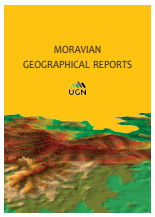

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Adoption of renewable energy innovations in the Portuguese rural tourist accommodation sector

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Abstract

The imperative of decarbonisation represents a great challenge for the tourist accommodation sector. This article examines the adoption of renewable energy innovations in the tourist accommodation sector of Portugal. The analysis focuses on one of the most known tourist accommodation products in the Portuguese countryside: Tourism in Rural Areas (TER). Drawing from two complementary e-mail-based surveys conducted with TER owners/managers, the results of the study show that there is a substantial gap between their positive perceptions of renewables and levels of renewable energy innovations adoption. The reasons pinpointed relate to unfavourable market factors and to institutional, legal, regulatory, or administrative hurdles. In addition, except for geographical location, the characteristics of the units and respondents had no significant influence on adoption.

Keywords: *renewable energy innovation, tourist accommodation, drivers, barriers, rural areas, Portugal*

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1. Introduction

To achieve the Paris Agreement goals, the global economy must fully decarbonise by 2050 (IPCC, 2018). This imperative represents a great challenge for the tourist accommodation sector. Based on 2005 data, it has been estimated that accommodation contributes 21% to tourism's global CO_2 emissions (Scott et al., 2008, pp. 132–133). Furthermore, emissions from tourist accommodations are forecasted to increase significantly in the coming decades in the "business as usual" scenario, notably "from 1,101 Mt CO_2 in 2010 to 2,957 Mt CO_2 by 2050" (Gössling and Peeters, 2015, p. 651).

Nevertheless, there is a great potential for the accommodation sector to reduce its CO_2 emissions by improving energy efficiency and using renewable energy sources (Scott et al., 2008, pp. 10–11; Dalton, Lockington and Baldock, 2007, p. 568), including solar, wind, hydro, geothermal and biomass energy. Accordingly, and in line with the European Union's objective of achieving carbon neutrality within 30 years (European Commission, 2019a), the European Travel Commission has encouraged "all countries to accelerate the deployment of 'best practice' energy-efficiency retrofits and renewable energy investment in the accommodation sector" (Scott and Gössling, 2018, p. 32).

A considerable body of research about the adoption of energy efficiency measures in tourist accommodations has already been produced (e.g. Becken, 2013; Becken and Dolnicar, 2016; He, Zha and Loo, 2020; Pace, 2016; Warren and Becken, 2017), including in Portugal (e.g. Mendes and Santos, 2014; Moutinho, Costa and Bento, 2015). Far less attention has been devoted to the uptake of renewable energy in tourist accommodation facilities. Most of the few existing studies on this subject focus on the feasibility and on the economic and environmental benefits of renewable energy supply in hotels (Dalton, Lockington and Baldock, 2008; 2009; Karagiorgas et al., 2006; Zografakis et al., 2011), or else, on the drivers and/or barriers to the adoption of renewable energy technologies in hotels (Dhirasasna, Becken and Sahin, 2020; Mahachi, Mokgalo and Pansiri, 2015; Sardianou and Kostakis, 2020). Other types of tourist accommodation remain underexplored. Moreover, there is a paucity of research on the uptake of other renewable energy innovations in tourist accommodations.

This article addresses these gaps by studying a Portuguese case. Four research questions are posed:

1. What are the levels of adoption of renewable energy innovations in tourist accommodations?;

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2. What types of renewable energy innovation are the businesses investing in?;
3. What are the main reasons for adopting, or not, such innovations?; and
4. Do the characteristics of the establishments and/or their owners/managers influence adoption?

The focus of this study is on one of the best known tourist accommodation products in rural Portugal: TER – Tourism in Rural Areas.

Rationale for this study adds knowledge to a research topic that merits further attention for several reasons. First, the supply of and the demand for rural tourist accommodations have been growing in Portugal and in other developed countries since the 1980s due to the rise of a lifestyle-led and leisure-oriented society, and the widespread mobilisation of tourism as a strategy for rural development and revitalisation (Silva and Prista, 2016; Walmsley, 2003). Second, recent research has shown that a considerable number of Portuguese emigrants and their descendants (especially those aged between 29 and 39) who own a house in a rural municipality would like to return to their place of origin to invest in tourism activities (Santos, 2021). Third, this topic remains understudied in the scholarly literatures on "rural energy transitions" (Naumann and Rudolph, 2020) and "energy tourism" (Frantál and Urbánková, 2017). Finally, climate change demands a faster transition towards more sustainable energy systems in all sectors of economic activity at the global level (IPCC, 2021).

2. Theoretical background

The concept of social acceptance of renewable energy innovation is useful for the arguments presented in this article. The most influential definition of that concept is Wüstenhagen, Wolsink and Bürer's (2007) framework, distinguishing three dimensions of social acceptance: socio-political acceptance, community acceptance and market acceptance. The first dimension combines the acceptance of policies and technologies by policymakers, by key stakeholders and by the general public (often measured through opinion polls). The second refers to the local responses to the siting of renewable energy projects and associated infrastructures. The third relates to the consumers (in the case of decentralised generation of energy and green power marketing), investors and intra-firm acceptance. This article focuses on the adoption of renewable energy innovations by consumers, notably by the owners/managers of tourist accommodation establishments.[1]

Research carried out in Europe and beyond has shown that the adoption of renewable energy innovations or renewable energy technologies in hotels and other types of tourist accommodation is low, namely between 6% and 25%, and the highest rate is for solar thermal panels (Coles, Dinan and Warren, 2015; Dalton, Lockington and Baldock, 2007; Karagiorgas et al., 2006; Knezevic and Vicic, 2008; Knowles et al., 1999). A review of the literature identifies several factors that influence the uptake of renewable energy in hotels. For instance, Mahachi, Mokgalo and Pansiri (2015) identify political leadership, financial benefits, the availability of environmental sustainability programs, and strong environmental values as the driving forces for the adoption of renewable energy technologies in Botswanan hotels. Likewise, Sardianou and Kostakis (2020) concluded that economic, informational, organisational, and human-related factors obstruct the uptake of those technologies in Cretan hotels.

