the 2030 Climate and Energy Framework [28], focusing on RETs in existing university buildings [29], the objective of this research is to identify the different types of barriers the objective of this research is to identify the different types of barriers to the implementation of RETs in existing university buildings. For this reason, semi-structured interviews have been carried out with technical professionals who work in the maintenance offices of university infrastructures in Spain and Portugal.

The structure of the article continues with the literature review, the description of the qualitative methodology used, and the analysis and discussion of the results, and it ends with the conclusions.

## 2. Literature Review

Despite the advantages of using RETs in new and existing buildings, a series of barriers have arisen that have slowed down their adoption, arousing the interest of scientists and politicians [22,30]. Some barriers have already been identified by the European Commission itself—pointing out the poor application of current legislation, administrative procedures, accessing existing networks or the implementation of adequate measures by the Member States to guarantee their growth, among others [31]. These factors may be specific to one type of technology, while others may be specific to a region or country [32,33].

The literature classifies the factors that influence RETs development and installation in various ways. Some classifications try to cover all types of RETs, while others focus on some type of energy and/or technology (solar, wind, photovoltaic, thermal or geothermal) or on a specific country or region [33–39].

The number of factors and their grouping varies from one author to another. Beck and Martinot [34] include economic and regulatory factors, institutional disadvantages, lack of skills and information, and technological biases. The exhaustive list by Klessmann et al. [36] encompasses economic and market factors, legal and administrative factors, related to networks, lack of experienced labor, and information and acceptance barriers. Sidiras and Koukios [35] find that the main barriers for solar thermal installations are cost, installation difficulty, lack of energy saving incentives, short product lifespan and poor quality of materials and aesthetics.

Regardless of the number of factors that condition RETs use and their classification, their multidimensional nature is outlined [37]. If these technologies are to be applied to the building sector, new conditions must appear with different weights and treatments depending on whether they are applied to new or existing building, as well as their use, due to the different energy consumption profiles [40].

A number of economic and financial factors have been pointed out. Among the economic barriers, the high cost of RETs [41–43] stands out, particularly in building-mounted systems [6,44]. Regarding financial barriers, there is the need for a high level of initial

funding, fewer financial resources, the lack of adequate financing, high financing costs, the absence of adequate structures to facilitate investment, increased credit risk perception, and long investment recovery periods (long payback periods) [7,10,21,25,33,34,45].

Likewise, existing barriers relating to network connection have been documented, mainly electric power, where it is difficult to obtain access due to factors such as not being open to renewable energies, lack of transparency in procedures, and long time periods to obtain the permit or lack of network capacity [36]. Related to the above, a European Commission [46] report indicates that renewable energy producers in different Member States have problems with regulatory procedures.

Social acceptance is a factor that also influences the use of RETs. It includes multiple personal, psychological and/or contextual elements. Furthermore, perceived utility, intention to use, installation conditions, cost, trust, place and people's position in relation to the renewable energy used play an important role [38]. Moreover, not all RETs are treated equally, as there is more local opposition to the development of one type of project compared to others [39]. Social acceptance barriers have also been explained by attitudes such as "not in my back yard—NIMBY", which can be determined by feelings of fairness, justice, selfishness or ignorance [47].

Considering the set of barriers to RET implementation, their identification and classification is essential. This will allow the design of appropriate approaches and policies [24], which in turn will facilitate the installation of this type of equipment in existing university buildings.

### 3. Methodology

Qualitative research is a rigorous and internationally recognized method of social research that has been recently used in research related to building energy [48–52], proving its usefulness in studies on drivers and barriers to RET adoption [30].

This research is an exploratory study through semi-structured interviews, to allow the participants the freedom to give their opinions and experiences [53]. The data collected provide specific information on relevant aspects of the RETs, the adequacy of policies and the barriers that appear in this environment, instead of quantity, proportion or magnitude of factors [49,54]. The research does not intend to generalize the results among populations but rather to collect data that clarifies the study phenomenon based on the opinions and experiences of the technicians who work in the infrastructure management offices of the universities of Spain and Portugal [33,50].

These professionals have been chosen because they are the ones who intervene in the entire life cycle of any project that affects university's real estate. In addition to being responsible for real estate maintenance, they are familiar with their individual problems, the current conditions of the buildings, and factors related to their use on a daily basis. No requirements have been established regarding their academic qualification in order to participate in this research, since each university freely decides when recruiting them.

Participants' citations are identified with a number together with the letters E (Spain) or P (Portugal), to identify the country of origin [21].

The research has focused on Spain and Portugal due to the fact that they constitute a very well defined geographical and climatic unit in the Iberian Peninsula [55] and to the common characteristics that both countries share in the EU [56].

The script of questions for the interviews was developed based on a literature review [39,57]. As the number of interviews progressed, new factors appeared in participants' responses, causing questions to be added or removed from the initial questionnaire [58]. Considering that Directive 2012/47/EU was in force during the period of time in which the interviews were carried out, the questions asked were the following:

1. What is your opinion on Directive 2012/27/EU of the European Parliament where it establishes the reduction of CO<sub>2</sub> emissions by 20% and the increase in the use of renewable energies by 20%?

2. I am going to ask your opinion about the existence of a series of barriers that can affect the integration of renewable energy technologies in university existing buildings:
  - What are the financial barriers?
  - What are the technological barriers?
  - What are the barriers in connecting to existing networks?
  - What are the regulatory or administrative barriers?
  - What are the social acceptance barriers?
  - What are the architectural barriers?
  - What are the urban planning barriers?
3. If you think there are other barriers, please describe them.

Two different strategies were followed for the interview format. Face-to-face interviews were carried out if the distance by road was less than 300 km, or if there was a combination of high-speed trains between Cuenca (main author's residence) and the destination city. The second strategy consisted of telephone interviews when the above conditions were not met. In the case of the Portuguese universities, there were difficulties in arranging telephone interviews with technicians, so it was decided to do all the interviews face-to-face. Table 1 shows the type of interview and the universities that took part in the research.

**Table 1.** Participating universities and type of interview conducted.

Country	Face-to-Face Presential	Telephone Interview
Spain	University of Castilla-La Mancha	University of Oviedo
	Polytechnic University of Madrid	University of Málaga
	University of Valencia	University of Santiago de Compostela
	University of Zaragoza	University of Vigo
	University Juame I	University of Cantabria
	University Carlos III of Madrid	University of Valladolid
	University of Córdoba	Polytechnic University of Catalonia
	Polytechnic University of Valencia	CEU Cardenal Herrera Oria University
	National Distance Learning University (Madrid)	University of Mondragón
		University of Las Palmas de Gran Canaria, University of La Coruña
	University of La Laguna (Tenerife)	
Portugal	University of Porto	
	University of Lisbon	
	Lusófona University	

The process of finding the technicians from the different universities, establishing contact with them and interviewing them was complicated and time-consuming [21]. Hence, the data collection phase lasted for a period of 27 months [30], taking place from May 2017 to August 2019.

