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The cover image shows the building of Kharkiv National University of Civil Engineering and Architecture, destroyed as a result of a missile and bomb attack. March 2022 (Source: STRINGER/Reuters/Forum. https://www.pism.pl/publications/sweden-on-the-russian-aggression-against-ukraine)

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The small smart city: renewable energy sources in little town of Italy

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Abstract

The topic of energy has burst into the international and national scientific debate. Urban systems have taken on a fundamental role in having to support technological progress aimed at increasing renewable energy sources such as wind power. On the one hand, the scientific community has concentrated its studies on optimization models to support the energy organization of territorial contexts and on the other, on identifying optimal strategies within complex management systems. In turn, many efforts have also been made in the development of support tools for the improvement of urban energy systems to support decision-making processes. Wind energy is a valid option to improve the economic conditions in the region and reduce the environmental impact, even if the regulatory framework, especially in Italy, has shown structural deficiencies. In this direction, the work takes its cue from a scientific technical consultancy of the Department of Engineering of the University of Sannio and of the Department of Civil, Environmental, Land, Construction and Chemistry Engineering of the Polytechnic of Bari in support of the technical office of the municipality of Biccari (FG) in the definition of the guidelines for the drafting of the General Urban Plan.

Keywords

Urban Planning; Renewable energy sources; Municipal urban plan (PUC).

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1. Introduction

The global energy crisis is determining a decisive economic-industrial shift towards the production of energy from Renewable Energy Sources (RES). The greatest energy supply needs are manifested by the large anthropic settlements where most of the use is concentrated due to the high density of activities located in the area. However, outside these metropolitan contexts, settlements of limited size should also be considered, located in areas of high landscape value, which contribute decisively to the connotation of the national territory and in many cases preserve historical-architectural peculiarities which contribute to the cultural value, national recognition and also to the tourist polarization of the various countries. Italy has a heritage of small towns, generally located in the internal Apennine and Alpine areas, many of which are characterized as "villages" of ancient foundation (about 300), represent an invaluable territorial heritage and which, also due to recent events pandemics, has rekindled the attention of extra-metropolitan housing on itself. This relevance is demonstrated by the recent policies of the National Agency for Territorial Cohesion which has promoted a specific policy and a series of related actions for these territories. In particular, 72 areas have been selected as part of the National Strategy for inland areas, equal to 1060 Municipalities (13.4% of the national total), with an overall population of less than 2 million inhabitants (3.3% of the national total) and an area that represents 17% of the country's soil (https://www.agenziacoesione.gov.it/news_istituzionali/aree-interne/). In the face of this sensitivity, however, an inherent territorial contradiction emerges in the fact that in many of the municipal areas of these settlements, in areas such as the south of Italy which are richer in RES such as: wind, sun, geothermal, etc., plants are installed, especially wind, with a high territorial and perceptual impact. These plants significantly change the perception of the landscape both during the day, when the density and size of the wind turbines intercept the lines of the hilly profiles, and at night, when the red lights signaling obstructions to flight placed on each generator storm the darkness of rural contexts. Furthermore, in many cases, the energy produced by these plants is transferred to other anthropized contexts leaving the settlement sites only the problems of territorial entropy (Fistola, 2012) attributable to the perceptive modification of the landscape, noise pollution, of local biotopes, the subtraction of vast areas (buffer zones) that the plants require for safety, etc. This contribution reflects on the possibility of defining territorial compatibility policies capable of providing small extra-metropolitan centers with autonomous energy production systems compatible with the specificities of the places and capable of defining multifunctional uses that actively contribute to the cultural, sporting and tourist attraction of the settlement.

