

## Article

# Towards Nearly Zero Energy and Environmentally Sustainable Agritourisms: The Effectiveness of the Application of the European Ecolabel Brand

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**Abstract:** Tourism represents an important economic driver in Italy, being responsible for approximately 13.2% of the total GDP (a value higher than the reference European average) and for nearly 10% of the regional GDP. Among the touristic sectors, the agritourist ones show a persistent growth, experiencing in 2019 a 6.7 point percentage improvement compared to the 2017 figures. Given this situation, the transition towards a low-carbon path, affecting the building sector for some time, should also involve agritourist buildings, through the release of EU directives, member state laws, and technical rules. On the other hand, agritourism sites could be awarded the Community EU Ecolabel. Unfortunately, awarding the EU environmental excellence brand implies the availability of several data on building energy behavior that should then be managed by complex evaluation tools. To overcome this issue, the use of the simplified ARERA (Italian Regulatory Authority for Energy Networks and Environment) technical datasheets, issued to assess environmental improvements consequent to energy efficiency interventions in the urban residential building stock, is proposed. The application of this tool totally avoids using building computer-based simulation models, thus facilitating the preparation of the EU Ecolabel request documentation by agritourism owners. Being awarded the Community EU Ecolabel also implies approaching a net zero energy condition because of a lower energy consumption and a minor recourse to fossil fuels. For this purpose, an application of an easy graphical method, previously developed for residential and commercial buildings, which visually represents improvements achievable by a given agritourism when implementing energy efficiency measures, is presented.

**Keywords:** building energy efficiency; European environmental brands; tourism sector; agritourism; nearly zero energy buildings (nZEB)

## 1. Introduction

Tourism, and the activities connected to it, represent an important sector of the economic system. According to recent statistics the tourism industry represents about 10% of total global gross domestic product (GDP) and 7% of global trade [1,2], accounting for approximately 11% of the world's employment, with an expected positive economic growth trend [3,4]. Tourism constitutes a significant contributor to energy consumption, both at a global and European scale [5–7], which translates to a significant impact on the environment and ecosystem; it is in fact responsible for about 5% of the global CO<sub>2</sub> emitted by human activities [1,8].

Accommodation (thus the building), in particular, is the third energy consuming item (after travel and transport), much of which is consumed in space heating or air conditioning (up to 50% in some cases), followed by hot water, and cooking [9,10]. Moreover, a study conducted by the World Tourism Organization and the United Nations Environment Programme [11] estimates that accommodation generates 21% of tourism's total greenhouse gas (GHG) emissions. Accordingly, the number of papers analyzing tourism significance, in terms of energy consumption [12,13] and impacts on emissions [14,15], has been increasing lately.

Consequently, in recent years much attention has been paid to the concept of sustainable tourism, which in accordance with the United Nations Environment Programme (UNEP) and the United Nations World Tourism Organization (UNTWO) is defined as "development of tourism activities with a suitable balance between the dimensions of environmental, economic, and sociocultural aspects to guarantee its long-term sustainability". Hence, the challenge of sustainable tourism is to mitigate its negative impacts, consisting mainly in: (i) high energy consumption, (ii) increasing GHG emissions in the atmosphere, and (iii) the contribution to climate change [16].

Therefore, taking into consideration global [17,18], European [19–22], and national [23] policies, the UNWTO recommended three central actions on which the tourism sector should concentrate in order to contribute in achieving a more sustainable development [1,24], which are resource efficiency, environmental protection, and climate change (linked to sustainable development goals (SDGs) 6, 7, 8, 11, 12, 13, 14, and 15) [25].

At the European scale, the European Commission set the basis for the best environmental management practice in the tourism sector in accordance with Article 46 of the Eco-Management and Audit Scheme (EMAS) regulation [26,27]. Furthermore, by means of the "Guide on EU funding for the tourism sector 2014–2020" [28] the EU states that effective governance, policies, frameworks, and tools need to be implemented in order to properly guide and support (also from an economic point of view) the development and promotion of sustainable tourism practices.

Tools like these are indeed important because they encourage the owners and/or managers of the accommodation facilities to use practices and systems that allow both energy savings and pollutant emissions, by favoring the visibility of these structures in terms of environmental sustainability, which represent an added value, given that tourists are becoming increasingly more attentive to this issue.

In this regard one of the first initiatives undertaken by the European Community has been the releasing of the EU Ecolabel for tourist accommodation services [29], created to improve the environmental performance of hotels, campsites, hostels, agritourisms, holiday homes, and bed & breakfasts, by providing efficient guidelines on the action to be implemented in order to lower their environmental impact; and which still remains one of the most implemented initiatives.

The promotion of sustainable tourism is also the basis of the nearly zero-energy hotels (neZEH) project, launched by the Intelligent Energy Europe Programme of the European Commission, with the intent of supporting European hotels in complying with the nZEB (nearly-Zero Energy Buildings) regulations [1]. On this subject, various studies have been conducted aimed at analyzing the achievable energy saving measures [30–32] and proposing suitable strategies and policies to be adopted [33,34].

Looking at the national scenario, the tourism issue is particularly relevant, considering that 16.5% of EU accommodation facilities are located in Italy [35], and since in the last two years Italy resulted to be amongst the top five most visited European tourist destinations (for accommodation in hospitality facilities), with a 13.4% share of the total of the EU-28 [36,37].

According to some recent statistics, the Italian tourism sector represents 13.2% of the national GDP (for a total contribution of around 230 billion euros), higher than both the world and European figures (which stand at around 10%). The economic impact of tourism is significantly reflected in the job market, accounting for 14.9% of the country's total employment [38]. Tourism is in fact one of the fastest growing industries in Italy, and both public and private business organizations are strongly interested in its economic and environmental impact, both at national and regional level [39,40].

Thus, from the collaboration between such organizations and the national and regional governments, different initiatives have been undertaken from an environmental sustainability point of view in recent years. These include the creation of a set of national environmental quality certifications (besides the previously cited EU Ecolabel), including the “Green Key” [41], “Bandiera Blu” [42], and “Spighe Verdi” [43], born from the collaboration between the Italian Foundation for Environmental Education—FEE Italia (whose actions are supported by ONU, UNEP, UNWTO, and UNESCO) and national authorities dealing with environmental policies [44].

Furthermore, other economic initiatives have been implemented to encourage the use of sustainable energy solutions through financial incentives. The “Tax Credit Alberghi—Bonus alberghi e agriturismo” (bonus for hotels and agritourism), a tax facility that encourages various upgrading activities, including those aimed at improving energy efficiency, has recently been introduced, specifically for accommodation facilities [45].

Agritourism, or rural tourism, has been promoted as a practice able to encourage the use of green practices, making farms sustainable and also maintaining the local historical and natural settings [8,46].

Thanks to this, according to recent statistics in Italy, the agritourism sector continues to record a growing trend, both in the number of structures, and in the presence of customers and its economic value. Agriculture economic reports make it possible to measure the economic dimension of the agritourism sector, which is equal to 1.36 billion euros, up 6.7% compared to the previous year. In particular, 60% of agritourisms are located in the regions of central and southern Italy, where Sicily prevails with more than 600 farms [47].

The growing interest in the agritourism sector is also reflected in the academic world, where studies concerning both the economic and social benefits of various tourist activities in the rural area, including agritourism [48], and the environmental performance of agritourism companies in terms of energy performance [49,50], can be found.