In total, 26 universities were contacted in Spain and six in Portugal, of which 21 in Spain and three in Portugal agreed to participate.

As mentioned, different methods were used during the data acquisition process. Sixteen individual face-to-face interviews, two group personal interviews, and twelve telephone interviews were conducted [48,52]. The reason for this mix of methods was the location of the interviewees, the availability of the participants, or the country [59].

In total, 33 technicians were interviewed: 30 from Spain and 3 from Portugal. Given the exploratory approach of the research, Guest et al. [60] (p. 79) state that "for most research projects, . . . , in order to understand common perceptions and experiences among a group of relatively homogeneous individuals, 12 interviews should suffice".

Initially, participants were asked to provide information on their age, gender, academic qualifications and years of experience in the position (see Tables 2 and 3). Twenty-eight men and five women participated. Their qualifications cover a wide range of disciplines [25]:

six are architects, seven industrial engineers, one is a mining engineer, one is a computer engineer, one is an industrial organization engineer, five are building engineers, one is a maritime engineering graduate, one is a statistics graduate, one is a political science graduate, five are industrial technical engineers, three have a baccalaureate and one has a vocational training certificate.

**Table 2.** Participants' age.

Age (Years)	Number of Participants
From 30 to 34	1
From 35 to 39	6
From 40 to 44	5
From 45 to 49	6
From 50 to 54	4
From 55 to 59	4
From 60 to 63	7

**Table 3.** Years of experience in the job.

Years of Experience in the Position	Number of Participants
Less than 5	6
From 6 to 10	7
From 11 to 15	3
From 16 to 20	6
From 21 to 25	1
From 26 to 30	7
More than 30	3

The same list of questions was used [61] in both telephone and in-person interviews. The interviews, including those conducted in Portuguese, were recorded and transcribed verbatim and fully into Spanish [61]. The average duration of the in-person interview was 32 min, the telephone interviews were approximately 26 min and the group interviews took around 39 min.

Creswell's proposal [62] was used for the analysis. It consists of six main steps: data organization and preparation for analysis; data reading repeatedly to get its general sense; coding; description of the environment; contextualization and location of links between topics; and, finally, data interpretation.

The ATLAS.ti v.8.0 program was used throughout the data coding and interpretation process.

Open coding was used, which allowed for the categorization of concepts, and the establishment of common themes and patterns through careful examination of the data [50,63]. In this phase, the use of constant comparison of the data contained in the text segments [64] was essential, which made it possible to refine the concepts, identify their properties and explore their interrelationships [65]. Common patterns appeared that formed different categories and relationships between them, and that allowed for grouping of the text segments into specific analysis constructs [65,66].

Although perceptions of the effect and importance of barriers vary among participants [24], differences between responses are also part of the results [57]. The analysis reflects what respondents consider important at a specific point in time [57].

## 4. Results and Discussion

### 4.1. Opinion on Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012

All participants are aware of the objectives of reducing total greenhouse gas emissions by 20% and achieving 20% energy consumption renewable in 2020. They are conscious of the need to reduce energy consumption and polluting emissions. Even so, they express varied opinions, considering these objectives as “very or too ambitious” (No. 1E and 8P), “necessary” (No. 18E), “very necessary” (No. 21E), “very important” (No. 28P), “praiseworthy” (No. 5E), “A utopia” (No. 3E), “difficult to achieve” (No. 5E) or “insufficient” (No. 9E). Some also emphasize the importance of increasing the implementation of RETs in university buildings. More than half believe that it will be very difficult to achieve the targets proposed in Directive 2012/27/EU [67].

Several respondents believe that Public Administrations should set an example in the implementation of these measures in its buildings, especially the University: “It is mandatory from an ethical point of view and beneficial for society. It is the responsibility of the Administrations to contribute to this change” (No. 23E). This opinion is reflected in the Energy Efficiency Plan 2011 [13], according to which the public sector should promote an exemplary role, accelerating the pace of public building renovation, leading to high levels of energy performance.

Few participants affirm that this type of policy should have begun to be applied earlier, pointing out that the targets imposed should have been higher. They recognize that these objectives seemed impossible to achieve at first, but with recent technological developments, they are now achievable. Some were unaware that the first Energy Performance of Buildings Directive (EPBD) was approved in 2002 [68], since all referred to the subsequent reworking published in 2010 [4], which expanded the objectives of the original directive [5,69].

Some interviewees believe that deadlines for reducing emissions and implementing the technologies have been short and, as there are no intermediate milestones to verify the degree of scope, policy application has not been easy. In this regard, they are unaware that the Energy Efficiency Plan 2011 provides that the European Commission would present a legal instrument requiring public authorities to renovate at least 3% of their buildings (by surface area) every year [13].

Regarding the common percentage marked throughout the EU, the differences between the countries is pointed out and how these circumstances can affect the achievement of the targets: “that is one of the problems, which is about unifying and we cannot have the same peculiarities that Norway or Germany have” (No. 4E). They identify differentiating factors such as culture, climate, existing infrastructures and/or the country’s economic situation.

In their opinions, the participants acknowledge that politics and economics have affected the Directive implementation. At the political level, several Spanish technicians consider that there has been no will to achieve the objectives due to the lack of coordination between the different public administrations or the approval of laws that did not facilitate or delayed the implementation of some technologies, such as the Personal Consumption Royal Decree 900/2015 [70]: “The tax on the sun. It is that the position of these (electricity) companies and the government is detrimental to this being possible” (No. 16E).

Another factor associated with politics is the difference between the terms set by national governments, which work under the perspective of a 4-year legislature, versus the 10 or 20-year terms established in the directives. This gap means that the priorities and the degree of achievement of the results are not aligned.

It is also identified that, when establishing a common energy policy in the directives, some countries have not been aware of the economic investment necessary for its development: “My opinion, as a technical manager with 25-year experience in a public university, is that the Public Administration will find it difficult to attain those values, if not more involved: It’s complicated” (No. 12E).

The participants report that in a proposal as important as this one, with such a large existing building stock, there has not been an economic policy that helps to achieve the objectives. As noted by Curtius [30], insufficient government incentives are a barrier to development in adopting integrated photovoltaic energy in buildings.

In addition to the lack of financial support, they consider that the way to achieve the targets or what to do has not been adequately specified: “One thing is to put on paper everything you want to do, and another thing is to tell us how to do it in the day to day” (No. 15E). Although the EPBD requires minimum standards in the case of major renovations of existing buildings, according to Rosenow and Kern [69], meeting the energy performance requirements of building codes in rehabilitation actions can be problematic.

Finally, all the participants point out that the recession has negatively impacted the development of both Spain and Portugal: “we came out of a major crisis with a population who had made a lot of sacrifices. Achieving everything at once is very difficult” (No. 8P). Furthermore, different member states, in particular those most affected by the 2008 international recession, have reduced or eliminated support schemes for renewable energies [71].