Similarly, Dhirasasna, Becken and Sahin (2020) showed that the interplay between incentive policy, owner/manager perceptions, tourists' behaviours, technology advancement and electricity grid prices may either enable or hinder the adoption of renewable energy technologies in Queensland hotels. In turn, Dhirasasna and Sahin (2021) ascertain that the adoption rate of renewable energy technologies in Queensland hotels follows an S-curve growth only when market conditions are favourable, that technology performance increases adoption more than the government incentives, and that the perceptions of hoteliers and tourist behaviours act as market accelerators.

These factors are similar to those that affect the adoption of other environmental technologies and practices in hotels. Chan, Okumus and Chan (2020), for example, identify seven barriers to the adoption of environmental technologies in Hong Kong hotels, of which the first three are the most important: 1) environmental feasibility; 2) lack of green knowledge and a green network; 3) monopolised after-sales service; 4) government and initial support; 5) customer experience; 6) human resource limitations; and 7) financial performance. Equally, Wang, Font and Liu (2020) showed that market needs, managers' attitudes towards the environment and the demand from stakeholders are antecedents of willingness to adopt eco-innovation practice in Chinese hotels.

Given that these drivers and barriers were identified in studies investigating the adoption of renewable energy technologies and/or other environmental measures in medium- and large-sized urban hotels, the uptake of renewable energy innovations in tourist accommodations located in rural areas – which tend to be small-scale and family-based businesses – may well be influenced by other factors. For example, there is evidence that the business' location and success, as well as the managers' experience, education level and place of residence, influence the adoption of local development practices in rural tourist accommodations in Central Portugal (Dinis et al., 2019).

3. Geographical context

3.1 Tourism and carbon emissions from tourism in Portugal

Portugal is one of the European countries most dependent on the tourism industry, especially inbound tourism, whose importance in the national economy has been increasing over the past decade (cf. OECD, 2020). According to the Tourism Satellite Account produced by the National Statistics Institute (INE, 2020a), in 2018, tourism accounted for 8.0% of Portugal's gross added value and 11.5% of the gross domestic product, contributing to 9.4% of employment and 22.3% of total exports. In addition, the accommodation sector contributed 26.0% to the total expenditure of international tourists, representing the second largest single contributor after food and beverages (26.9%). It also amounted to 32.9% of the total expenditure of domestic tourists, being the largest single contributor.

[1] On the acceptance of renewable energy innovations by other consumers, see, for example, Sauter and Watson (2007) and Wolsink (2012).

Until the emergence of the COVID-19 pandemic in Portugal and in other European countries in March 2020, the tourism industry was still growing in the country, with 24.6 million international tourists – coming mainly from Spain (25.5%), the United Kingdom (15.4%), France (12.6%), Germany (7.9%) and Brazil (5.5%) – and an additional 5.4 million domestic tourists in 2019 (INE, 2020b). The pandemic had a huge impact on tourism worldwide as well as in Portugal, with consequences for the flow of tourists and the weight of the sector in the country's economy (cf. INE, 2021).

According to Eurostat (2020), in 2018, Portugal's greenhouse gas (GHG) emissions (including international aviation, but excluding land use, land-use change and forestry, or LULUCF) reached 71.6 million metric tonnes of CO_2 equivalents – representing a 1.8% share of GHG emissions in the 27 European Union (EU) Member States – down from the 88.0 million tonnes in 2005 but up from the 60.2 million tonnes in 1990. Based on 2010 data, the most recent available data on the subject, the accommodation sector accounts for about 5% of CO_2 emissions from tourism activities in Portugal which, in turn, contributes about 10% to national CO_2 emissions (Moutinho, Costa and Bento, 2015, p. 218). In brief, the accommodation sector is a key element of the tourism industry in Portugal and will play a central role in achieving carbon neutrality by 2050.

3.2 Portugal's renewable energy policy

Since the mid-2000s, Portugal has made extensive investments in renewable energy sources, in line with its international commitments. The country met the ambitious target of sourcing 39% of electricity from renewable sources in 2010 and reached 59.6% in 2020, slightly below the target of 60%. It also met the 2020 target of 31% share of its gross final energy consumption from renewable sources. In 2020, the main renewable energy sources of electricity were hydropower (43.6%) (whose inclusion as a renewable energy source is debatable) and wind power (38.5%), followed at some distance by biomass (10.1%) and solar power (5.3%). Most (97,9%) of this electricity came from large-scale, centralised projects (DGEG, 2021).[2]

This pattern of development can be explained by the policy framework and the uptake of renewable energy by the private sector. Portugal's governments have been promoting renewable energy generation through feed-in tariffs, fiscal incentives, green certificates, targets, and funding for research and development projects, as well as tenders and auctions for granting rights to connect wind and solar energy to the electricity grid (see Delicado et al., 2014; Silva and Sareen, 2021, for details). Combined with a system of planning decisions taken at the national level, such energy policy measures have mostly privileged large-scale renewable energy generation projects and favoured large utility companies, rather than small-scale projects and collective or individual prosumers (cf. Delicado et al., 2014, for wind energy; Sareen and Nordholm, 2021; Silva and Sareen, 2021, for solar energy). The outcome is hindering the adoption of renewable energy innovations by smaller actors, such as those involved in rural tourism businesses, of which TER is an example.