In the present work we verified whether the simplified ARERA (Italian Regulatory Authority for Energy Networks and Environment) technical datasheets [51], issued for the urban residential building stock, can be easily applied to estimate the increase in energy efficiency (or the corresponding decrease in the release of polluting substances) consequent to the adoption of some improvements to a building or plant, planned for the issuance of the EU Ecolabel brand for accommodation facilities [29]. The convenience in the use of these technical datasheets lies in the fact that they allow the estimation of the energy demand reductions without necessarily going through the building simulation. For this purpose, a case study has been conducted to estimate what advantages agritourism owners could gain in adopting a well-known brand such as the EU Ecolabel [29], with particular reference to the actions aimed at saving energy and reducing emissions of pollutants, from the perspective of a possible “nearly Zero Energy Agritourism (nZEA)”, in parallel with the previously cited nZEB and neZEH projects.

The idea at the base of this work stems from the numerical consistency of agritourisms in Sicily [47] and their conceivable growth trend, which is a consequence of the increased interest in the rural landscape of the territory and in the products of the land that are strongly orienting tourism, directing it not only towards the urban context. The adoption of an environmental certificate like the EU Ecolabel [29] can therefore represent an advantage both for agritourism owners and for the entire territory.

Furthermore, the owners of agritourism in Sicily can apply for subsidized loans and financial funding [28,52] in the regional area and beyond. However, such requests must be supported by information concerning the consumption and energy efficiency of the agritourism and, in line with the new European directives on sustainability [17–19], by information on the environmental performance of the buildings themselves (premises).

Normally this information is of a complex nature and tends to imply the use of sophisticated simulation models, the use of which is not always the prerogative of (or available to) the managers of the holiday farms. The same problem can be found by analyzing the work of the decision makers who have to assess the adequacy of the requests for funding.

Essentially, the availability of simple but reliable tools for evaluating these premises is of paramount importance for the orientation of this important tourism sector towards a sustainable path.

Hence, as previously mentioned, in order to provide a contribution to this important issue we assessed the reliability of a scheme of simple computational methods provided by the Italian Regulatory Authority for Energy Networks and Environment—ARERA [51], specifically for the residential and tertiary building stock. The advantage in the use of this computational scheme lies indeed in the fact that it is based on excel spreadsheets (technical datasheets) which, as already mentioned, allow the estimation of the energy demand reductions without the need of simulating the building behavior.

## 2. Materials and Methods

The proposed methodology aims at considering together in an easy and accessible way two aspects of the sustainability, which are energy efficiency and environmental safety, in order to help agritourism owners, and/or managers, to make decisions that are more favorable to them and consistent with the European policies in force. Specifically, according to the presented approach, the selection of energy efficiency interventions is based on a combination of the ARERA technical datasheets and the EU Ecolabel criteria, hence taking into account the environmental sustainability aspects, and also in view of achieving a possible nearly zero energy condition (nZEA). Therefore, two Sicilian agritourisms have been selected to show how the application of the proposed methodology actually works.

The considered approach can also be seen as a simple diagnosis method aimed at facilitating the social appropriation of knowledge and technology, so that the owners of agritourism facilities can confidently check their level of eco-efficiency. Moreover, the method can be utilized in order to choose between addressing actions concerning the energy performance of the structure or interventions regarding the installation of new (renewable) energy plants.

### 2.1. Agritourism Definition

The Italian national legislation [53], and the regional Sicilian one [54,55], define as ‘agritourism’ activities, those reception and hospitality activities exercised by agricultural entrepreneurs, through the use of their own company connected with the activities of cultivation of the land, forestry, and animal breeding. Thus, agritourism activities include:

- providing accommodation;
- administering meals and beverages consisting mainly in products of their own production and products from farms in the local area;
- organizing recreational, cultural, educational, sports, and excursion activities aimed at promoting and supporting the territory and the rural heritage.

### 2.2. The ARERA Technical Datasheets

In the present work, the use of ARERA technical datasheets [51] was not an arbitrary (random) choice, but it was decided to turn to these methods since, although simplified, they constitute an official reference at the Italian national level.

The Italian Regulatory Authority for Energy Networks and Environment—ARERA is indeed an independent body, established with the task of protecting consumers’ interests and promoting competition, efficiency, and the spread of services, and having adequate quality levels, through regulation and control activities. The action of ARERA concerns the sectors of electricity and natural gas [56], water services [57], district heating and district cooling [58], and the waste cycle [59].

One of the main tasks of ARERA is to promote the rational use of energy, with particular reference to the promotion and diffusion of end use energy efficiency and/or energy saving actions, and the adoption of measures for sustainable development. Among the feasible actions, there are both active measures, which involve the installation of high efficiency equipment, or the insertion of regulation

devices for a more efficient use of energy, and passive interventions such as the modification of buildings' envelope in order to reduce losses.

In this regard, the technical datasheets proposed by ARERA establish the guidelines for the preparation, execution, and final evaluation of specific actions, aimed at increasing energy efficiency (or promoting energy saving), providing reduced rates of primary energy consumption actually achieved (expressed in toe—Tons of oil equivalent), and also for the purpose of issuing energy efficiency certificates. Table A1 in Appendix A reports a comprehensive list of the current standardized and analytical ARERA technical datasheets.

### 2.3. The EU Ecolabel Brand

Established in 1992 (by Regulation n. 880/92 [60], now disciplined by Regulation (EC) n. 66/2010 [61] in force in the EU-28) and recognized across Europe and worldwide (Figure 1), the EU Ecolabel is a voluntary environmental performance certificate that is awarded to products and services meeting high environmental standards. The EU Ecolabel encourages companies to develop products and provide services that consume less energy, and generate less waste and CO<sub>2</sub> emissions. As of March 2019, an increase by 88%, with respect to 2016, of the number of EU Ecolabelled products/services has been registered. Leading countries for number of products/services are: Spain, Italy, Germany, Belgium, and France [62].



Figure 1. Official EU Ecolabel logo [62].

The EU Ecolabel provides exigent criteria, and relative guidelines, depending on the type of product and/or service, in order to reduce their overall environmental impact. Such criteria are established at a European scale with a wide participation of interested parties, including both public authorities, and consumer and environmental associations [63].

In particular, the EU Ecolabel for tourist accommodation services [29] was created specifically for hotels, campsites, hostels, agritourisms, holiday homes, and bed & breakfasts, in order to improve their environmental performance, by providing a set of criteria on the action to be implemented in order to lower their impact. Such criteria are divided into mandatory and optional, and focus on the five categories; general management, energy, water, waste and wastewater, and other, as shown in Table A2 in Appendix A.

In order to be awarded the EU Ecolabel a tourist accommodation service, other than falling within the product group “tourist accommodation” according to the legal obligations of the country in which the accommodation is located, must comply with all the mandatory criteria (if applicable), and receive at least twenty points under the optional criteria [29].

An added value, in terms of visibility, for tourist accommodation owners lies in the fact that the EU Ecolabel is recognized by the majority of travelers as a way of legitimizing the accommodation's claims that it is making real efforts to reduce its impact on the environment in its operational activities.

### 2.4. Analysis Methodology

#### 2.4.1. Merging the ARERA Technical Datasheets and the EU Ecolabel Criteria

As mentioned in the introduction section, the aim of the present work is to verify whether the simplified ARERA technical datasheets can be applied to estimate the increase in energy



efficiency consequent to the adoption of some actions planned for the issuance of a EU Ecolabel for Tourist Accommodation Services, without necessarily going through the building simulation. Obviously, an increase in the energy efficiency implies a corresponding decrease in the release of polluting substances.

Therefore, since this work is mainly focused on the energy criteria, starting from the assumption that the considered agritourism meets all the mandatory criteria, it was decided to analyze possible “environmental action packages”, consisting of different combinations of the actions established by the optional energy criteria, which are better suited to a scenario such as agritourism, and which allow the obtaining of the weight of the energy category on the twenty points minimum limit set by the regulation, which corresponds to 7.34 points.

To this purpose, only the ARERA datasheets regarding the actions related to the improvement of the structure energy efficiency that could be transferred and applied to agritourism structures, according to the EU Ecolabel for Tourist Accommodation energy criteria, have been considered, as reported in Table 1, where the correspondent energy consumption categories have also been reported.