2. Literature review

Urban systems play a key role in supporting progress towards reducing emissions of greenhouse gases (GHG) (Sethi et al., 2020). Urban areas as complex systems have the task of exploiting the opportunities offered in the recovery and resilience plans for renewable energy in order to respond to the current urban sustainability standards (Gaglione & Etigo, 2022; Gaglione & Ayiine-Etigo, 2021). In recent years, population extension, economic development and improvement of living standards have increased the demand for energy resources. The different territorial contexts are the largest consumers of energy, accounting for approximately 60-80% and at the same time 75% of carbon emissions (Cheng et al., 2021). The creation of infrastructures based on renewables requires considerable efforts in the management of urban and territorial transformations (Soares et al., 2018). The role of planning today is in reducing environmental and health impacts, recognizing the link between the urban form and all its components (Jabareen, 2006; Mobaraki & Oktay Vehbi, 2022). The scientific debate is strongly accessed on the analysis of energy systems in a multidisciplinary vision in line with the approach adopted Energy for Sustainability (EfS) at the University of Coimbra. At the same time, the European Union has also taken on a leading role through Urban Europe which promotes research activity on the city system in a unitary key which aims to optimize the local energy system through energy efficiency, flexibility, and generation of energy from renewable sources in actions towards (urban) energy transition and climate

neutrality and the integration of these actions into urban planning processes (Gargiulo & Russo, 2017). Thus, the identification of the potential of renewable energy has become an area of interest in the policy field as well (Richards et al., 2012). However, the difficulties of administrative management as well as of economic resources indirectly lead to having to think about how to "optimize" the energy possibilities and opportunities of urban systems. Optimization can become an effective tool for identifying optimal strategies within complex management systems (Salehin et al., 2016). Surely the main element remains the need to recognize through coherent technical analyzes how renewable energy can be implemented and can have on other parts of the energy system (Lund & Mathiesen, 2009). Such analyzes require technical-scientific skills capable of giving useful answers to the defined energy systems. In particular, the scientific community has developed, in recent decades, numerous optimization models to support the energy organization of territorial contexts. Models have been widely used to define an optimal allocation of relevant energy resources, technologies and services within one or more administrative objectives (Fakhari et al., 2021; Wimmler et al., 2015). On the one hand, the studies investigate linear programming methods based on the desire to provide dynamic models relating to energy supply on a national scale (Farzaneh et al., 2016; Jebaraj & Iniyan, 2006) and others instead on non-linear programming models to identify optimal energy consumption schedules within production factories (Ostadi et al.,2007). The study by Beck, Samy and Yuan, propose a modeling approach to support optimal planning of energy networks such as regional-scale power generation by combining global optimization and agent-based modeling tools (Beck et al., 2008; Samy et al., 2022; Yuan et al., 2014). The technological support turns out to be a significant and crucial element for the development of a series of software to support the scientific research of reference. The study by Connolly of 2010 illustrates an overview of the different IT tools that can be used to analyze the integration of renewable energies. Some significant examples are EnergyPLAN (user friendly analysis of national energy systems); MESAP PlaNet (linear network models of national energy systems); LEAP (Usage Analysis for National Energy Systems); STREAM overview of national energy systems to create scenarios useful for measuring the environmental and economic effects of energy activities (Urban et al., 2007; Lund et al., 2007; Schlenzig, 1999). Numerous efforts by scientific research have also been made in the development of support tools for the management and improvement of urban energy systems in support of decision-making processes (Becchio et al., 2018). Most of the tools are based both on geographic information systems (GIS) capable of acquiring and managing spatial data related to land features combined with multi-criteria analysis to help decision makers to explore and solve problems that require trade-offs between multiple and conflicting objectives (Hettinga et al.,2018). The studies of Noorollahi, Mrówczyńska, and Elleuch, analyzed a multi-criteria decision support system to determine the potential of wind energy and to enhance the utilization of renewable energy resources and meet new international environmental requirements and provide self-sufficient domestic energy supplies (Noorollahi et al., 2016; Mrówczyńska et al., 2021; Elleuch et al., 2021). In turn, wind offers direct benefits for renewable electricity generation, but also indirect benefits for ventilation, pollution dispersion and mitigation of the urban heat island effect. In territories where urban wind is used such as New Zealand it has the potential to supply 33% of the electrical needs of residential buildings with horizontal axis wind turbines (HAWT) and 40% with counter-rotating vertical axis wind turbines (VAWT). Unfortunately, the construction of modern wind farms is still an ambitious and difficult project in the territorial planning processes although they generally produce from 2 to 3 W/m 2 with horizontal axis wind turbines (HAWT) and with vertical axis wind turbines counter-rotating (VAWT) can reach 30 W/m^2 (Kammen & Sunter, 2016). Even considering that there are advantages in the construction of wind power, it is still difficult for local communities to accept energy systems in relation to the environmental impact of the choices (Scorza et al., 2020; Tira, 2020). It is evident that we are faced with a complex process of territorial transformation that aims at the production of clean energy (Batty, 2013). Unfortunately, the territorial planning in this regard, especially in the Italian regulatory framework given that the case study of this research work is found to be in the Puglia region, has shown structural deficiencies. The legislation in this regard identifies the