Although the Portuguese governments have been promoting small-scale renewable energy generation by individuals and companies since 2002 (Decree-Law No. 68/2002), several economic and legal factors have hindered its development. First, initially attractive feed-in tariffs (e.g. €650/MWh in the case of solar energy) running for 15 years have declined since 2010 (cf. DGEG, 2018) and were eliminated in 2015. Second, the grid connection limits for decentralised generation set by the governments are low (see Silva and Sareen, 2021; European Commission, 2019b, regarding solar energy). Third, a legislation of the Production Units for Self-Consumption – referred to as UPACs ("Unidades de Produção para Autoconsumo") – imposed the limitation that the electricity generated had either to be consumed by a single user entity or injected into the national grid in exchange for a nominal tariff set at 90% of the market price (Decree-Law No. 153/2014). Fourth, the remuneration regime for projects (of up to 0.25 MW) that generate electricity exclusively to be injected into the grid – referred to as UPPs ("Unidades de Pequena Produção") – is not particularly attractive, because it is set by a biding scheme in which producers offer discounts to the reference tariff annually established by the government (Decree-Law No. 153/2014).[4] Fifth, since 2012, the income earned by producers from the sale of electricity is taxed under the Personal Income Tax regime, whereas, before, producers did not have to pay Personal Income Tax when the annual income earned was less than €5,000.

Nevertheless, in recent years, Portugal's government brought out legislation and implemented some measures to promote the adoption of renewable energy innovations at the household, small company, and community-scale. In 2019, the government passed new legislation that enables the existence of community and collective self-consumption of renewable energy (Decree-Law No. 162/2019), which came into force in January 2020. The government also reintroduced some incentives schemes for self-consumption – a deduction of up to €1,000 in the Personal Income Tax in 2020 for the installation of solar PV panels (and heat pumps) in households (Law No. 2/2020) and, in 2021, created a subsidy of up to €2,500 (grant rate of 70% of the eligible costs) for the installation of solar PV panels (and energy efficiency measures) in buildings constructed before 2006 (Administrative Order No. 8745/2020).[3] Additionally, the government created a credit line for decarbonisation and the circular economy with an allocation of €100 million to support projects of micro-, small- and medium-size industrial and tourism companies aiming to reduce energy consumption, to generate renewable energies for self-consumption, and to change to a circular economy.[5] The fact that peer-to-peer delivery is not included reflects the rigid energy market

[2] As of December 2020, registered small-scale projects totalled 480.7 MW of installed capacity, including solar power (466.5 MW), wind power (4.0 MW), hydropower (0.2 MW) and other renewable energy sources (biomass, biogas) (9.9 MW) (DGEG, 2021).

[3] Tax incentives for micro-generation were introduced in 2007 – the date on which taxpayers could deduct up to €796 (grant rate of 30% of the eligible costs) in the Personal Income Tax – but were eliminated in 2010. The amount allocated to that subsidy was €1,750,000 in 2020 and €2,750,000 in 2021.

[4] In 2019, the government increased the maximum installed capacity of the UPPs to up to 1 MW, but maintained the remuneration regime (Decree-Law No. 76/2019).

[5] This credit line has a term of 12 months, with a maximum amount of €2 million per company and a grace period of up to two years. To be eligible, projects must consume at least 10% of energy produced through renewable energy sources.

structure and the restrictive regulatory framework in Portugal (Klein et al., 2020). The impact of such legislation and measures is still not noticeable.

Aside from setting a target of sourcing 80% of electricity from renewable sources in 2030, Portugal's National Energy and Climate Plan 2021–2030 (European Commission, 2019b) sets a target of 45% to 55% of CO_2 emissions reduction (excluding LULUCF) compared to 2005 by 2030. Although there are no specific targets for tourism activities, this Plan envisages a CO_2 emissions reduction of 70% in services and of 40% in transport by 2030, sectors which are closely linked to tourism. Meanwhile, the Tourism Strategy 2027 sets as a target that over 90% of tourism businesses adopt energy efficiency measures by 2027 (Resolution of the Council of Ministers No. 134/2017). Regarding solar energy, in 2019, 43% of tourist accommodations had installed solar thermal panels and only 14% had solar PV panels (Turismo de Portugal, 2020). In part, this is a consequence of the 23% VAT rate applied to renewable energy devices since 2012 in mainland Portugal.

3.3 Tourism in Rural Areas (TER)

Created in 1986, TER is a set of "commercial homes" (Lynch, McIntosh and Tucker, 2009) consisting of small-scale and family-based tourism businesses offering accommodation in a household environment, as well as additional facilities permitting outdoor activities in rural areas, such as swimming, tennis and horse riding. TER differs from all other types of tourist accommodation available in Portugal because it is regulated by specific legislation regarding the characteristics of the units and businesses.