**Table 1.** Correspondence between the Italian Regulatory Authority for Energy Networks and Environment (ARERA) datasheets and the EU Ecolabel energy criteria.

ARERA Technical Data Sheet N.	EU Ecolabel Criterion N.	EU Ecolabel Achievable Points	Energy Consumption Category <sup>1</sup>
5	33	4	HVAC
7	39, 40, 41	3.5	RES
8T	6	2	DHW
15T	6, 7	1.5	HVAC
19T	7	3.5	HVAC
27T	6	1.5	DHW
6	-	-	HVAC
20T	-	-	

<sup>1</sup> HVAC—Heating, Ventilation, and Air Conditioning; DHW—Domestic Hot Water; RES—Renewable Energy Source.

As can be seen in Table 1, under the dotted line, the two ARERA datasheets 6T and 20T, additional to those that can be associated to the EU Ecolabel, have also been taken into account. In fact, even though these two intervention typologies are not foreseen by the current Ecolabel scheme, they represent actions that can actually be applied to an agritourism structure in the perspective of a possible “nearly Zero Energy Agritourism (nZEA)” as a parallel with the well-known nZEB concept; and also, in view of a possible future improvement of the Ecolabel scheme.

The selected datasheets (Table 1), have been then put into the form of appropriate excel spreadsheets.

The equations relative to the ARERA calculation procedures, for each considered technical datasheet, are given in Appendix B.

One aspect that must be highlighted here regards the fact that while datasheets 5, 6, 15T, 19T, 20T, and 27T enable obtaining savings of consumed energy (energy saving measures, ESM), datasheets 7 and 8T allow, instead, the production of energy from renewable sources (renewable energy sources, RES).

#### 2.4.2. Methodology Application Feasibility

With the aim of assessing the potential energy savings, with reference to a real context, it was decided to select two agritourisms situated in the Sicilian province of Palermo, considered as representative of the whole regional agritourism context regarding the size, the provided services, and more importantly for the purpose of the proposed methodology object of the present work, in terms of energy consumption. Apart from these physical and energy features, both agritourisms were selected thanks to their wide offer of services, which are representative of these kind of farms, and due to the fact that they operate in the two climatic zones where agritourisms are mainly sited in

Sicily. Specifically, the two agritourism are *Villa Dafne*, sited in Alia and belonging to climatic zone D, and *Bergi*, located in Castelbuono and classified as climatic zone C. Both agritourisms fall into solar belt 3. Table 2 describes the main general characteristics of the two structures.

**Table 2.** General characteristics of the two selected agritourisms.

Characteristic	<i>Villa Dafne</i>	<i>Bergi</i>
Covered surface (m <sup>2</sup> )	1000	1400
Glazed surface (m <sup>2</sup> )	236	305
Opaque surface (m <sup>2</sup> )	2768.5	2791.75
Surface/Volume ratio (-)	0.62	0.5
N. of seats in the dining area	150	180
N. of rooms	35	34

In Table 3 is reported the information relative to the energy characteristics of interest for the conducted study, which were obtained by on field surveys and interviews with the owners of the two businesses, thanks to which it was possible to reconstruct the energy consumption relative to an entire year of operation of the structures. In particular, the data regarding the energy consumption were distributed between four main categories and accordingly broken down into percentages, and corresponding toe/year, also with reference to the corresponding energy sources. As for the energy sources' average costs, the following values were used:

- 0.19 €/kWh for electricity;
- 1.17 €/Sm<sup>3</sup> for natural gas;
- 0.90 €/lt. for diesel oil.

**Table 3.** Energy sources and energy consumption breakdown for the two selected agritourisms.

Category	Source	<i>Villa Dafne</i>		<i>Bergi</i>	
		%	Toe/Year	%	Toe/Year
Domestic Hot Water (DHW)	natural gas/diesel oil	0	0.00	16	5.09
	electricity	22	9.72	6	1.91
Lighting	electricity	15	6.63	15	4.77
Heating, Ventilation and Air Conditioning (HVAC)	natural gas/diesel oil	25	11.05	15	4.77
	electricity	14	6.19	24	7.64
Other	natural gas/diesel oil	0	0.00	0	0.00
	electricity	24	10.60	24	7.64
<b>Total</b>			<b>44.18</b>		<b>31.82</b>

Subsequently, it was hence possible to obtain the achievable energy savings (AES), in terms of percentage of electricity consumption covered by the datasheets proposed interventions on an annual basis, by comparing the values obtained from Equations (A1) to (A8), and the total energy consumption (Table 3), by means of the following equation:

$$AES_i = \frac{R_i}{Tot. cons._j} [\%] \quad (1)$$

where:

- $R_i$  represent the energy savings obtained from Equations (A1) to (A8);
- $Tot. cons._j$  is the total figure reported in Table 3;
- $i$  and  $j$  represent the selected intervention and the considered agritourism, respectively.

Regarding the pollutant emissions, an assessment of the CO<sub>2</sub> emissions' reduction was conducted assuming for the considered climatic context an emission factor equal to 2.30 tCO<sub>2</sub>eq/toe for the electrical supply [64,65], while for natural gas and diesel oil an emission factor of 3.08 tCO<sub>2</sub>eq/toe and 2.34 tCO<sub>2</sub>eq/toe, respectively [66].

In order to single out the most convenient aforementioned “environmental actions packages”, an economic estimation relative to the interventions suggested by the ARERA technical datasheets was also performed. To this purpose, the information relative to the costs of supply and installation for the materials, used to calculate the proposed interventions costs, were obtained from the current regional price list [67] and from local market surveys, as reported in Table 4.

**Table 4.** ARERA technical datasheets proposed interventions costs.

Datasheet N°	Proposed Intervention	Cost
5	Replacement of simple glazing with double glazing	407.13 €/m <sup>2</sup>
7	Use of photovoltaic systems with an electrical power of less than 20 kW	1898.42 €/kW <sub>p</sub>
8T	Installation of solar collectors for the production of domestic hot water	578.73 €/m <sup>2</sup>
15T	Installation of outdoor air electric heat pumps instead of boilers in newly built or renovated residential buildings	4901.323 €/UFR *
19T	Installation of high efficiency outdoor air conditioners with cooling capacity lower than 12 kW <sub>f</sub>	490.13 €/kW
27T	Installation of electric heat pump for domestic hot water production in new and existing plants	570.65 €/UFR *
6	Wall and roof insulation	29.32 €/m <sup>2</sup>
20T	Thermal insulation of walls and roofs for summer cooling in domestic and service sectors	29.32 €/m <sup>2</sup>

\* UFR—Reference physical unit.

Successively, the economic savings, in terms of saved €/year, were obtained by multiplying the energy savings with the energy sources' average costs, according to the considered categories breakdown (Table 1). Furthermore, in order to select the optimal “environmental actions packages”, for these the pay-back periods (not discounted) were also calculated and expressed in years.