articulated responsibilities of territorial bodies (mainly public) which operate in the elaboration and management of planning. The region has the task of identifying suitable areas and criteria for installations and measures for the exploitation of renewable energies. Municipalities are directly responsible for the authorization cycle of small-scale renewable energy plants. In the light of these considerations, two difficulties and criticalities emerge: on the part of the scientific community in the availability of finding effective data that serve the modeling and evaluation capacity to support decision makers in the management of territorial development and on the other in the rigidity of the prescriptive regulations, in the management of territorial transformations both in terms of resources and monitoring of territorial impacts.
In this direction, this contribution illustrates a segment of the technical-scientific consultancy work carried out by the Department of Engineering of the University of Sannio and the Department of Civil, Environmental, Land, Construction and Chemistry Engineering of the Polytechnic of Bari in support of the technical office of the municipality of Biccari (NA) in the drafting of a Municipal Urban Plan. In particular, the definition of a wind farm is examined in accordance with the provisions of the plan choices[1].

3. Smart energy for small town

As mentioned elsewhere (Fistola et al., 2021) in the governance processes of territorial transformations, technology must be "adopted" in the preparation of future structures of the urban system and not merely added or even imposed, as is widely the case with regard to large energy production systems. The energy problem is, without a doubt, one of the elements of crisis of the human settlement and, together with the systems of mitigation and adaptation to climate change, the topic on which most of the international scientific research is currently concentrated. As shown in the previous paragraph, the energy problem and the need to produce energy from RES is suggesting new territorial transformation processes oriented towards the production of clean energy (Batty, 2013).
It should also be considered that the current historical phase and the global energy crisis, also triggered by the war conflict generated at the gates of Europe, are determining the casual and dangerous overcoming of the compatibility checks of the canonical energy production plants, with the characteristics (and fragility) of settlement territories. This problem is even more felt in those territories, extra metropolitan and rural, characterized by small settlements with a high historical-environmental value and by landscapes connotative of national territorial contexts. For these anthropic settlements it could be useful to provide, within the instruments of territorial government, compatible energy production systems, with reference to the limited energy needs of the centers themselves. It should also be considered that the small centers represent, due to the high potential of Internet connection now available in almost all territorial contexts, also thanks to the fiber optic cabling policies and the diffusion of Wi-Fi systems, the elective place of settlement for new types of residence, which can carry out their work remotely within a decidedly healthier context than metropolitan settlements.
What is of interest here is the possibility, for small urban centers, of setting up autonomous, sustainable and non-invasive energy supply systems, safeguarding the territorial and vocational landscape characteristics typical of extra-metropolitan urban settlements. In other words, what appears interesting to underline is how the small towns and villages of the internal areas of many European contexts, and in particular of the Italian sub-Apennine internal areas, can escape the invasive installation of energy systems that damage their own landscape peculiarities of these areas by degrading their perceptive image (Lynch, 2006). For these areas, the possibility of integrated constructions that configure the center as an independent energy community capable of producing the energy necessary for its survival must be explored. In many cases, and particularly in the internal areas of the Italian context, the energy problem has been solved through the installation of large wind

[1] The scientific coordination of the convention is entrusted to prof. D. Camarda and R. Fistola; the members of the research group are the arch. I. Zingariello, Eng. M. R. Stufano Melone, Eng. F. Gaglione and Eng. G. Mastrodonato".