#### 4.2. Barriers to the Implementation of TERs in Existing University Buildings

Participants’ answers to the specific questions about factors that may act as barriers to RETs installation are detailed below. Being related to each other, some barriers do not act in isolation. The combined impact of several barriers can have a significant negative effect on the implementation of these technologies [72]. In any case, the barriers place RETs at a relative disadvantage compared to other forms of energy supply [34].

##### 4.2.1. Economic-Financial Barriers

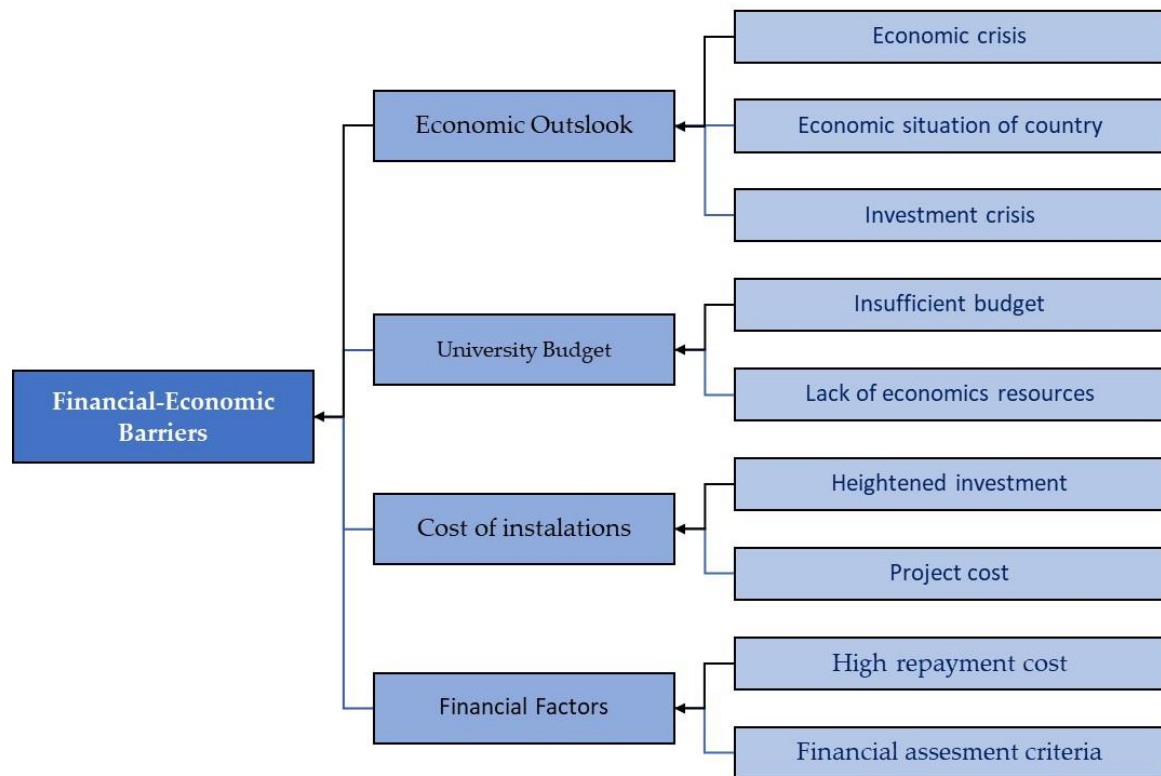
All those interviewed point to the economy as the main barrier that conditions RETs implementation in university buildings. This barrier has, in turn, different components shown in the responses: high investment, the cost of the projects, the country’s economic situation, the economic crisis, the investment crisis, the financial assessment criteria, high repayment terms, insufficient budgets or simply the lack of financial resources. As Figure 1 shows, these could be grouped into four interrelated categories: the national economy, university budgets, the cost of facilities and financial factors.

There is a direct relationship between the different economic components mentioned. The cost of the projects is related to the investment that the universities have to make, as well as their financial capacity and/or the availability of funding to tackle them. As Nasirov et al. [33] point out, economic and financial barriers act as a key obstacle for the development of RET’s projects.

Although some participants acknowledge that the cost of certain technologies, such as photovoltaic modules, has gone down, the investment required and the initial financial cost continue to be very high [25,73].

Hiring specialized personnel to maintain said facilities is also identified as a cost, which increases the repayment period. As stated in Yaqoot et al. [74], the hiring of personnel for maintenance services is considered as one more barrier.

On a financial level, these projects are usually assessed based on their repayment term or based on economic benefit criteria. As a condition of viability, it is usually imposed that the repayment be as short as possible, as participant No. 27P summarizes: “Here a great effort is made by the technicians who prepare the project to demonstrate that it can have an average payback of 7, at most 15 years for a great project”. The combination of long repayment terms and low profits derived from the energy generated, in the face of high investment costs, means that university management does not consider these projects economically attractive [6,45].



**Figure 1.** Factors considered as economic-financial barriers.

The payback period is directly related to the amount of energy generated by the RET, clearly a technological factor. In this sense, several variables are cited that directly condition the repayment period, such as the low performance of the facilities, the availability of the energy resource (wind, solar radiation, outdoor temperatures, etc.), the geographical location, the characteristics of the urban environment where the building is located, the amount of energy used in the building and its price in the energy marketplace.

To implement the RETs, some universities have had to request a “lease”; participate in calls for regional, state or European aid for this type of project; or seek aid through contracts with energy companies. The general opinion is that there are not enough external aids or subsidies for these actions.

More than half of the sample of Spanish public universities confirm that they do not have a budget for these projects: “the regional government considers that in the budget it gives us for the operation of the University everything is already included” (No. 2E). They relate the political decisions adopted by the autonomous governments to the economic restrictions to implement RETs.

In both countries, reduced budgets and lack of funding for universities are associated with the economic situation of the individual states and the economic crisis suffered. Furthermore, the financial crisis has also had a negative effect on the availability of funds provided by the banking sector [39].

#### 4.2.2. Administrative and Legislative Barriers

Many interviewees who have been involved in the entire process of administrative concession, legalization and/or execution of an RET project in their universities, identify the associated bureaucracy as a barrier, although some do not consider it insurmountable. As stated in ürge-Vorsatz et al. [75], regulatory barriers make it difficult to implement RETs in buildings.

This bureaucracy depends on the country and its energy policy. The participants from Portugal do not currently acknowledge administrative or legislative barriers to RET implementation in their country. In Spain, one participant describes RET projects carried out in the



first decade of the 21st century, taking advantage of the facilities and aid established in the Renewable Energy Promotion Plan and the legislation approved in those years [76].

Based on their experience, more than half of the sample acknowledged that the procedures are numerous. For some it is a serious barrier: “they are an insurmountable problem” (No. 19E), and others recognize the difficulty of the process describing it as “laborious” (No. 20E), “complex” (No. 15E), “complicated” (No. 12E) or “heavy-going” (No. 23E). Several consider that the procedures can be solved by increasing the human and technical resources of the university destined to these projects, assuming that there will be a delay in project execution.