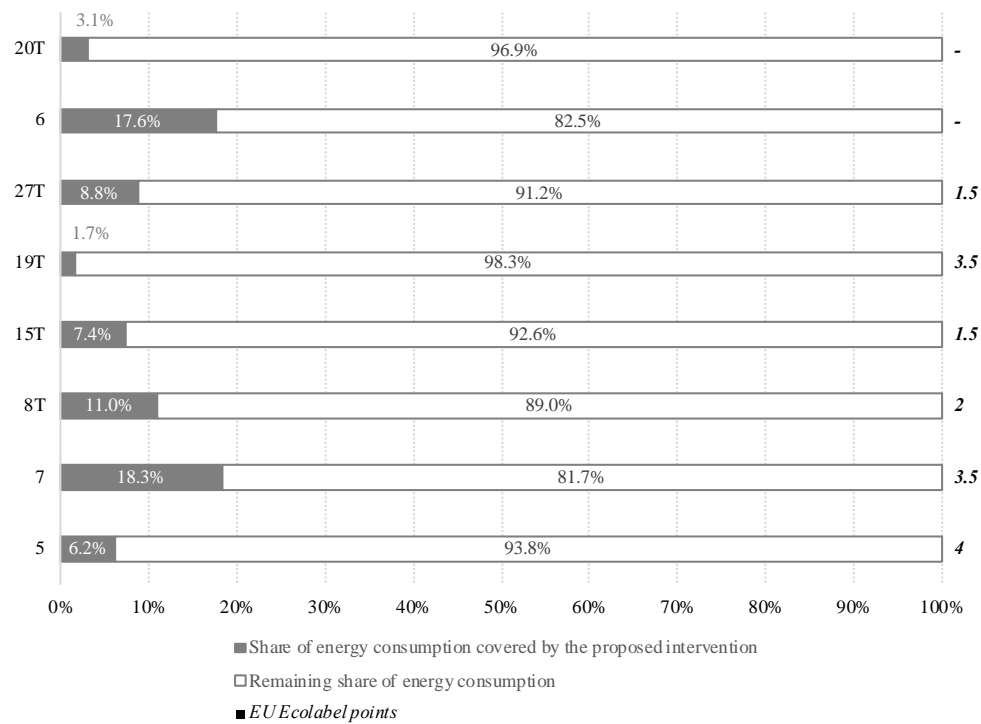
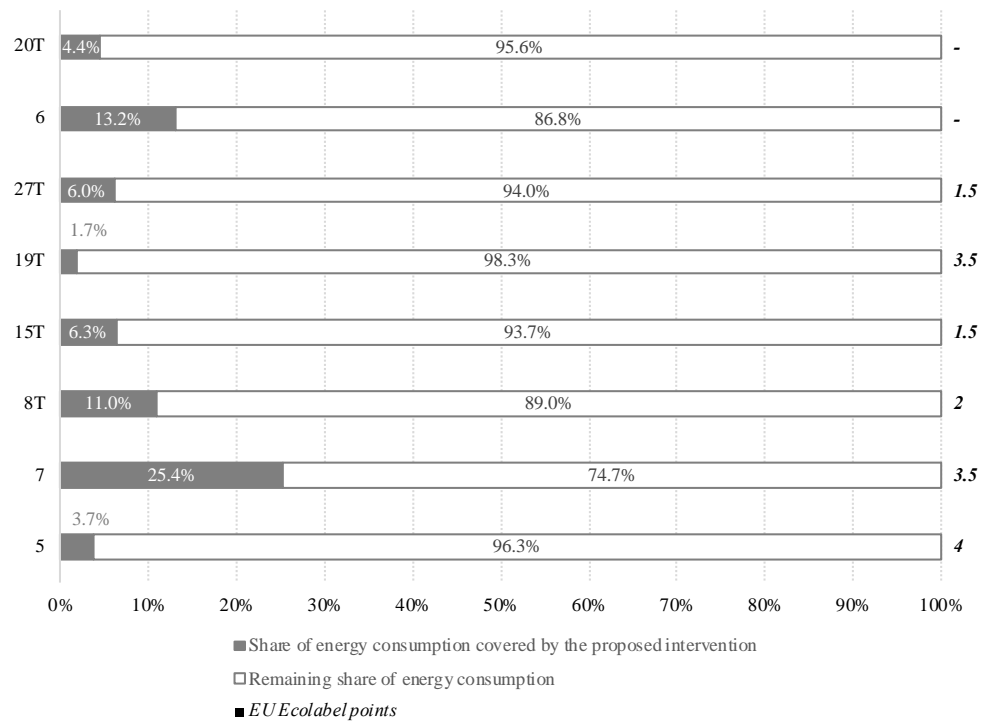
### 3. Results

In this section the outcomes of the application of analysis methodology are reported.

Regarding the input parameters used in the equations relative to the ARERA calculation procedures, for each considered technical datasheets, these are given in Table A3 in Appendix B.

The following Figures 2 and 3 show the achievable energy savings (AES) on the total annual consumption, relative to the application of the intervention proposed by each considered ARERA datasheet, to the two agritourisms. On the right side of the graphs, the EU Ecolabel points corresponding to each datasheet are also reported.



*Villa Dafne* agritourism' achievable energy savings for each datasheet**Figure 2.** Achievable energy savings (AES), on an annual basis, and EU Ecolabel points relative to each considered ARERA datasheet for *Villa Dafne* agritourism.*Bergi* agritourism' achievable energy savings for each datasheet**Figure 3.** Achievable energy savings (AES), on an annual basis, and EU Ecolabel points relative to each considered ARERA datasheet for *Bergi* agritourism.

Figures 2 and 3 show how, amongst the ARERA proposed interventions enabling the obtaining of an EU Ecolabel score, the implementation of a photovoltaic (PV) system (datasheet 7) would be the one allowing the gain of a greater advantage in terms of energy consumption. Concerning the savings related to the domestic hot water (DHW) category, by comparing datasheets 8T and 27T, which are alternatives to each other, it can be observed how 8T would be the more convenient choice. Regarding the heating, ventilation, and air conditioning (HVAC) category, the savings achievable through the application of datasheets 15T and 19T should, instead, be considered jointly (15T + 19T) as they can be attributed to the same improvement intervention. As for datasheet 5, although it represents one of the easiest measures to implement, it does not seem to bring the benefits that would have been expected.

With respect to datasheets 6 and 20T, also in this case the consideration that the attainable benefits must be considered together (6 + 20T) is valid. As already explained these two datasheets fall out of the Ecolabel scoring scheme, nevertheless they represent the second-best intervention that allows the highest energy savings, after datasheet 7.

The overall obtained results for the two considered agritourisms are reported in Tables 5 and 6.

**Table 5.** Proposed interventions costs and environmental benefits for *Villa Dafne* agritourism.

ARERA Datasheet N.	EU Ecolabel Points	Proposed Intervention Cost (€)	Energy Savings (AES)	CO <sub>2</sub> Emissions Reduction (tCO <sub>2</sub> eq/Year)	Economic Savings (€/Year)
5	4	123,971.09	6.20%	7.7	2831.21
7	3.5	37,588.70	18.26%	18.6	8053.63
8T	2	13,392.91	11.00%	11.2	4851.56
15T	1.5	98,026.40	7.37%	10.0	3429.31
19T	3.5		1.67%	1.7	738.75
27T	1.5	20,930.15	8.80%	9.0	3881.25
6	-	81,172.42	17.55%	23.9	738.74
20T	-		3.13%	3.2	1381.90

**Table 6.** Proposed interventions costs and environmental benefits for *Bergi* agritourism.

ARERA Datasheet N.	EU Ecolabel Points	Proposed Intervention Cost (€)	Energy Savings (AES)	CO <sub>2</sub> Emissions Reduction (tCO <sub>2</sub> eq/Year)	Economic Savings (€/Year)
5	4	95,980.90	3.70%	2.73	1350.79
7	3.5	37,588.70	25.35%	18.59	8053.63
8T	2	14,608.10	11.00%	8.18	4595.95
15T	1.5	73,519.80	6.29%	4.69	2767.13
19T	3.5		1.74%	1.28	554.06
27T	1.5	10,182.10	6.00%	4.40	1905.96
6	-	81,854.11	13.16%	9.81	1212.67
20T	-		4.39%	3.22	1393.51

As can be observed, according to what has been previously pointed out, a single intervention cost was given to datasheets 15T and 19T as the proposed intervention corresponds to the same type of system, i.e., the same system allows operation for both heating and cooling. The same consideration can be made for datasheets 6 and 20T in relation to the insulation of the building.