turbines which have heavily modified the panorama and the landscape of those areas. It should also be considered that, in most cases, these plants have been installed in rural areas, but often they do not return the energy produced to the existing urban settlements, which is then transferred to other areas.
Another non-trivial component of the problem is the social acceptance of large energy production plants or fossil fuel extraction plants which are perceived, by the socio-anthropogenic component of the urban system, as elements of degradation and territorial vulnerability.
Considering also that in some cases they have even been implemented in plants that used fracking for the extraction of energy fossil sources. What we want to support here is the possibility of foreseeing within the drafted urban planning instruments, processing plants for renewable energy sources that can be integrated into the territorial context, without compromising the perception of the landscape both acoustically and visually.
Furthermore, these systems can be integrated with further installations that small towns should give priority to in non-functional areas of their territory such as abandoned quarries or former landfills. These areas, which constitute deep wounds in the landscape, continue to represent an element of territorial vulnerability but can easily be reconverted into RES production areas through the installation of solar capitation systems made through photovoltaic panels capable of covering the extraction. In the same way, it is possible to set up integrated wind farms that do not require the installation of mega generators, but small collection systems that can be easily installed in the area. Reiterating a consideration set forth, the opportunity of integrated use of the settlement areas of the plants should be underlined for which it is possible to provide additional equipment, for example of a sports type at the service of citizens and which can represent an element of polarization of use also by non-municipal utilities.

4. The case study of the Municipality of Biccari

Assuming that currently, in the Italian context, the Region has the task of identifying the areas and criteria suitable for the plants and measures for the exploitation of renewable energies, it is necessary to observe that the municipalities are directly responsible for the authorization cycle of the renewable energy plants of small size.
Compared to the reference scientific framework, the research work in question falls within the territorial context of the Puglia region, precisely in the municipality of Biccari in the province of Foggia.
In order to synthetically frame the municipal territory of Biccari from a physical-environmental, socio-demographic and socio-economic point of view, it is deemed necessary to outline its attributes as well as recall the initiatives and projects underway in terms of energy production from renewables.
The municipality of Biccari has an altitude of 450 m a.s.l. and extends over a land area of 106.64 km² with a population density of 24.76 inhab. /km². From an orographic point of view, the Biccarese territorial system is structured in a composite way and sees an important mountainous relief, made up of the heights of Monte Cornacchia (the highest in Puglia) at 1,151 m a.s.l., a predominantly wooded hilly part (which houses the park Daunia Avventura) and a plain that extends towards the Foggia area. At 900 m a.s.l. north-east of Monte Cornacchia, we find Lake Pescara, a natural lake of about 3 hectares (Fig.1).
Not negligible is the condition of fragility in which part of the territory finds itself and in particular the southern slope, which, due to the current hydrogeological structure, is subject to a landslide risk, which is particularly attentive and is currently the subject of a study conducted by the Department of Civil, Environmental, Land, Construction and Chemical Engineering (DICATECH) of the Polytechnic of Bari following a research agreement stipulated with the Government Commissioner for the hydrogeological emergency of the Puglia Region, relating to the first level framework of the structures geomechanics, on the basis of existing data, of the area in which Lake Pescara is located in the territory of Biccari (FG).