According to Silva (2009), considering the characteristics of the buildings, their furniture and interior decoration in general, TER establishments offer two types of rural dwelling, in reference to a "noble" or to a "peasant" rural past, for touristic consumption. The noble past corresponds to accommodation in manor houses and other residential houses with recognised architectural value. They are furnished and decorated with antiques and exquisite objects, from crystal tableware and silverware to 18th century Portuguese furniture, obtained through family heirlooms or purchased at antique shops. In turn, the peasant type corresponds to accommodation in adapted rustic houses or outbuildings on a farm, offering interiors to match. They are decorated with artisanal and vernacular objects, from farming tools to handicrafts, either collected or purchased at arts and crafts shops. These businesses are usually run by their owners, in most cases involving the family unit, or individuals aged between 45 and 60 years old, most of whom hold a university degree, have a complementary occupation, and started the activity to recover and monetise properties obtained through family inheritances.

According to the INE (2021), in 2020, there were 1,374 TER establishments offering 23,430 beds, representing 26.5% of the national tourist accommodation sector – the second most prevalent type of tourist accommodation after local accommodation, units often located in large cities such as Lisbon and Oporto – but only 6.8% of the national tourist accommodation capacity.[6] As shown in Table 1 (see also Fig. 1), the regions with the highest number of TER units and beds were the North (38.9% and 35.5%, respectively), the Centre (24.2% and 23.1%) and the Alentejo (23.1% and 25.4%). In addition, this segment registered 596,239 guests and 1,293,828 overnight stays, representing 5.7% of the guests and 5.0% of the overnight stays in the tourist accommodation sector of Portugal.

Country Houses were the most prevalent type of accommodation in this segment with 796 establishments and 11,234 beds, and they also ranked first in overnight stays with a market share of 45.9%. Agritourism units were second in number of both establishments (237) and beds (3,960),

Portuguese region	No. of establishments	No. of beds
North	535	8,314
Centre	332	5,411
Lisbon Metropolitan Area	19	369
Alentejo	317	5,952
Algarve	85	1,718
Azores	49	*
Madeira	37	*
Total	**1,374**	**23,430**

Tab. 1: TER establishments and accommodation capacity by region in 2020 (Confidential data)*
Source: INE (2021 and https://www.ine.pt/)

Fig. 1: Regions of Portugal
Source: author's elaboration

[6] Although Lodging Tourism is considered as distinct from TER since 2008 because it can be situated in both urban and rural areas, in this study it is aggregated in TER, since most establishments (about 92%) are situated in the countryside. Lodging Tourism and TER units are also aggregated in the statistics produced by the INE.

and third in overnight stays (16.1%). Lodging Tourism units were third in number of establishments (182) and fourth in both beds (2,803) and overnight stays (8.7%). Rural Hotels were fourth in number of establishments (97) and second in beds (4,444) and overnight stays (26.4%). Fifth in number of establishments (62), beds (989) and overnight stays (2.8%) were "Other" types of tourist accommodation.[7]

4. Study methods

This article draws upon two complementary e-mail-based surveys conducted by the author with TER owners/managers in 2020 and 2021. This methodological tool was chosen because it allows reaching a greater number of recipients in a short period of time (cf. Levefer, Dal and Matthíasdóttir, 2006). The study focussed on these respondents because they run the most abundant rural tourist accommodation products and because their perceptions and attitudes towards the adoption of renewable energy innovations also reflect, albeit indirectly, those of other actors involved in businesses operating in the Portuguese countryside. The first survey was carried out in the second half of 2020. The e-mail request was sent to all TER owners/managers in Portugal using the addresses available in the "Registo Nacional de Turismo" (National Tourism Register) online portal. A total of 365 TER owners/managers responded, corresponding to a response rate of 26.6%. This was complemented by another survey

Category	Frequency (1st survey)	Frequency (2nd survey)	No. of units in Portugal	Sampled businesses 1st survey (%)	Sampled businesses 2nd survey (%)
Agritourism	71	43	238	29.8	18.1
Country Houses	178	124	796	22.4	15.6
Lodging Tourism	46	26	182	25.3	14.3
Rural Hotels	22	15	99	22.2	15.2
Others	48	5	62	77.4	8.1
Total	**365**	**213**	**1,374**		

Tab. 2: Sampled businesses by TER accommodation type
Source: INE (2021) and author's surveys

Category	Frequency (1st survey)	Frequency (2nd survey)	No. of units in Portugal	Sampled businesses 1st survey (%)	Sampled businesses 2nd survey (%)
North	116	65	535	21.7	12.1
Centre	104	66	332	31.3	19.9
LMA	15	8	19	78.9	42.1
Alentejo	83	52	317	26.2	16.4
Algarve	20	9	85	23.5	10.6
Azores	18	10	49	36.7	20.4
Madeira	9	3	37	24.3	8.1
Total	**365**	**213**	**1,374**		

Tab. 3: Sampled businesses by region
Source: INE (2021 and https://www.ine.pt/) and author's surveys

No. of rooms	Frequency	% of all respondents	No. of beds	Frequency	% of all respondents
≤ 3	51	14.0	≤ 3	24	6.6
4–5	92	25.2	4–5	53	14.5
6–9	137	37.5	6–9	102	27.9
10–14	56	15.3	10–19	126	34.5
15–20	21	5.8	20–29	30	8.2
≥ 21	8	2.2	≥ 30	30	8.2

Tab. 4: Number of rooms and beds offered by the establishments sampled in 2020
Source: author's survey

[7] The category "Others" refers to a type of accommodation – Rural Tourism – that was eliminated in 2008. The maximum number of rooms, suites, or apartments for guests in all accommodation types associated with TER except Rural Hotels is 15 (Decree-Law No. 39/2008).

conducted from October 24 to November 15, 2021, with respondents to the first survey. This survey was responded by 213 recipients, resulting in a response rate of 15.5%.