Looking at the economic savings column it can be noticed how, from this point of view greater advantages can be associated with datasheets 7 and 8T, followed by 15T + 19T, 27T and lastly 5. Considering the whole set of interventions, instead, the (6 + 20T) option would also result second in this case.

Referring to CO<sub>2</sub> emissions reduction, the obtained results are obviously in line with what was seen beforehand (Figures 2 and 3) and commented on with the energy savings.

#### 4. Discussion

The application of the ARERA data sheets to agritourism raises a question concerning the suitability of these simplified forms to the energy performances of agritourism sites, being originally developed for residential and commercial buildings.

On the other hand, a possible improvement of the energy features of an agritourism, due to the actions referred to in the ARERA datasheets, should be evaluated on the base of its effectiveness in addressing a given site, towards a nearly-zero energy path, as required by the current international standards [20,21,28].

Both issues are briefly discussed in the following.

##### 4.1. Effectiveness of the Proposed Actions

The obtained results could seem not too encouraging in terms of energy savings. In fact, the reduction of the energy demand following the proposed actions accounts for about one third of the annual energy consumption for both the considered agritourisms. However, this is not surprising; the fact that the ARERA technical datasheets proposed interventions have been designed for the residential sector, in fact, place some limits on their application in a wider context, such as the agritourism one. Specifically, the limitations set on the reference physical units (UFRs) sizes might have made the outcomes much lower than the actually achievable results.

For instance, concerning datasheet 7 a maximum  $kW_p$  of 20 kW is reductive for an agritourism, which could employ PV better having wide areas available to install such systems. Supporting this observation, during the survey of the agritourisms, it arose that both currently have a 100-kW PV undergoing design phase. In this context it would be more sensible to impose a limit on the maximum percentage of yearly energy consumption to be covered with the proposed intervention.

The latter consideration also applies to datasheet 8T.

Regarding, instead, datasheet 15T the application problem is mainly related to the residential standard apartment size (80–90 m<sup>2</sup>), which is difficult to translate into an agritourism setting. In the conducted analysis, for instance, in order to comply with such a parameter, three to four rooms were grouped and assumed equal to 1.5 standard apartments, but it could be a questionable criterion.

As for datasheets 19T, it would be more reasonable to install a centralized system rather than considering the replacement of the single air conditioning units (the same goes for the heat pumps proposed by datasheets 15T).

Nevertheless, since one of the aims of this work was that of singling the most convenient EU Ecolabel “environmental actions packages”, based on the comparison of the results reported in Tables 5 and 6 it was decided to tentatively choose three alternative options, both for *Villa Dafne* (VD-*n*) and *Bergi* (B-*n*), as follows:

- options VD-1 and B-1, constituted by datasheets number 5 and 7;
- options VD-2 and B-2, constituted by datasheets number 7, 8T and (15T + 19T), the latter two must be considered together for the reasons indicated at the end of Section 2.4.2.;
- options VD-3 and B-3, constituted by datasheets number 7, (15T + 19T) and 27T.

Table 7 summarizes the obtained results relative to the selected “environmental actions packages”.

By analyzing the data reported in Table 7 it was, therefore decided to consider as optimal options VD-2 for *Villa Dafne* and B-2 for *Bergi*. These two options allow, in fact, the obtaining of greater economic and energy savings and, correspondingly, higher CO<sub>2</sub> emissions reductions. Moreover, they are characterized by the lower pay back periods.

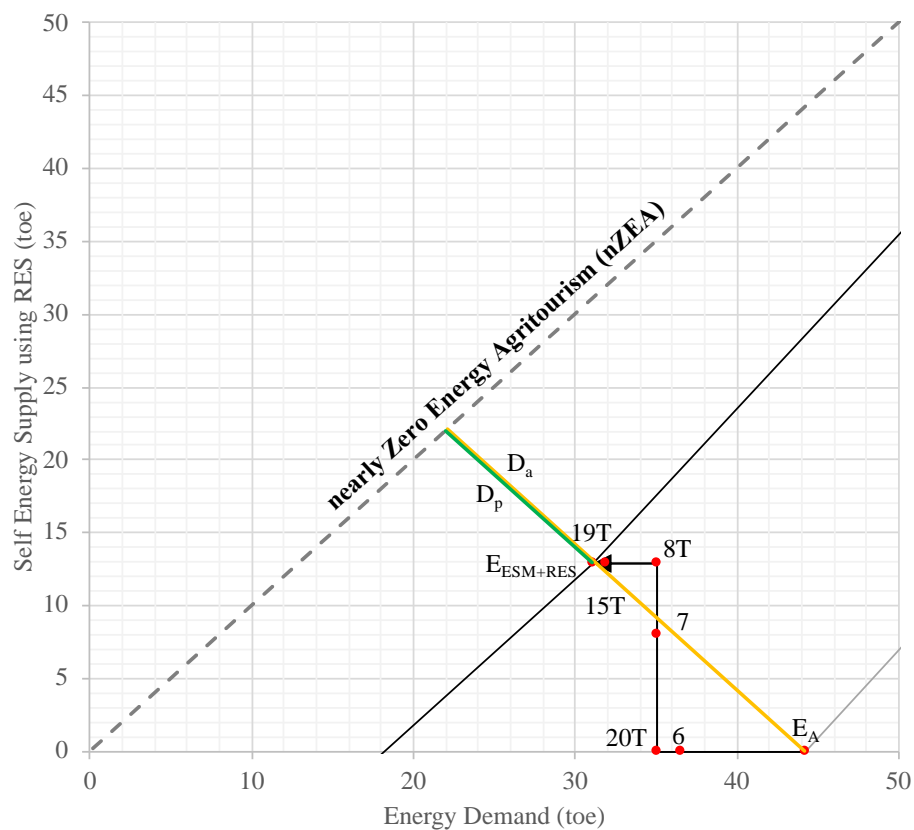
It must be observed that the availability of effective and reliable methods for evaluating the energy actions involving agritourism is of paramount importance for suitable planning of this important sector. Therefore, the ARERA technical data sheets should be properly reconsidered in order to render them more complicit with the energy features of agritourism buildings and dwellings.

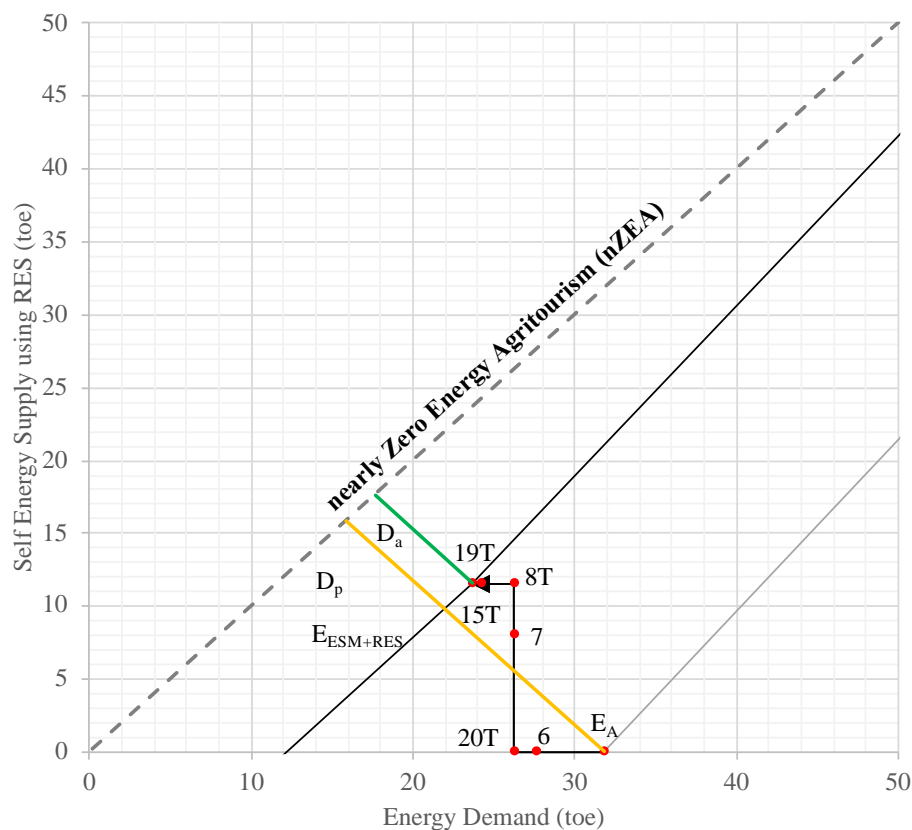
**Table 7.** Summarized results for the two agritourisms.