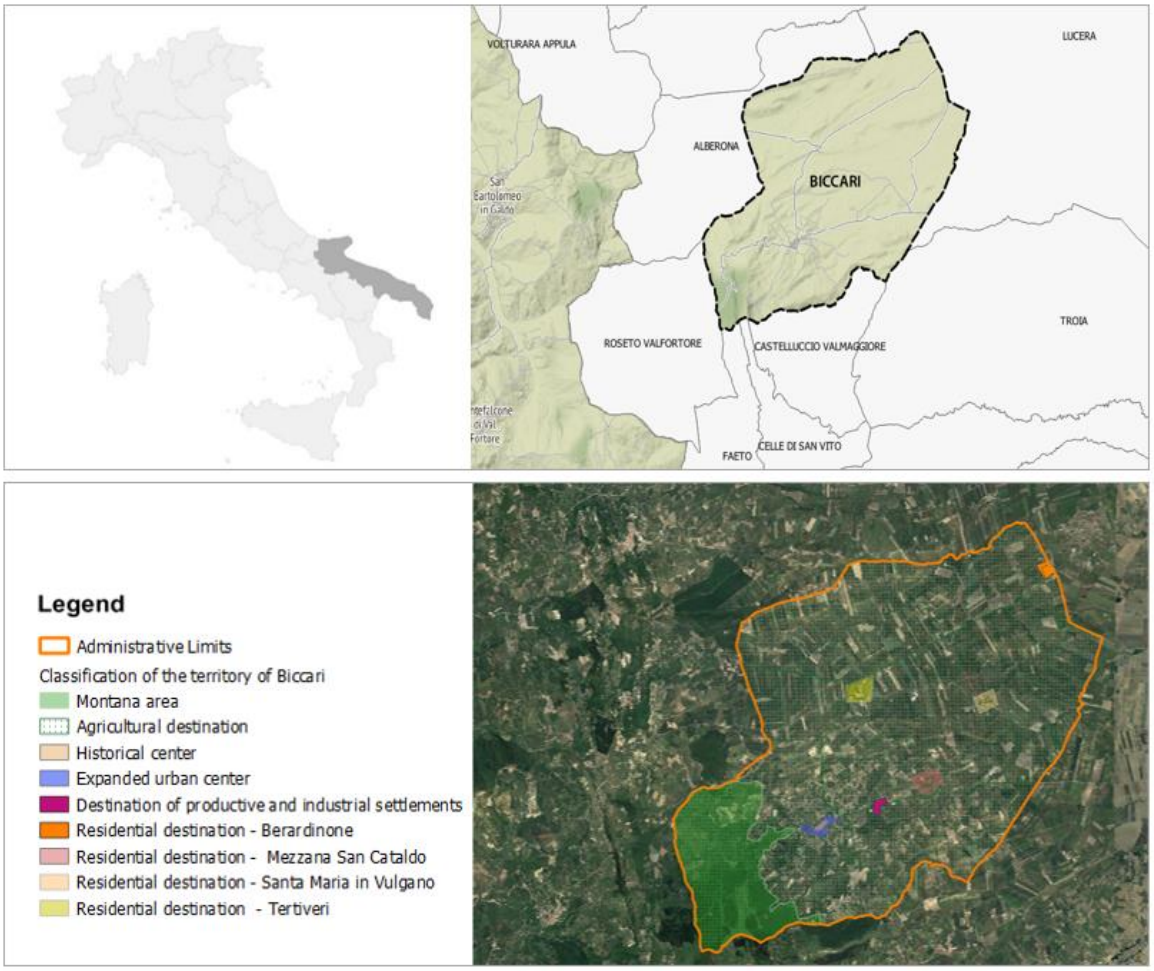

Fig.1 Landscape from the municipality of Biccari

According to National Statistical Institute (ISTAT) data updated on 31 December 2021, the municipality of Biccari has 2627 inhabitants. If we focus on the demographic trend of the resident population from 2001 to 2021, there are no doubts about the ongoing processes of depopulation and decline in births (Fig.2). The average age of the resident population is 47.8 years with an old age index (number of inhabitants over 65/number of inhabitants under 14 * 100) equal to 238.5. This figure reveals a significant process of aging underway, if we consider that for every 100 young residents of Biccari there are almost 239 elderly people.

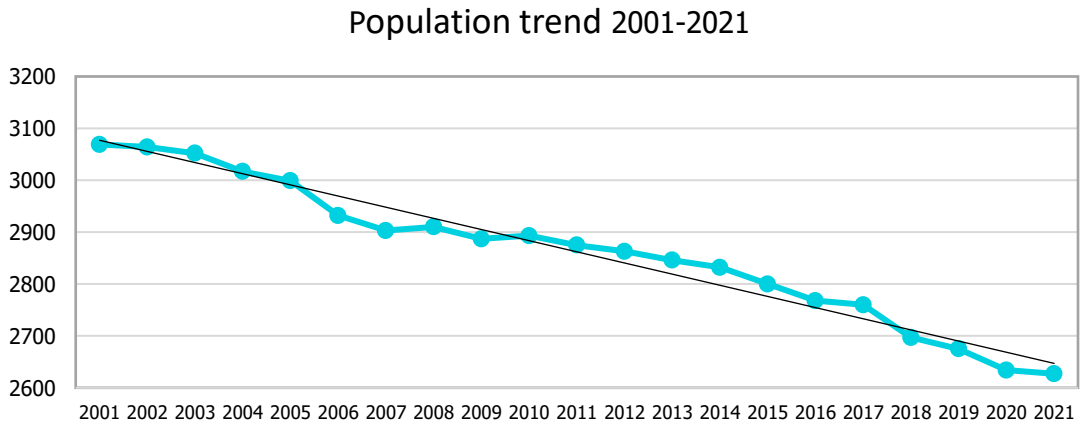

Fig.2 Population trend between 2001 and 2021 (Source: National Statistical Institute)