In both cases, the e-mail contained a link to the survey, which was available in Portuguese and English. On average, respondents took 20 minutes to answer the first survey and 3 minutes to answer the second one. In addition to the name, location, size, ownership, number of employees and category of facilities, the first survey focused on the respondents' perceptions and attitudes towards the uptake of renewable energy in tourist accommodations. Topics related to the latter subject included: opinions about the need to reduce GHG emissions from tourist facilities; opinions about renewable energy generation and utilisation in tourist accommodations; technologies to generate electricity in which the businesses invested; prosumer systems (individual and collective); and motivation for and barriers to invest in such innovations. The complementary survey focused on the adoption of other renewable energy innovations that were not included in the first survey, namely, energy management systems, demand response management systems, energy storage technologies, participation in energy cooperatives/communities and electric vehicles chargers. Microgrid assets and other elements that integrate Distributed Energy Systems were not included because they are still scarcely available in the country.

Considering the types of accommodation within TER, "Others" had the highest response rate in the 2020 survey, while Agritourism had the highest response rate in the 2021 survey (see Tab. 2). Regarding the geographical location of the TER units, the Lisbon Metropolitan Area (LMA) achieved the highest response rate in both surveys (see Tab. 3). As can be seen in Table 4, over three-quarters of the businesses in the 2020 sample offered less than 10 rooms and over four-fifths offered less than 20 beds. Part of these rooms and beds (33.2% [919/2770] and 34.5% [1573/4556] of the sample, respectively) were situated in outbuildings. Additionally, 33.7% (123/365) of the units' main houses were built in the 21st century, 27.9% (102/365) were constructed in the 20th century and 35.9% (131/365) date back to previous centuries, spanning from the 13th (1260) to the 19th centuries, while 2.5% (9/365) were erected in an unknown date.

Aside from providing accommodation, 33.2% (121/365) of TER establishments had a restaurant and 36.2% (132/365) hosted events such as weddings and christening receptions. Most, 63.8% (233/365), units were situated in farms, of which 44.2% (103/233) exceeded six hectares and 45.1% (105/233) carried on agricultural production activities, mainly viticulture and livestock husbandry. The majority, 91.2% (333/365), of units were run by their owners, of whom 47.1% (172/365) were family businesses and 41.9% (153/365) were an individual. Also, most TER managers were Portuguese and females, held a university degree and had between 45 and 65 years old (see Tab. 5).

5. Results

5.1 Perceptions and attitudes towards the adoption of renewable energy innovations

Most, 97.0% (354/365), TER owners/managers who responded to the 2020 survey expressed their agreement with the idea that tourist accommodations should reduce their GHG emissions to mitigate global warming and its impacts, whereas the remainder stated that they had no opinion on this matter. Additionally, 95.3% (348/365) of respondents stated that they were in favour of renewable energy generation and utilisation in tourist establishments, while the remaining ones declared that they had no opinion.

Despite the significant number of favourable responses, only 24.9% (91/365) of respondents reported having installed renewable energy innovations in their establishments and properties. As can be seen in Table 6, most of those innovations were electricity generation technologies and, above all, solar PV technologies. Furthermore, 52.6% (60/114) of such innovations were associated with the UPPs regime. There were no peer-to-peer or collective prosumer schemes. There was also no collective self-consumption. This can be explained by three factors. First, collective and community self-consumption of renewable energies are only permitted since 2020. Second, there is still no specific legal framework (Campos et al., 2020, pp. 5, 7). Third, potential upscaling for sectoral transformation is likely to be preceded by a period of pilot schemes and, therefore, near-future developments may well be characterised by some inertia (Sareen and Nordholm, 2021, p. 1059).

In all cases, the electricity generation units were owned and controlled by respondents. UPAC units tended to be sited on rooftops, while UPP units tended to be sited on land. In contrast to utility-scale solar PV power plants (e.g. Silva and Sareen, 2021; Mulvaney, 2019), the installation of solar PV UPP units entailed no significant land use changes (see Figs. 2 and 3). All units were also funded by their owners, except one case in which the solar PV UPP unit (with 7.1 KW of installed capacity) was crowdfunded by Coopérnico, Portugal's first solar energy cooperative, created in 2013.

Considering the information collected in the 2021 survey, the adoption of energy management systems, demand response management system, energy storage systems and electric vehicles chargers in TER was even lower than the adoption of electricity generation technologies (see Tab. 6). Moreover, respondents' participation in energy cooperatives or communities was barely existent, as only one respondent declared to be a renewable energy cooperative member.