In Spain, due to the decentralization of the administrative system, the participants recognize the problems of RET projects due to the numerous legislations that they have to consider at the national, regional and local levels [77], as well as the regulations of electric suppliers, in the case of photovoltaic installations. This was pointed out by Coenraads et al. [78] when the number of authorities involved in obtaining construction permits for these projects was high. As Byrnes et al. [43] discussed, legislative processes must be rational, both within and between the different administrations.

In addition, the lack of communication between different Public Administrations (state, regional and local) has been identified throughout the administration of tendering procedures, legalizations, etc., aggravated by the lack of interlocutors to facilitate said communication. In this sense, the impossibility of clearly identifying the professional roles involved and the lengthy procedures are regulatory deficiencies [14]. This situation restricts the development of the RETs, poses a risk to the project during the development phase [33] and may cause a significant delay in the commissioning of the facilities [32].

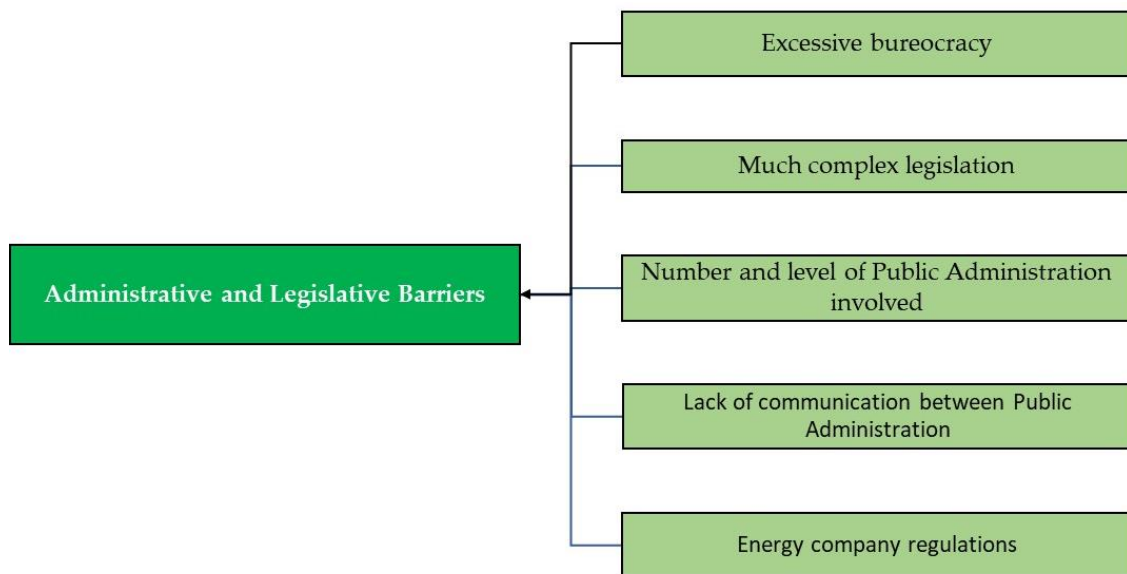
Another negative factor is the complexity of the legislation, which makes it difficult to interpret, as well as the rigidity associated with its compliance. In the responses of the Spanish participants, Law 9/2017 on Public Sector Contracts [79] is repeatedly cited as an added problem that involves more workload for them, as stated by technician No. 23E: “the Contract Law itself makes any type of project very heavy-going, very complicated”. As new laws appear, doubts about their interpretation, the complexity of their analysis [80] and the lack of experience in their application can become an administrative barrier that limits, slows down or prevents the development of these projects. Some of these barriers appear at Figure 2.

There is unanimity that the public bidding processes for the supply or work related to the implementation of RETs in university buildings are very complex and require a trial and error process to meet all the necessary requirements.

Based on the need to reduce CO<sub>2</sub> emissions and improve the existing building stock, some interviewees hope that the entire bureaucratic process associated with RETs implementation will be simplified in the future.

There seems to be an important difference between the countries investigated at the energy policy level. In Portugal, the participants acknowledge that the policy favors the implementation of photovoltaic solar installations. In the case of Spain, the problems highlighted by Coenraads et al. [78] persist, and the administrative authorization procedure depends on each region and is not harmonized, with regulatory differences between the 17 autonomous communities.

The greater or lesser difficulty of drafting, processing and implementing RETs projects is linked to the applicable national legislation. In Spain, during data collection there was a change in the law that governed the production and supply of electrical energy through self-supply systems. With the first Royal Decree 900/2015 [70], the participants affirmed that the bureaucratic and technical procedures were very complicated, making it difficult to implement photovoltaic solar installations: “Legalising a photovoltaic installation is a hassle” (No. 19E). However, the new law, Royal Decree 244/2019 [81], is more flexible and does not impose as many requirements as the previous one, which changed the perception of those interviewed: “the problems have greatly diminished” (No. 20E).



**Figure 2.** Factors considered administrative and legislative barriers.

The situation described is a clear example of how a law approved according to a specific energy policy can become a barrier for the development and implementation of certain RETs, such as photovoltaic installations in this case. Thus, legal instability negatively affects the development of RETs [77], as it generates a risk associated with the level of reliability and continuity of state policies [30]. Frequent policy changes aimed at promoting RETs discourage widespread adoption of technologies [82].

#### 4.2.3. Architectural Barriers

This section includes factors that can prevent, hinder or involve an increase in the cost of execution in the implementation of RETs. Quite a few participants consider that architectural barriers are an extra cost in these projects. One even supports that “the architectural barrier hangs over the economic one, there is no architectural barrier if there is money to do the installation” (No. 18E). Thus, some architectural barriers could be eliminated with the necessary budget, transforming the architectural factor into an economic one.

More than half of the sample considers that buildings’ age can be a problem for the implementation of RETs. It involves a technical complexity added to the project, which can be solved with an increase in the cost of execution, due to the works to be carried out and the auxiliary equipment to be used: “we have old buildings, not protected, but old or of poor construction quality, so we need to carry out more work than planned” (No. 31E). This is confirmed by Dadzie et al. [83], who found that investing heavily in renewable technologies when buildings are old is considered uneconomical as the cost of implementation exceeds the savings attained.

Some respondents highlight that one of the main difficulties to be solved is the integration of RETs without negative impact on the building, especially in buildings classified as heritage or those with a special design. Historic buildings impose limitations when it comes to maintaining their authenticity [84]. To solve this problem, they propose to move away from standard solutions and to carefully study the options offered by the different technologies to choose the one that best suits the building and its environment. As participant No. 25E affirms: “you have to have imagination.” Each RET project in existing buildings is unique and requires a careful study of possible solutions on a case-by-case basis [22].

Factors have also been identified such as the difficulty of adapting certain technologies to buildings depending on the materials used in their construction, the future conservation of the building envelope involved, the size and adequacy of the affected technical premises, and the difficulty and/or security of access to the installation for future maintenance jobs.