An analysis of the employment sectors sees most of the Biccaresi engaged in activities relating to the non-commercial tertiary sector and the agricultural sector, in fact the agricultural vocation of the territory is historically connected to olive growing. A large part of the building stock is for residential use and prior to 1945, nevertheless, the quality of the building stock is of a medium-high level if we consider that almost 80% of the buildings are in excellent or good condition. The houses are concentrated almost exclusively in the inhabited center, contrasting all forms of urban sprawl (Fig.3).

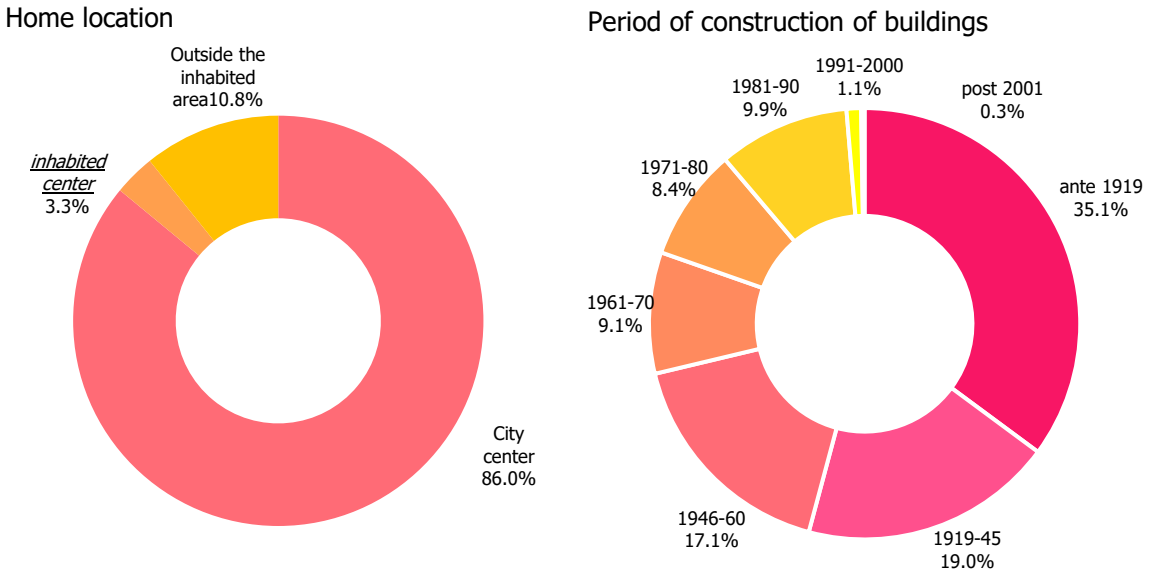

Fig.3 Geographical location of the inhabited center and its period of construction (Source: National Statistical Institute)

Regarding the tourist offer, tourism in Biccari is divided into three main sectors: naturalistic, historical-cultural, and gastronomic. The naturalistic heritage of the Biccarese area is of such great value that it allows numerous and varied activities such as fishing, hunting, excursions, as well as recreational and sporting activities within the "Daunia Avventura" park which allows, among other stay overnight in the woods in suggestive tree houses and Bubble Rooms. The historical-cultural tourism sector is also relevant, a "slow" tourism that aims at the rediscovery of the ancient village, of the local history and culture. Alongside these two sectors, gastronomic tourism is making its way; a minor type of tourism, often daily and characterized by people from the neighboring villages who on their free days, or on festivals and fairs, move to Biccari to enjoy the culinary excellence. The system of mobility by vehicle, in terms of daily journeys, is mainly made up of mobility using private vehicles which, from 1991 to 2011, saw a significant increase both for municipal journeys and above all for inter-municipal journeys, to the detriment of public transport using collective means. The system of mobility by vehicle is accompanied by slow mobility, on foot or by bicycle, limited to the municipal boundaries. The municipality of Biccari is also an important area of energy production, both from renewable and fossil sources. The gas extraction activity, for which the municipality is in second place among the municipalities of the Dauni mountains, seems to be currently underway, and it seems that new research authorizations have been granted by the Ministry for Economic Development totally bypassing the municipal administration in the authorization process. It is also feared that the fracking technique is also being implemented for the extraction of Shale gas; extremely dangerous practice in a seismic area such as the one in question. As far as the production of energy from renewable sources is concerned, 23 wind turbines of 2 MW and about 40 smaller ones of 60 KW are installed and functioning (Fig.4). On the other hand, the project for the "Montaratro" wind farm is in the process of being approved, which will have 23 wind turbines, each with a nominal power of 5.3 MW for a total power of 121.90 MW and will be in the municipal areas of Biccari and nearby centers of Troia