Agrit.	Environm. Actions Package	EU Ecolabel Points	Environmental Actions Package Cost (€)	Energy Savings (AES)	CO <sub>2</sub> Emissions Reduction (tCO <sub>2</sub> eq/Year)	Economic Savings (€/Year)	Pay Back Period—Not Discounted (Years)
<i>Villa Dafne</i>	VD-1	7.5	161,559.79	24.46%	26.3	10,884.84	14.8
	VD-2	10.5	149,008.01	36.63%	39.8	16,334.51	9.1
	VD-3	10	156,545.25	34.43%	37.6	15,364.20	10.2
<i>Bergi</i>	B-1	7.5	133,569.60	29.05%	21.3	9,404.42	14.2
	B-2	10.5	125,716.60	42.64%	31.5	15,416.72	8.2
	B-3	10	121,290.60	37.64%	27.7	12,726.73	9.5

#### 4.2. Towards a Nearly Zero Energy Agritourism

As already mentioned, another intention of this work concerned the possibility of applying some actions to the agritourism structures, additional to those envisioned by the EU Ecolabel, in order to move towards a potential “nearly Zero Energy Agritourism (nZEA)”. For this purpose, the results relative to ARERA datasheets 6 and 20T were added to the selected optimal options VD-2 and B-2 for *Villa Dafne* and *Bergi*, respectively; the outcomes of such combinations are reported in Figures 4 and 5.

**Figure 4.** Path towards a nearly zero energy condition (nZEA) for *Villa Dafne*.



**Figure 5.** Path towards a nearly zero energy condition (nZEA) for *Bergi*.

According to such approaches and visual representations, already used in the literature [68–70], the nearly zero energy condition (nZEA) is reached when the energy demand (reported on the x axis) is completely covered by the self-energy supply from renewable sources (reported on the y axis).

Therefore, the effectiveness of the ARERA proposed interventions in moving agritourism towards a sustainable path, nZEA, is given as a simple summation of the effects provided by the energy saving measures— $E_{ESM}$  (datasheets 6, 15T, 19T, and 20T) and those attributable to the renewable energy sources— $E_{RES}$  (datasheets 7 and 8T).  $E_A$  represents, instead, the current energy consumption and,  $D_a$  and  $D_p$  the current (ante operam) and achievable (post operam) minimum distances (hence the perpendicularity) from the nZEA condition, respectively.

For the sake of simplicity, this assumption does not take into account the synergetic effects that are likely induced by the contemporary adoption of different energy actions on a given agritourism site.

Consequently, the results reported in Figures 4 and 5 show that the selected combinations of interventions allow an improvement of 59% for *Villa Dafne* and a 62% for *Bergi*, in terms of approaching the nZEA condition with respect to the current conditions.

Regardless of the obtained results, the proposed methodology can be seen as a simplified scheme for analyzing and ranking the “environmental actions packages” applicable to agritourisms, and could be usefully adopted by local administrations to define the impact of different scenarios in order to better define environmental policies concerning the agritourism sector.

The proposed assessment/estimation methodology could, therefore, also represent important information for the design of the rural tourism sector, and of the/a regional energy plan by stakeholders and decision makers [71,72].

#### 4.3. On the Correspondence between the EU Ecolabel Criteria and the ARERA Technical Datasheets

The application of the ARERA technical datasheets and the EU Ecolabel criteria to two different agritourisms in Sicily (here considered representative of the whole regional agritourism context) enabled

us to better understand the level of compliance between two such schemes. The level of correspondence cannot totally match, since the ARERA methodology has been designed specifically for residential buildings and, on the other hand, the EU Ecolabel for Tourist Accommodation Services applies expressly to tourism facilities, with features that could not be perfectly applicable to agritourisms. These latter, in fact, are generally characterized by the presence of cultivated soils and the production of agrifarm foods and products.

Nevertheless, the comparison exerted on the two sites has shown that some useful correspondences can be assessed. In fact, by means of the combination of the ARERA technical datasheets and the EU Ecolabel energy optional criteria, it is likely possible to identify some “environmental actions packages”, suitable to the agritourism context. Such packages are allowed to obtain a 7.34 points minimum limit for the energy category, set by European regulation. In particular, it emerged that the combination of datasheets 5 and 7 (options *VD-1* and *B-1*) allowed obtaining 7.5 EU Ecolabel points, while by adding datasheets 7, 8T and 15T + 19T (options *VD-2* and *B-2*) it is possible to achieve 10.5 points, and from the union of datasheets 7, 15T + 19T, and 27T (options *VD-3* and *B-3*) a total of 10 points can be reached.

Therefore, a suitable implementation of the ARERA technical datasheets (that, apart from other things, permits an easy computation of the energy performances of various building and system components) is recommended to be ancillary utilized with the EU criteria in order to assess a unique scheme for the application of the EU Ecolabel brand.

In addition, the above verified correspondence, allowed us to introduce a criterion for ranking the effectiveness of the proposed measures within the framework of the nearly Zero Energy Buildings approach (nearly Zero Energy Agritourism, in this case). In other words, once the ARERA datasheets have provided useful energy saving results, achieved thanks to the implementation of the proposed interventions, it is easy to report such results in terms of closeness to a zero energy situation for a given agritourism.

## 5. Conclusions

Agritourisms represent an important reality in the Italian tourism sector, specifically in Sicily due to their numerical consistency and constantly growing trend. The idea at the base of the presented work stems from some considerations regarding the use of a simple method, based on the ARERA technical datasheets (which constitute an official Italian reference), to assess the energy, environmental, and economic benefits related to the implementation of some energy efficiency measures on a given agritourism, specifically aimed at achieving the EU Ecolabel environmental excellence brand, in the perspective of approaching a potential nearly Zero Energy condition.

The results of the conducted analysis put in evidence some discrepancies regarding the application of the ARERA calculation methods, devised for the residential sector, in a wider context, like that of agritourism. Such an outcome was foreseeable, but it has probably been highlighted even more by the fact that the datasheets results are outdated, having not been updated in the last few years.

Nevertheless, the adoption of the proposed efficiency interventions, despite not being specifically defined for the agritourism context, contributed in addressing both structures toward a nearly Zero Energy path, hence, improving their performances in terms of sustainability.

Apart from the interventions proposed by the ARERA, clearly agritourism sites can be interested in further renewable technologies in order to promote their energy sustainability. In fact, the application of solutions like micro wind turbines, biomass, and high efficiency cogeneration for such purposes has been demonstrated [73]. Similar and/or recently available technologies could represent a driver for implementing new ARERA technical datasheets, in order to render them more compliant with the agritourism context, and the EU targets for energy efficiency and emissions reductions in the civil sector.

In conclusion, it arose that, although it was possible to combine the ARERA technical datasheets with the EU Ecolabel criteria, in order to apply the proposed analysis methodology to the agritourism



context in a more efficient way, the existing ARERA technical datasheets should be suitably updated and/or replaced by other more effective tools, expressly planned for the accommodation and catering business sector.