They also indicate that the improper placement of solar installations on roofs has been a source of damage due to loss of waterproofing, generating humidity and leaks, which have led to conservation problems, with the corresponding economic cost. Polo and Frontini [85] point out that the origin of these problems is that installers and engineering companies try to implement the cheapest solution without taking into account the future conservation of the building.

Likewise, problems derived from the age of the existing facilities are mentioned. The implementation of RETs may involve the comprehensive remodeling of the facilities related to the new project. "Older buildings generally have embedded installations, they are not easy to register, which requires significant additional funds." (No. 20E)

Furthermore, age is directly related to the criteria used during the design and construction of buildings. Hence, adequate spaces were not considered for the laying of the facilities [25] in their conception and construction. This reality greatly conditions RETs implementation, being an added problem. As participant No. 33E highlights: "many times the buildings have an architecture or a distribution that complicates the implementation".

Another factor that limits the integration of technologies based on solar radiation appears in buildings with complex and irregular geometries, without an adequate orientation to capture the energy resource [86]. According to Dadzie et al. [83], existing buildings with complex designs make the selection and installation of these technologies difficult.

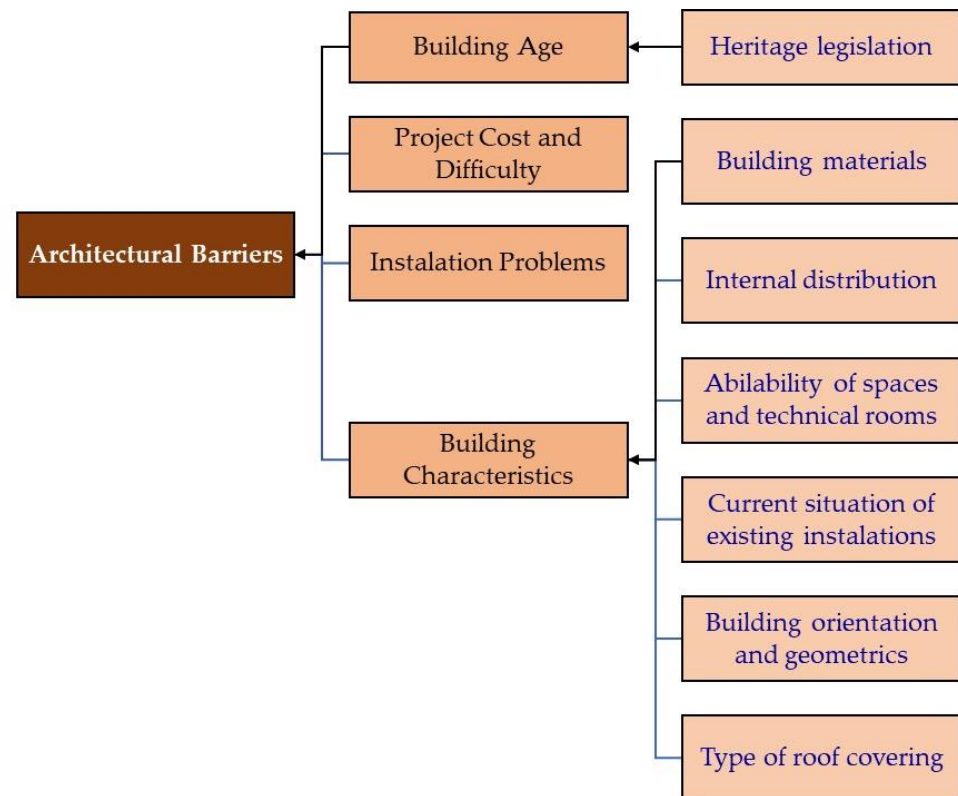
In any case, roofs are identified as the best location to install RETs (photovoltaic, thermal and/or mini-wind), due to the limitation of free space around the existing building [86] and the possibility of providing the proper orientation and inclination of photovoltaic and thermal modules to maximize energy production [84]. Despite this, they mention possible drawbacks: the roofing of the building, recommending acting only on flat roofs; the materials that make up the cover; or the existence of other facilities that occupy a lot of surface area, leaving little space available [87]. Furthermore, as the available surface area is reduced, the amount of energy generated is limited [25], affecting the repayment period of the projects.

Buildings' age could be related to administrative and legislative factors when they are classified as of heritage status. In this regard, both countries have organizations for the preservation of historical heritage, at all levels of the administration, which impose rigorous conditions to be met in projects for RETs implementation in listed buildings [88]. Some of these factors and barriers appear at Figure 3.

Directive 2010/31/EU [4] states that Member States may decide not to establish or apply the requirements set forth in its Section 1 in the case of officially protected buildings when the implementation may unacceptably alter their character or appearance. In this regulatory framework, AbdelAzim et al. [6] indicated that policies and standards related to the sustainability of buildings, in general, are more focused on new buildings, paying less attention to the existing buildings as a whole.

Given the experience with listed buildings, several researchers recognize the difficulty of taking action in compliance with the constraints, their high cost and the need to hire specialized companies. In some cases, they are discouraged because the end result has not been very good despite the effort invested. They consider that the cost becomes an economic barrier, hence any improvement in energy performance is perceived as a prohibitive investment.

Most interviewees admit that they are not considering the installation of RETs with this type of building, except those that can be installed on the roof, such as photovoltaic and solar thermal. Astiaso et al. [11] mention that not all energy efficiency interventions or thermal systems can take place in historic buildings. Technologies that can be installed out of sight of building users and visitors have to be selected [88].



**Figure 3.** Factors considered as architectural barriers.

For some participants, historical heritage regulations are not a barrier as such. They prioritize the conservation of this type of building over any type of intervention that could negatively affect its historical value. Several authors recommend that historical buildings must preserve their antiquity, integrity and cultural significance as well as architectural aspects and be in harmony with the surrounding cultural heritage [86,88,89].

#### 4.2.4. Urban Planning Barriers

Factors in this section are related to the structure and dispersion of university campuses, their situation in the city and its urban planning regulations. Due to legislative aspects, this last factor is related to administrative barriers, because as participant No. 30E points out: “the municipal ordinance is often a bit rigid, and that rigidity means we have administrative barriers.” In Spain, the organizations responsible for urban planning are the autonomous communities and, basically, the local bodies [77,90]. At the urban level, factors such as aesthetics, noise or safety are factors considered by urban planning technicians of local bodies [34].

The shape and arrangement of the buildings within the university campus can either be a barrier or a facilitator for RETs implementation. Thus, in a campus with a distribution of nearby buildings of different heights, the shade generated can reduce the energy production of solar installations. This drawback does not occur on large campuses and with buildings of similar height. In addition, campuses located on the outskirts of urban centers have fewer problems regarding municipal regulations. In contrast, those located within the urban center or that have their buildings scattered across the city have their capacity to act limited to the roof.

Buildings not classified as heritage but located in a protected area such as historic neighborhoods may also be affected. Since they play an important role in cities, contributing economic and tourist value to their heritage [91], maintaining the authenticity of buildings in the processes in these neighborhoods is usually a mandatory requirement [84]. This

situation increases the difficulty of the work and the extension of the administrative procedures to be done.