5.2 Factors influencing the adoption of renewable energy innovations

As shown in Figure 4, most respondents to the 2020 survey, when asked about the reasons for investing in electricity generation technologies, chose options associated with economic factors, notably "reduces energy cost". A significant number of respondents, however, also chose

Characteristics	Number
Nationality	Portuguese: 347
	Other: 18
Age	≤ 44 years: 93
	45–65 years: 203
	> 65 years: 69
Education level	4th grade: 8
	9th grade: 25
	12th grade: 60
	University degree: 272
Gender	184 females; 181 males

Tab. 5: The profile of the respondents to the 2020 survey
Source: author's survey

Renewable energy innovations	Agritourism	Country houses	Lodging tourism	Rural hotels	Others	% of all respondents
Solar PV UPP	20	21	6	3	10	16.4*
Solar PV UPAC	7	10	3	3	6	7.9*
Solar powered water pump	7	6	3	1	4	5.8*
Biomass/biogas UPAC	0	1	1	0	1	0.8*
Micro/mini hydropower plant	1	0	0	0	0	0.3*
Wind UPP	0	0	0	0	0	0*
Wind UPAC	0	0	0	0	0	0*
Digital energy management systems	4	8	1	1	0	6.6**
Demand response management system	0	3	0	0	0	1.4**
Energy storage technologies	3	3	0	1	0	3.3**
Electric vehicles chargers	7	11	2	3	2	11.7**

Tab. 6: Renewable energy innovations adopted by accommodation type
*Source: * author's 2020 survey; ** author's 2021 survey*

Fig. 2: Ground-mounted solar PV UPP in the Algarve region (Photo: L. Silva)

Fig. 3: Ground-mounted solar PV UPP in the Centre region (Photo: L. Silva)

options related to environmental factors, chiefly "helps mitigate climate change". In turn, as can be seen in Figure 5, when asked about the reasons for not investing in such technologies, most respondents chose options concerning market factors, principally "high equipment cost" and "lack of state subsidies". Yet, an expressive number of respondents also mentioned other factors, including "lack of grid connection infrastructure" and "legal, regulatory, or administrative barriers".

Regarding the 2021 survey, when asked what are the main reasons for adopting, or not, other renewable energy innovations, adopters mentioned "energy cost savings" (88% = 22/25), "environmental concerns" (76% = 19/25) and the "creation of a competitive advantage" (48% = 12/25), while non-adopters mentioned "high equipment costs" (64.9% = 122/188), "lack of money" (43.1% = 81/188) and "lack of quality information about technologies and systems" (33.5% = 63/188).

To identify other factors that could influence the adoption of renewable energy innovations in TER, we related the characteristics of the accommodation units and their owners/managers to adoption. The following variables were tested: 1) type of accommodation; 2) geographical location; 3) establishments' number of rooms; 4) building age; 5) age of owners/managers; 6) education level; 7) gender; and 8) nationality. Of these variables, only the second proved to be significant for the adoption of renewable energy innovations, as demonstrated below.

Considering the information collected in both surveys, there was no statistically significant variation related to type of accommodation in the adoption of renewable energy innovations (see Fig. 6). However, as shown in Table 6, the types of accommodation with the highest number of renewable energy innovations were Country Houses and Agritourism. We cannot assess the existence of possible regional variations in the adoption of renewable energy innovations for each accommodation type because these are unevenly distributed across the country. For example, Lodging Tourism units prevail in the North. But the highest percentage of respondents with renewable energy innovations were situated in the Lisbon Metropolitan Area region, followed closely by the Autonomous Region of Madeira, while those with the lowest percentage were situated in the North and the Azores regions (see Fig. 7).

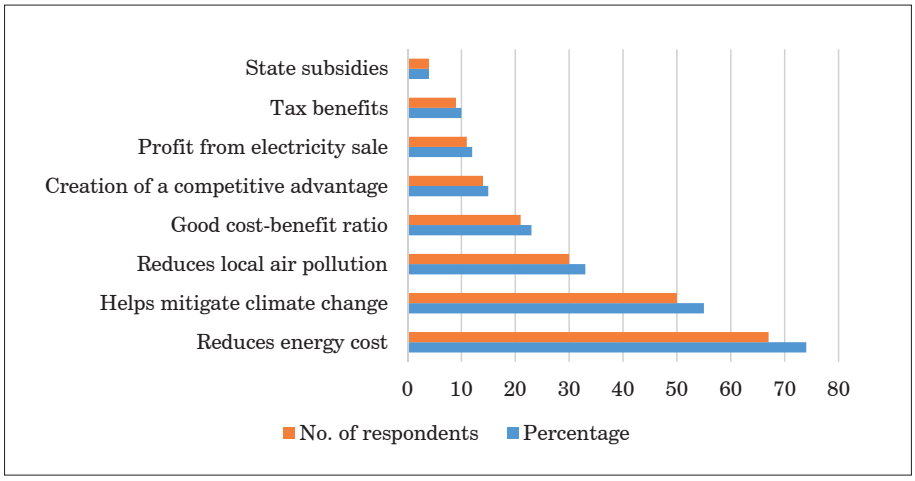

Fig. 4: Motivations for adopting renewable energy innovations
Source: author's 2020 survey