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## Appendix A

**Table A1.** ARERA technical datasheets.

Datasheet N°	Proposed Action
1-tris	Installation of high-quality compact fluorescent lamps, not exceeding 15 W power
2	Replacement of electric water heater with gas water heater with sealed chamber and piezoelectric ignition
3	New installation of 4-star single-family efficiency boiler fueled with natural gas
4	Replacement of gas water heater (with open chamber and pilot flame) with gas water heater (with sealed chamber and piezoelectric ignition)
5	Replacement of simple glazing with double glazing
6	Wall and roof insulation
7	Use of photovoltaic systems with an electrical power of less than 20 kW
8T	Installation of solar collectors for the production of domestic hot water
9T	Installation of electronic frequency regulation systems (inverters) in electric motors operating on pumping systems with power lower than 22 kW
10T	Electricity recovery from natural gas decompression
11T	Installation of engines with higher efficiency
13a-bis	Installation, in residential environments, of water saving kits consisting of low-flow aerators and low-flow shower heads
13b-bis	Installation of low flow shower dispensers in hotels and guest houses
13c-bis	Installation of low flow shower dispensers in sports facilities
15T	Installation of outdoor air electric heat pumps instead of boilers in newly built or renovated residential buildings
16T	Installation of electronic frequency regulation systems (inverters) in electric motors operating on pumping systems with power greater than or equal to 22 kW
17T	Installation of luminous flux regulators for mercury vapor lamps and high-pressure sodium vapor lamps in outdoor lighting systems
18T	Replacement of mercury vapor lamps with high pressure sodium vapor lamps in public lighting systems
19T	Installation of high efficiency outdoor air conditioners with cooling capacity lower than 12 kW <sub>f</sub>
20T	Thermal insulation of walls and roofs for summer cooling in domestic and service sectors
21T	Application in the civil sector of small cogeneration systems for winter and summer air-conditioning of rooms and the production of domestic hot water

Table A1. Cont.

Datasheet N°	Proposed Action
22T	Application in the civil sector of district heating systems for room air conditioning and domestic hot water production
23T	Replacement of incandescent traffic lights with LED traffic lights
24T	Replacement of incandescent votive lamps with votive LED lamps
25Ta	Installation of devices for automatically switching off equipment in standby mode in the residential sector
25Tb	Installation of devices for automatically switching off equipment in stand-by mode in the hotel sector
26T	Installation of centralized systems for winter and/or summer air conditioning in civil use buildings
27T	Installation of electric heat pump for domestic hot water production in new and existing plants
28T	Realization of high efficiency systems for the illumination of main motorway and extra-urban tunnels
29Ta	Implementation of new high-efficiency lighting systems for roads destined to motorized traffic
29Tb	Installation of high efficiency lighting fixtures in existing lighting systems for roads destined to motorized traffic

Table A2. EU Ecolabel for Tourist Accommodation Services criteria.

Mandatory			Optional
<i>General management criteria</i>			
1	Basis of an Environmental Management System	23	EMAS registration, ISO certification of the tourist accommodation (up to 5 points)
2	Staff training	24	EMAS registration or ISO certification of suppliers (up to 5 points)
3	Information to guests	25	Ecolabelled services (up to 4 points)
4	General maintenance	26	Environmental and social communication and education (up to 2 points)
5	Consumption monitoring	27	Consumption monitoring: Energy and water sub-metering (up to 2 points)
<i>Energy criteria</i>			
6	Energy efficient space heating and water heating appliances	28	Energy efficient space heating and water heating appliances (up to 3 points)
7	Energy efficient air conditioning and air-based heat pumps appliances	29	Energy efficient air conditioning and air-based heat pumps appliances (up to 3.5 points)
8	Energy efficient lighting	30	Air-based heat pumps up to 100 kW heat output (3 points)
9	Thermoregulation	31	Energy efficient household appliances and lighting (up to 4 points)
10	Automatic switching off of HVAC and lighting	32	Heat recovery (up to 3 points)

Table A2. Cont.

Mandatory		Optional	
11	Outside heating and air conditioning appliances	33	Thermoregulation and window insulation (up to 4 points)
12	Procurement of electricity from a renewable electricity supplier	34	Automatic switch off appliances/devices (up to 4.5 points)
13	Coal and heating oils	35	District heating/cooling and cooling from cogeneration (up to 4 points)
		36	Electric hand driers with proximity sensor (1 point)
		37	Space Heater emissions (1.5 points)
		38	Procurement of electricity from a renewable electricity supplier (up to 4 points)
		39	On site self-generation of electricity through renewable energy sources (up to 5 points)
		40	Heating energy from renewable energy sources (up to 3.5 points)
		41	Swimming pool heating (up to 1.5 points)
<i>Water criteria</i>			
14	Efficient water fittings: Bathroom taps and showers	42	Efficient water fittings: Bathroom taps and showers (up to 4 points)
15	Efficient water fittings: Toilets and urinals	43	Efficient water fittings: Toilets and urinals (up to 4.5 points)
16	Reduction in laundry achieved through reuse of towels and bedclothes	44	Dishwasher water consumption (2.5 points)
		45	Washing machine water consumption (3 points)
		46	Indications on water hardness (up to 1.5 points)
		47	Optimised pool management (up to 2.5 points)
		48	Rainwater and grey water recycling (up to 3 points)
		49	Efficient irrigation (1.5 points)
		50	Native or non-invasive alien species used in outdoor planting (up to 2 points)
<i>Waste and wastewater criteria</i>			
17	Waste prevention: Food service waste reduction plan	51	Paper Products (up to 2 points)
18	Waste prevention: Disposable items	52	Durable goods (up to 4 points)
19	Waste sorting and sending for recycling	53	Beverages provision (2 points)
		54	Detergents and toiletries procurement (up to 2 points)
		55	Minimisation of the use of cleaning products (1.5 point)
		56	De-icing (1 point)
		57	Used textiles and furniture (up to 2 points)
		58	Composting (up to 2 points)
		59	Waste water treatment (up to 3 points)

Table A2. Cont.

Mandatory		Optional	
		<i>Other criteria</i>	
20	No smoking in common areas	60	No smoking in rooms (1 point)
21	Promotion of environmentally preferable means of transport	61	Social policy (up to 2 points)
22	Information appearing on the EU Ecolabel	62	Maintenance vehicles (1 point)
		63	Environmentally preferable means of transport offer (up to 2.5 points)
		64	Unsealed surfaces (1 point)
		65	Local and organic products (up to 4 points)
		66	Pesticide avoidance (2 points)
		67	Additional environmental and social actions (up to 3 points)

## Appendix B

In the following the equations relating to the ARERA calculation procedures for each considered technical datasheet are given, in order to define the parameters reported in the following, Table A3.

Datasheet N° 5, “Replacement of simple glazing with double glazing”, allows obtaining the gross primary energy savings ( $RL$ ) achievable per individual building:

$$RL = RSL \times S_{window} [toe/year/building] \quad (A1)$$

where:

- $RSL$  is the specific gross primary energy savings per  $m^2$  of replaced glass surface, dependent on the climatic zone and the buildings intended use (residential, office, school, hospital, etc.), expressed in  $toe/year/m^2$ ;
- $S_{window}$  is the replaced glass surface, expressed in  $m^2$ .