The general urban planning plans are identified as a barrier to carrying out some actions, as stated by technician No. 11E: “Within buildings prior to 1980, not being impossible, not being unfeasible, you can transform roofs, but if they are in urban spaces it is very difficult, you cannot transform a tile roof, because the general urban plan won’t let you”. Curtius [30], in his study on the implementation of photovoltaic installations, found that obtaining the necessary building permits was an important barrier because local administrations sought to preserve the original character of the urban environment.

Despite the above, several participants do not consider general urban plans an insurmountable problem for RETs implementation. In fact, they have recently noticed an evolution of these regulations to favor their use.

Some interviewees raised the need for the general urban planning plans and their subsidiary regulations to evolve at the local authority level to allow and/or facilitate both the legislative processing and the execution of RET projects. As a more ambitious proposal, some indicate that the plans should contemplate the option of integrating the district’s energy generation into urban land: “sooner or later planning will conform to the fact that urban spaces can be made, or have to be left, for energy districts” (No. 25E).

Some respondents include here the negative effects that some buildings may have on others in order to obtain the energy resource, such as the generation of shade for solar radiation [84,92] or of obstacles to wind circulation: “The buildings in front of us prevent us from achieving the desired sunlight” (No. 24E). In this regard, providing existing and/or future buildings with access to solar radiation should be one more aspect to include in the consideration of ordinances and urban development plans.

#### 4.2.5. Technological Barriers

All Portuguese participants and two-thirds of the Spaniards believe that, given the current level of RETs development, technology cannot be considered a barrier. Although renewable energies require much more advanced technology than conventional ones [93], some are convinced that the advances that are taking place will further facilitate the application of RETs in the future. Technological innovation has been a crucial variable for the removal of barriers and cost reduction of these technologies [94].

However, the technicians point out a series of factors that hinder the application of RETs in existing university buildings. One is the high energy demand they have, with their peak and valley consumption hours [95–98], and its relationship with the amount of energy produced; the availability of the energy resource; and the performance of renewable energy production systems, both electrical and thermal [25,42]. They also mention that the reliability of these technologies in supplying energy during peak periods depends on uncontrollable weather factors [32,99]. Finally, the potential risk of equipment failure to perform its task is added [73].

Thus, in the case of solar thermal installations, they report that setting up sanitary hot water production equipment in buildings with little consumption (cleaning the building and employee hygiene) generates serious problems that have forced them to be rendered inoperative. In addition, in facilities for sports centers, swimming pool water heating, etc., systems to cover solar collectors during closing months have had to be implemented or designed.

Another drawback, related to the multidimensional nature of the barriers, is the requirements imposed by the technical regulations that govern the projects of each type of installation [100]. The technical requirements contained in them may limit, condition or hinder the application in certain buildings.

The large amount of space or the high volume required for the implementation of some RETs are also pointed out. Thus, in the case of biomass heating installations, several interviewees refer to the large warehouse capacity required to have adequate autonomy [99]. They also outline its maintenance cost as a disadvantage along with the need to hire specialized operators.

Regarding low temperature geothermal installations, they report that those carried out with vertical boreholes are more efficient than those done with horizontal ones [11]. In addition, they identify the large number of necessary boreholes as an obstacle, as well as the space they occupy to avoid thermal influence between the different boreholes. They reject the use of shallow buried horizontal boreholes, due to the large surface area required for their implementation. Related to this result, Čenejac et al. [101] recommend this type of exchange only in medium-sized buildings. Regarding their application in existing buildings, several participants consider that geothermal facilities present great difficulties if there is no free space around them or, simply, “geothermal energy is not viable in existing buildings” (No. 28P).

The poor performance of some of these technologies is also pointed out as a barrier, normally focusing on photovoltaic installations. This forces an increase in the surface area to be installed when the space of the building envelope is insufficient and/or inadequate to generate all the necessary energy [87,102], although they do affirm that they can help reduce the electrical energy consumed from the network, reducing expenditure [103].

Concerning the above, they also report that the local weather and the geographical location of the buildings have a strong influence. As Sovacool [104] points out, the energy production of solar systems varies with the season; the time of day; and the presence of fog, clouds and rain. Despite the good geographical situation and the climate of the Iberian Peninsula compared to other European countries [105], all participants from the North of the Peninsula point out that factors such as the low value of solar irradiation and the reduced number of daily sunshine hours in autumn and winter prevent these facilities from being repaid over a reasonable period.

Likewise, the integration of photovoltaic modules in the building must be considered, although according to Jelle [106], these facilities are the ones that can best be incorporated into the architectural design. Thus, they can be integrated without difficulty anywhere in the envelope, with different cell options (rigid, flexible, opaque or transparent) [107], with different types of modules, over or on roofs and walls, and on opaque and semi-transparent envelope surfaces [30,102,103].

In the case of installation on the façade, interviewees affirm that energy production is influenced by their orientation and the limitations in the inclination of the modules. However, they point out that it can be a very good solution as a shading element for classroom windows, offices and laboratories [75,106]. Thus, with this application, it is possible to reduce energy consumption in the air conditioning of these spaces during the summer [108].

#### 4.2.6. Network Connection Barriers

Direct access to the existing network infrastructure is essential for successfully implementing photovoltaic solar installation projects [72]. Concerning this barrier, participants from both countries show different perspectives. While the Portuguese technicians claim not to have had problems connecting to networks, complying with the conditions imposed in their legislation, the Spanish technicians do not show a unified response.

On one hand, around half affirm that the electricity companies themselves generate connection problems: “We are in the hands of the supply companies, which are the ones that are saying: “I’ll give it to you or I won’t give it to you” and, furthermore, in a relatively obscure way, because they don’t give you an explanation of why not either” (No. 14E). On the other hand, a minority recognizes that either they have not had this problem or it has been resolved with the new legislation. Finally, very few Spanish participants claim to be unaware of the current legislation or not to have had previous experiences, so they do not comment on this factor.

Several affirm that there can be no technical problems when connecting photovoltaic generators to the existing electrical distribution network. Based on their experience, they conclude that companies create an administrative problem which makes connection difficult.

The numerous bureaucratic procedures imposed by electricity companies in the process of legalization and connection of photovoltaic generators are also identified. Other researchers have identified the lack of clarity in the connection procedure of different types of RETs [78,93].

Some participants have developed theories about the reasons why electricity companies make it difficult for small energy producers to implement projects. Due to this and after negative experiences with this type of project, an interviewee recommends using these facilities only for self-supply.

In addition, they describe some problems of a technological nature such as the voltage difference of the photovoltaic generator and the grid voltage; the types of connection and control devices that companies require to install, increasing the cost of the project; or the difference between the electrical diagrams projected compared to those included in the company's technical regulations.

Another determining factor is the location of the building where the photovoltaic generator is installed. On campuses found in urban areas or isolated university buildings in the city, the age of the existing network and its degree of saturation may be the limitation that forces electricity companies to impose such strict technological conditions: "distribution companies are very clear, when you introduce something or disturb the network, everything goes down the drain" (No. 10E). According to Lehmann et al. [109], the lack of capacity of the existing network can become a barrier for new projects.