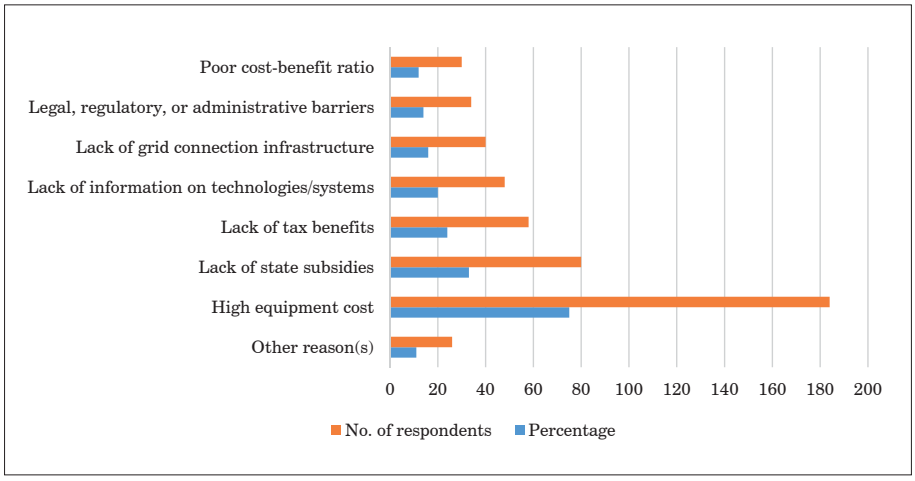

Fig. 5: Barriers to the adoption of renewable energy innovations[8]
Source: author's 2020 survey

[8] "Other reason(s)" included: lack of money; long payback period due to the small-scale of the businesses and the seasonality of the demand; bureaucratic hurdles in accessing state support; the prohibition of installing "modern" elements in the roofs of buildings located in protected sites; and the high cost and low efficiency of batteries for energy storage. On the cost of batteries for energy storage in Portugal, see Camilo et al. (2017).

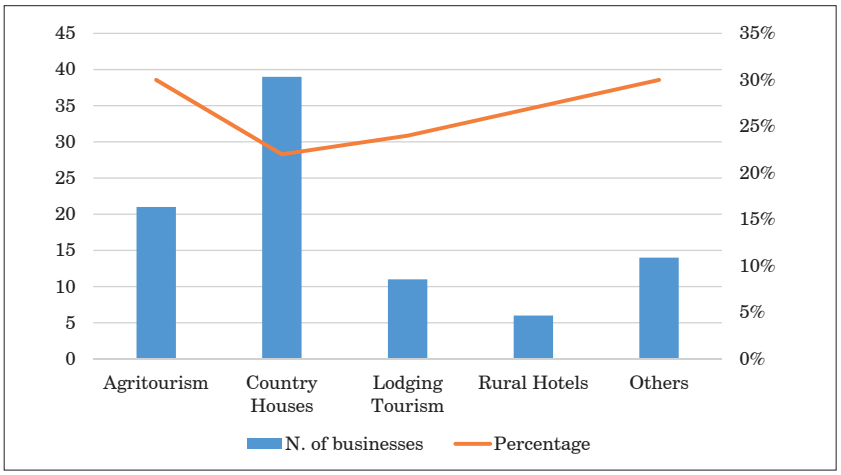

Fig. 6: Adoption of renewable energy innovations by accommodation type
Source: author's surveys

Additionally, there were no relevant statistical differences in innovation adoption when we consider the establishments' number of rooms – the highest number of TER establishments with renewable energy innovations offered between 6 and 9 rooms (29 units), followed by establishments offering between 4 and 5 rooms (20 units) and between 10 and 14 rooms (20 units), and these were the most prevalent TER sizes in the 2020 sample, as shown above (see Tab. 4).

There were also no significant differences if we consider the date of original construction of the main buildings associated with TER in renewable energy innovations adoption – both establishments with newer buildings and establishments with older buildings use such innovations (see Fig. 8). The same occurred with the sociodemographic characteristics of the owners/managers. Most adopters held a university degree, were between 45 and 65 years old and were Portuguese and females (see Tab. 7), in line with the characteristics of most respondents to the 2020 survey (see Tab. 5).

6. Discussion and conclusion

This article set out to examine the adoption of renewable energy innovations in the tourist accommodation sector of Portugal, with reference to TER. The above analysis has shown that the adoption of renewable energy innovations by the consumers at stake in this study is limited. Indeed, despite their positive perceptions of renewables, only one-quarter of respondents to our surveys have invested in renewable energy innovations, most of which were electricity generation technologies.

As to the factors influencing the uptake of these innovations, most respondents included economic benefits and environmental concerns in the reasons given for adoption. These research findings are consistent with the findings of other studies on the motivations for the uptake of renewable energy technologies and other environmental practices in hotels (Dhirasasna, Becken and Sahin, 2020; Dhirasasna and Sahin, 2021; Mahachi, Mokgalo and Pansiri, 2015; Wang, Font and Liu, 2020). Significantly, unfavourable market factors – high initial costs, lack of government incentives and lack of quality information about technologies and systems – were also highlighted as the main impediments to the adoption of renewable energy innovations by respondents. The case of TER thus parallels the findings of studies on the barriers to the uptake of renewable energy and environmental technologies in the hotel sector (Chan, Okumus and Chan, 2020; Dhirasasna, Becken and Sahin, 2020; Karagiorgas et al., 2006; Sardianou and Kostakis, 2020). Yet, several respondents also mentioned other barriers to adoption, including institutional, legal, regulatory, or administrative hurdles, which are related to the socio-political acceptance of renewable energy innovations or renewable energy technologies (cf. Sovacool and Ratan, 2012).