Datasheet N° 7, “Use of photovoltaic systems with an electrical power of less than 20 kW”, allows obtaining the achievable specific gross primary energy savings ( $RSL$ ) for each reference physical unit ( $UFR$ ), represented by a photovoltaic system with electrical power <20 kW:

$$RSL = kW_p \times h_{eq} \times k_1 \times 0.22 \cdot 10^{-3} [toe/year] \quad (A2)$$

where:

- $kW_p$  is the peak power of the system, expressed in kW;
- $h_{eq}$  is a coefficient dependent on the solar belt of the considered province, expressed in h/year;
- $k_1$  is a dimensionless coefficient that varies in function of the inclination ( $\beta$ ) of the photovoltaic modules on to the horizontal plane, that is  $k_1 = 0.70$  for  $\beta > 70^\circ$ , otherwise  $k_1 = 1$ ;

Datasheet N° 8T, “Installation of solar collectors for the production of domestic hot water”, allows obtaining the annual shares of primary net energy savings ( $RN_C$ ) for each reference physical unit ( $UFR$ ), represented by the opening surface ( $m^2$ ) of the installed collectors:

$$RN_C = RSN \times UFR [toe/year] \quad (A3)$$

where:

- $RSN$  is the net specific primary energy savings achievable per  $m^2$  of  $UFR$ , based on the system typology and on the solar belt to which the site belongs, expressed in  $toe/year/m^2$ ;

Datasheet N° 15T, “Installation of outdoor air electric heat pumps instead of boilers in newly built or renovated residential buildings”, allows obtaining the annual shares of primary net energy savings ( $RN_C$ ) for each reference physical unit ( $UFR$ ), represented by a standard apartment, which in terms of square meters of heated surface corresponds to about 80–90  $m^2$ :

$$RN_C = a \times RSL \times UFR \text{ [toe/year]} \quad (A4)$$

where:

- $a$  is the additionality coefficient (dimensionless);
- $RSL$  is the specific gross primary energy savings per single  $UFR$ , based on the COP of the heat pump typology, the surface/volume ( $S/V$ ) ratio of the heated environment and the climatic zone (c.z.), expressed in  $toe/year/m^2$ .

Datasheet N° 19T, “Installation of high efficiency outdoor air conditioners with cooling capacity lower than 12  $kW_f$ ”, allows obtaining the annual shares of primary net energy savings ( $RN_C$ ) for each reference physical unit ( $UFR$ ), represented by 1  $kW$  cooling capacity of the air conditioning system at nominal conditions (expressed in actual installed cooling capacity):

$$RN_C = a \times RSL \times UFR \text{ [toe/year]} \quad (A5)$$

where:

- $a$  is the additionality coefficient (dimensionless);
- $RSL$  is the specific gross primary energy savings per  $UFR$ , dependent on the solar belt of the considered province, expressed in  $toe/year/m^2$ .

Datasheet N° 27T, “Installation of electric heat pump for domestic hot water production in new and existing plants”, allows obtaining the annual shares of primary net energy savings ( $RN_C$ ) for each reference physical unit ( $UFR$ ), represented by an electric heat pump water heater for the production of domestic hot water (expressed in number of units):

$$RN_C = a \times RSL \times UFR \text{ [toe/year]} \quad (A6)$$

where:

- $a$  is the additionality coefficient (dimensionless);
- $RSL$  is the specific gross primary energy savings per single  $UFR$ , based on the COP of the heat pump typology and on the climatic zone, expressed in  $toe/year/m^2$ .

Datasheet N° 6, “Wall and roof insulation”, allows obtaining the gross primary energy savings ( $RL$ ) achievable per insulated surface unit ( $m^2$ ):

$$RL = RSL \times S_{wall-roof} \text{ [toe/year/building]} \quad (A7)$$

where:

- $RSL$  is the specific gross primary energy savings per  $m^2$  of insulated surface, dependent on the climatic zone and the building intended use (residential, office, school, hospital, etc.), expressed in  $toe/year/m^2$ ;
- $S_{wall-roof}$  is the insulated surface of walls and/or roof, expressed in  $m^2$ .

Datasheet N° 20T, “Thermal insulation of walls and roofs for summer cooling in domestic and service sectors”, allows obtaining the annual shares of primary net energy savings ( $RN_C$ ) achievable per  $m^2$  of insulated surface unit ( $UFR$ ):

$$RN_C = a \times RSL \times UFR \text{ [toe/year]} \quad (A8)$$

where:

- $a$  is the additionality coefficient (dimensionless);
- $RSL$  is the specific gross primary energy savings per  $m^2$  of insulated surface, based on the thermal transmittance  $K$  ( $W/m^2/K$ ) of the structure (walls and/or) before the intervention, expressed in  $toe/year/m^2$ .

**Table A3.** Equations (A1) to (A8) input data parameters for the two considered agritourisms.

Data-Sheet N. (Eq)	Villa Dafne		Bergi	
	Equation Input Data	Equation Result	Equation Input Data	Equation Result
5 (1)	$RSL = 0.009 \text{ toe/year/m}^2$	$RL = 2.7 \text{ toe/year}$	$RSL = 0.005 \text{ toe/year/m}^2$	$RL = 1.2 \text{ toe/year}$
	$S_{\text{window}} = 305 \text{ m}^2$		$S_{\text{window}} = 236 \text{ m}^2$	
7 (2)	$kWp = 19.9 \text{ kW}$	$RSL = 8.1 \text{ toe/year}$	$kWp = 19.9 \text{ kW}$	$RSL = 8.1 \text{ toe/year}$
	$h_{\text{eq}} = 1852 \text{ h/year}$		$h_{\text{eq}} = 1852 \text{ h/year}$	
	$k_1 = 1$		$k_1 = 1$	
8T (3)	$RSN_{\text{electrical}} = 0.210 \text{ toe/year/m}^2$	$RN_C = 4.9 \text{ toe/year}$	$RSN_{\text{electrical}} = 0.210 \text{ toe/year/m}^2$	$RN_C = 3.5 \text{ toe/year}$
	$RSN_{\text{gas}} = 0.123 \text{ toe/year/m}^2$		$RSN_{\text{gas}} = 0.123 \text{ toe/year/m}^2$	
	$UFR_{\text{electrical}} = 23 \text{ m}^2$		$UFR_{\text{electrical}} = 5 \text{ m}^2$	
	$UFR_{\text{gas}} = 0$		$UFR_{\text{gas}} = 21 \text{ m}^2$	
15T (4)	$a = 1$	$RN_C = 3.3 \text{ toe/year}$	$a = 1$	$RN_C = 2.0 \text{ toe/year}$
	$RSL = 0.181 \text{ toe/year/UFR}$		$RSL = 0.143 \text{ toe/year/UFR}$	
	$UFR = 18$		$UFR = 14$	
19T (5)	$a = 1$	$RN_C = 0.7 \text{ toe/year}$	$a = 1$	$RN_C = 0.6 \text{ toe/year}$
	$RSL = 0.0037 \text{ toe/year/UFR}$		$RSL = 0.0037 \text{ toe/year/UFR}$	
	$UFR = 200 \text{ kWf}$		$UFR = 150 \text{ kWf}$	
27T (6)	$a = 1$	$RN_C = 3.9 \text{ toe/year}$	$a = 1$	$RN_C = 1.9 \text{ toe/year}$
	$RSL = 0.106 \text{ toe/year/UFR}$		$RSL = 0.107 \text{ toe/year/UFR}$	
	$UFR = 37$		$UFR = 18$	
6 (7)	$RSL = 0.0028 \text{ toe/year/m}^2$	$RL = 7.8 \text{ toe/year}$	$RSL = 0.0015 \text{ toe/year/m}^2$	$RL = 4.2 \text{ toe/year}$
	$S_{\text{wall-roof}} = 2768.5 \text{ m}^2$		$S_{\text{wall-roof}} = 2791.75 \text{ m}^2$	
20T (8)	$a = 1$	$RN_C = 1.4 \text{ toe/year}$	$a = 1$	$RN_C = 1.4 \text{ toe/year}$
	$RSL = 0.0005 \text{ toe/year/UFR}$		$RSL = 0.0005 \text{ toe/year/UFR}$	
	$UFR = 2768.5 \text{ m}^2$		$UFR = 2791.75 \text{ m}^2$	

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