On the contrary, when it comes to buildings on exempt university campuses, with their own distribution network and transformation stations, there are fewer technical problems when making the connection.

#### 4.2.7. Social Acceptance Barriers

The majority of those in the sample do not perceive these obstacles. On the contrary, they point out that the student body, the teaching staff and the administration personnel of the universities are very aware, committed and sensitive to environmental issues. Indeed, due to this awareness, they ask for more actions of this type: "some demand that things be done and ask why they are not done" (No. 24E). Thus, what could initially have been a barrier becomes an incentive for RETs implementation, as summarized by participant No. 30E: "social non-acceptance would be doing nothing". When the RET project is considered beneficial and the community sees it in a positive light [110], it could be considered an example of PIMBY (Please in My Back Yard).

Some respondents think that this awareness is the result of training and dissemination that is being carried out in different areas of society: "the students are demanding it, they are asking for it. People are well educated, television has harped on us a lot" (No. 29E). Considering the age and education of the university community members, Bertsch et al.'s [111] words apply: education is a highly relevant socio-demographic variable in RETs' social acceptance.

However, others have encountered the rejection or mistrust of members of government teams, faculty deans or school directors regarding the usefulness of this type of project or, as participant No. 28P affirms, "there is a tendency to distrust new things". This misconception of RETs, possibly generated by a lack of understanding or knowledge of the subject, or fear of the unknown, can have a negative impact on their implementation [37,42].

Despite encountering initial reluctance in RETs implementation, they also report the change of opinion in their university management team members when they verify the return on the investments made and the benefits brought. Thus, as stakeholders become familiar with RETs and discover their advantages, their institutional development and social acceptance increases [43]. The phenomenon described by Hai [51] is reproduced (tendency to emulate when people from the same community share success stories).

Consequently, to prevent people with decision-making power from opposing these developments, some participants believe that more education on these issues should be carried out in the different governing bodies.

“The problem I see is that there is not good dissemination or awareness-raising. To me, education in saving and clean energy is essential, it’s fundamental” (No. 12E).

Considering that universities are part of the Public Administration [112,113], several interviewees argue that they should be a good example to society. Furthermore, as an added benefit, some universities use RETs implementation projects to promote themselves, by improving both their institutional image and their social commitment.

Some technicians believe that this social acceptance barrier could arise from negative effects that some types of RETs may generate, such as the increase in taxes to implement them, the smell of burnt wood on campus in the case of using biomass boilers in district heating, or noise from mini wind generators installed on building roofs or on campus.

Several respondents report news read or transmitted by colleagues, of positive or negative experiences of RETs implementation in other public administration buildings. This knowledge influences their opinion on the advantages and disadvantages of certain technologies. Based on this information, they establish value judgments rather than seeking the opinion of experts, which can influence their decision-making [21,24]. The impact of failure cases is relevant, since they generate a negative opinion towards the corresponding technology, causing the technicians to discard its use.

#### 4.2.8. Institutional Barriers

The concept of institutional barrier encompasses those factors existing in an organization that limit the acquisition of sustainable energy technologies [114].

More than half of the sample recognizes that RETs implementation in the university depends on the governing teams having the political will to present such projects to the government councils and adopt the necessary measures to carry them out. Therefore, it would be a decision-making process by multiple actors who may have different and even conflicting motivations, which can make it difficult to obtain funds or approve projects [114]. In these types of situations, although financial factors are important, the strategic nature of the action may have more of an influence on decision-making than the profitability of the projects itself [115].

Extreme opinions are found in the responses, from governing teams that have an active role, executing RETs implementation actions, to others that, despite recognizing their importance, do nothing. They claim that this inaction is due to economic factors, so this barrier is also multidimensional in nature. In any case, without the support of the university governing teams, RETs implementation programs cannot be carried out [17].

On the other hand, some universities propose to meet environmental targets by obtaining official certificates from regional governments or by trying to improve their international rankings such as the UI GreenMetric World University Ranking. In other cases, the policy consists of constructing new buildings with an almost zero energy building certificate (Net Zero Energy Building (NZEB)), such as the BREEAM, LEED or BEAM certification schemes [116,117].

Some interviewees acknowledge the difficulty of getting a rectoral team involved in a renewable energy project with a long-term return on investment since it would tie up university’s financial resources for several terms. According to technician No. 13E: “They do not think long term, they are interested in the four years that they are going to be in government. They are moved more by political interests than by energy efficiency”.

One strategy developed by universities in both countries consists of reinvesting the savings produced by RETs investments in projects of the same type, or in energy efficiency measures in buildings. This option constitutes a procedure for continuous improvement of the energy efficiency of buildings, avoiding dependence on energy policy changes of each government team.

However, in other universities, technicians regret not being able to implement it due to what they call an “accounting barrier” (No. 20E), preventing savings made to continue generating investments in this type of measure.



The existence of different service units related to the operation of buildings, independently of each other, is identified as a negative factor. For example, one unit is dedicated to building maintenance, another to works, another to sustainability, another to energy, etc. In these cases, the structure itself, with high segregation of functions, can act as a brake due to a lack of uniqueness of criteria focused on energy efficiency, consumption reduction and RETs integration. Furthermore, their capacity to act depends on the budget assigned to each unit, and if this is reduced, their work will be “exclusively a philosophical service” (No. 11E).

#### 4.2.9. Other Barriers

- Lack of training and/or experience in RETs.

Some technicians admit not being experts in these technologies or lacking knowledge and experience in executing related projects. The lack of skills and information can increase uncertainty about RETs implementation and make it difficult to make decisions about their application [34]. This confirms Cooke et al. [21], who found that “ignorance and lack of understanding” act as barriers.

Although it is not something to be generalized, there seems to be a certain training deficit in the application of RETs in building construction. This situation may be caused by inadequate human resource management in those universities that have not provided adequate training in new technologies to technicians working in infrastructure management areas [41].

- Lack of information.

Several technicians indicate not having enough information to adequately evaluate all the technical, economic and financial aspects of RETs application in their buildings. The lack of adequate, specific, simple and timely information makes it difficult to make relevant decisions regarding these projects’ implementation and execution [24,74,118].

Some participants say that they learn more through conversations with other colleagues and/or professors and in work meetings within the university environment. They value this source of information very much because, as participant No. 8P states: “I think that most of these people with whom I speak are from here, from the university, they do not have any commercial intention behind it. I give them more credit because I don’t think there are any underlying interests behind the things they say. They are taken in good faith”.

They also cite the reading of feasibility studies or proposals submitted by installation or commercial companies of these technologies. However, they manifest a certain suspicion towards its content because they lack the tools to ensure everything is correct. In addition, when they analyze the economic viability, the results do not coincide with their calculations: “when marketing companies present us with the repayment plan, they are not credible either, because there are times when we save more than we spend, which upsets me” (No. 29E).