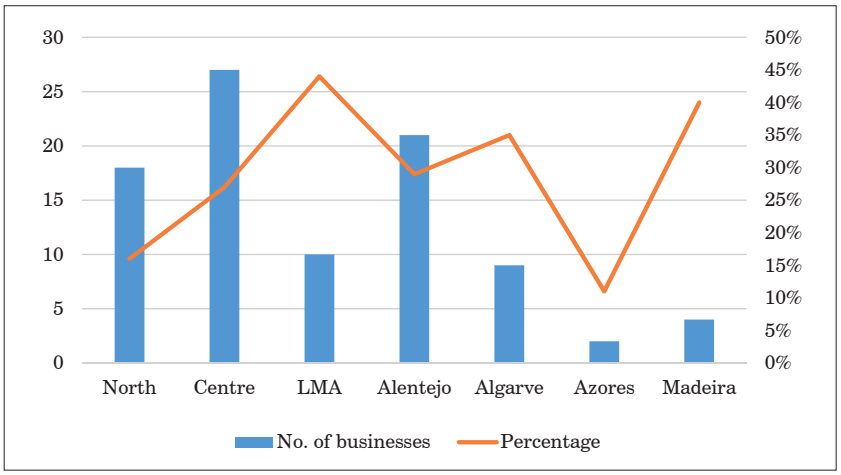

Fig. 7: Geographical location of the units with renewable energy innovations
Source: author's surveys

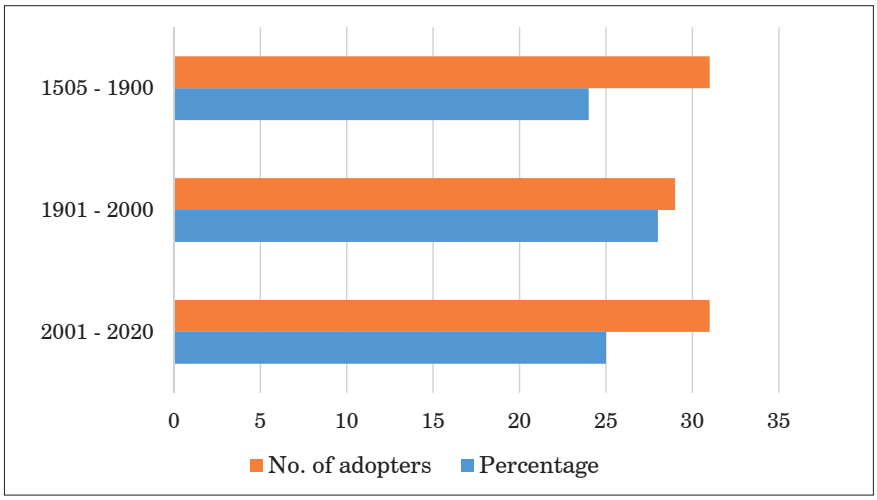

Fig. 8: Building age of the units with renewable energy innovations
Source: author's surveys

Characteristics	Number
Nationality	Portuguese: 87 (95.6%)
	Other: 4 (4.4%)
Age	≤ 44 years: 26 (28.6%)
	45–65 years: 51 (56.0%)
	> 65 years: 14 (15.4%)
Education level	4th grade: 0 (0%)
	9th grade: 6 (6.6%)
	12th grade: 15 (16.5%)
	University degree: 70 (76.9%)
Gender	Females: 50 (54.9%); Males: 41 (45.1%)

Tab. 7: The profile of the adopters
Source: author's surveys

Additionally, the analysis shows that the characteristics of the establishments and their owners/managers had no significant influence on the uptake of renewable energy innovations in TER, with the exception of geographical location. Establishments located in regions with high solar irradiation and where there is easier access to information about technologies and systems, such as the Lisbon Metropolitan Area region and the Autonomous Region of Madeira, are more likely to use renewable energy innovations. These results are partly similar to and partly different from the results of other studies. For instance, Coles, Dinan and Warren (2015) concluded that property age is not significant for the adoption of renewable energy technologies in tourist accommodations in England. Similarly, Mahachi, Mokgalo and Pansiri (2015) note that size is an important determinant of renewable energy uptake in hotels in Botswana. Likewise, Dinis et al. (2019) found that tourist accommodation managers with a university degree operating in the interior of Portugal are more likely to adopt local development practices.

This study has some limitations. First, its results do not fully reflect the adoption of renewable energy innovations in the whole tourist accommodation sector of Portugal because the study is centred on TER establishments and, hence, other types of tourist accommodation in the Portuguese countryside as well as accommodations in urban areas were not considered. Second, the study focused on the perspectives of TER owners/managers, leaving out those of other actors influencing the adoption (or non-adoption) of renewable energy innovations in tourist accommodations, such as national and local government representatives, electricity companies, electricity distribution system operators, tourists, and installers. Third, the other dimensions of social acceptance of renewable energy innovations included in Wüstenhagen, Wolsink and Bürer's (2007) theoretical framework, were not investigated.

Despite these limitations, this article enriches our understanding of a research topic that merits further investigation and offers information that can be used to design future strategies to promote the development of low-carbon tourism in Portugal. In particular, we strongly recommend the establishment of specific targets for the adoption of renewable energy innovations in tourist facilities, as well as measures to achieve them, such as higher government incentives, the provision of good quality information about technologies and systems to tourism entrepreneurs/managers, and the removal of remaining legal, regulatory, and administrative barriers. We further recommend the creation of a specific legal framework to support collective renewable energy prosumers, including peer-to-peer schemes. Future research could also examine the determinants of the uptake of renewable energy innovations in accommodations and other tourist facilities in both rural and urban areas in different countries.

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