The lack of information can condition the choice of a certain technology or negatively influence the decision-making process. As participant No. 4E acknowledges: “if we could have all the information, if we could manage all the parameters of what we want to implement, how we want to implement it, and that we are convinced that this is what we want to implement”.

Added to the above is the lack of confidence when the information is provided by installation or engineering companies that do not show adequate experience or reliability: “I did not see solid, dependable technical support, which is what you want to see with initiatives of this kind, but rather, it seemed a bit like an adventure to me” (No. 5E). Thus, when in doubt, the application and viability of these technologies is dismissed.

Several participants indicate a certain degree of isolation between the different universities. They identify little or no information transfer between the university infrastructure management offices to share experiences on RETs implementation or energy efficiency measures. “We are constantly reinventing the wheel. I am here in my office, I start inventing the wheel and when I have invented the wheel I realise that someone else has already done it . . . knowledge transfer is lacking” (No. 13E).

In this regard, there is the Spanish Confederation of Rectors of State Universities (CRUE) and the commission called CRUE-Sustainability, which have different working groups. Only half of the Spanish sample claim to know their reports, so there could be a disclosure problem. This lack of information exchange between technicians from different universities can negatively affect the spread of innovations in RETs [119].

- High daily workload.

It is acknowledged that the daily workload is so high that they do not have time to think about the implementation of these facilities during the day. Some refer to the large amount of documentation to be carried out for any task, as stated by participant No. 3E: “We are overwhelmed and now everything is paperwork, paperwork, paperwork”.

This excess of bureaucracy and the limitation of personnel in the infrastructure management offices make it difficult for the responsible technicians to consider the study of this type of projects. They also acknowledge that they cannot prepare all the documentation required to participate in official calls for aid for national or European renewable energy implementation projects.

- Recent actions on heating installations in buildings.

Having implemented recent renovations and/or upgrades of boiler rooms in buildings, associated with energy supply contracts with gas distribution companies for a certain period of time, appears as a limiting factor.

“When you decide on one, you have to exploit it for at least its useful life, those ten years that company X imposes on us” (No. 5E).

In this decision-making, it seems that those responsible for the university have only taken into account the economic factors and the technical advantages, prioritizing the products with the lowest initial cost [114], without considering the environmental effects arising from the continued use of conventional fossil fuel technologies [34]. This situation is favored by the direct and indirect financial support that promotes the supply of conventional energies, limiting the expansion of renewable energy sources [120].

Although RETs advantages are well recognized, some people are not inclined to use them since conventional fossil fuel technologies are better known, more available and more affordable [121].

## 5. Conclusions

The objectives set by the EPBD Directive, in its 2012 version, are known and generate a varied opinion among technicians who work in university infrastructure management offices, although the perception prevails that achieving them is very difficult.

Achieving the 20% reduction of CO<sub>2</sub> emissions and increasing the implementation of renewable energy technologies by another 20% in university's existing buildings involves the establishment of temporary milestones that have not existed previously and the provision of public funds that have not been received. The general perception is that, in the drafting of the EPDB directive, each country's economic situation and specific characteristics were not taken into account. In this case, the uniformity of criteria has set objectives that are difficult to attain for Spain and Portugal.

Although the objectives set out in the Europe 2020 Strategy are considered necessary, when the building park is of a certain age, increasing the percentage of RETs integrated into the buildings, without an economic policy that accompanies these objectives, can lead to the failure of their fulfillment. In addition, the time difference between the application of the directives (10 years) and the duration of the national governments' legislature may be a factor to consider for the application of the energy and economic policies necessary to comply with the directives. The people interviewed perceive that there have not been sufficient financial incentives to achieve the EPBD directive objectives. They highlight the persistence of the effects of the 2008 international economic downturn, which could have negatively affected the application of appropriate policies.

Based on the barriers identified in the literature review, participants' responses underline a series of factors that act as obstacles to the implementation of RETs in existing university buildings. These factors have been grouped into economic and financial, administrative and legislative, architectural, urban, technological, network-connection and institutional barriers of the university.

An important result found is that there are no social acceptance barriers. On the contrary, different groups demand greater implementation of this type of technology in university buildings.

Due to the characteristics of qualitative research, other barriers such as lack of training and/or experience, lack of information, technicians' daily workload and recent actions in engine rooms were discovered.

These factors can act either individually or jointly, in the latter case becoming real obstacles to the development of these projects. Although no attempt has been made to classify the importance of the different barriers, after analyzing the responses, the most important are economic-financial and administrative/legislative barriers.

The perception of insufficient direct support to achieve the objectives of the EPDB in public buildings, together with the difficulties generated by administrative and legal procedures, as well as the lack of aid and communication by and between the different public administrations involved in the legalization process of these projects, make it difficult to execute it. Furthermore, in the case of photovoltaic installation projects, the difficulties and barriers imposed by the electricity companies themselves must be taken into account.

A significant difference has been found in the perception of technicians from Spain and Portugal since the latter did not perceive that administrative and legislative barriers were as high in their country.

Cities are sources of energy consumption and gas emissions. Those responsible for preparing urban plans must allow for solutions that reduce or eliminate those urban criteria that prevent RETs installation in cities. Urban regulations need to evolve, including sustainability criteria that facilitate, or at least do not hinder, energy efficiency measures in actions on the outer envelope of buildings, as well as the integration of RETs that, at present, are impossible to apply in some municipalities due to their municipal regulations.

The main contribution of this paper is the identification of factors and their grouping into a series of barriers that can help to design strategies and actions that tend to eliminate them or, at least, to consider them as minimizing their impact and thus facilitating the development and implementation of RETs in existing university buildings. At the same time, this knowledge will help to achieve the UNSDG-9 and UNDSG-11 goals set out in the 2030 Agenda for Sustainable Development.

#### *Limitations and Future Directions*

During the sample preparation phase, it was impossible to achieve the same percentage of participants from both countries. The difficulties that arose during the arrangement of interviews with technicians from Portuguese universities could not be avoided. This limitation may have influenced the determination of other differences or similarities, and their effect, between the barriers and factors that affect the application of RETs in university buildings.

To take advantage of the results obtained, it would be useful to develop a quantitative investigation that would allow one to classify the different barriers in order to order them from greater to lesser influence, to establish actions or policies aimed at minimizing the negative effect of those barriers with greater importance.

Future lines of research would be to know if the barriers found affect the application of RETs in other existing buildings intended for teaching use such as schools and secondary education centers, as well as public administration buildings, at each of their levels: local, regional or state.

Public procurement processes for the supply or operation of RETs in university existing buildings are complex and need to meet many requirements set in the regulations. Hence, they generate difficulties and problems that have been identified as administrative and legislative barriers. In further research, it would be interesting to explore and determine the strategies used by universities in this respect, in order to improve them.

As the new 2030 Climate and Energy Framework raises more demanding objectives than the previous framework, this study could be replicated once the strategy has been developed, checking whether the barriers encountered continue or disappear, or whether new ones emerge.

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