and Lucera. In particular, the Biccari area will be affected by the installation of a single wind turbine in an area located to the east of the town and at 2.8 km from it.

Fig.4 Energy landscape from the Puglia region

Thanks to the spirit of initiative of the Biccari Community Cooperative, the municipal administration promoted in 2020 the establishment of a Renewable Energy Community (CER) thanks to the collaboration with the ènostra energy cooperative. Renewable Energy Communities are currently regulated by art. 42-bis of the Milleproroghe Decree 162/2019, which introduced, in the Italian scenario, the community exchange of renewable energy. Even the PNRR has recognized its fundamental role within the energy transition process and has allocated 2.2 billion for the construction of CERs in small Italian municipalities with fewer than 5 thousand inhabitants. Born with the aim of encouraging sustainable living through practices of self-production and self-consumption of energy from renewable sources, the CERs have become more current following the need to combat energy poverty, understood as the inability to pay primary energy services, which in the last year, due to the ongoing conflict and the related increase in energy costs, involved 14.6% of European households. The members of a CER are called to produce energy from renewable sources to meet their energy needs, as well as to share the excess energy produced with the other members of the community. Each member of a CER therefore becomes what has recently been defined as a prosumer, no longer and not just a simple consumer but a real producer, i.e., someone who owns his own plant and is able to produce energy.
The economic advantages of self-production and self-consumption are obvious, just think that all ancillary costs to actual energy consumption, such as network charges and related taxes, are eliminated from the bill. As evident, and already amply demonstrated, are the environmental benefits deriving from the production of photovoltaic energy in terms of reduction of CO_2 emissions and other climate-altering gases. Within this scenario, the Municipality of Biccari has launched a feasibility study that will lead about 50 resident families to become members of a CER. Thanks to an agreement with Arca Capitanata, manager of public residential housing, the Municipality has obtained, free of charge, the surface right for the roofing of the aforementioned buildings on which approximately 60 kW of photovoltaic panels will be installed which, added to the 30 kW

already installed on municipally owned buildings, will make it possible to set up a small CER whose members will be called to produce, exchange and store energy from renewable sources.
What has been outlined so far gives us back the image of a territory that is partly fragile but characterized by a high eco-environmental value, a remarkable quality of food and wine products and a high tourist potential, as well as the portrait of a community and an administration particularly sensitive to theme of sustainable living and active in the production of energy from renewable sources. This is the context that oriented and guided the project proposal object of this research study illustrated in the following paragraph.

5. The proposal

The theme of renewable energy is one of the priority axes of the plan aimed at enhancing the resources and the territorial context in which the study area is located. The operating procedure illustrated here has supported and directed the public administration in the choices of the Municipal Urban Plan (PUC) in relation to the issue of renewable energy. We started by analyzing the reference regulatory framework regarding the transition to renewable energy in the Puglia Region. First, it must be specified that the Constitutional Law 3/2001 on energy matters attributes the legislative competences to the State and the Regions. For this reason, the Region has the task of defining the sector regulations the rules and as well as the siting, construction and authorization procedures for the construction of energy production plants. In detail, the reference document is contained in the programmatic instrument, called the Regional Environmental Energy Plan (P.E.A.R.), adopted with Resolution of G.R. n.827 of 06-08-07, which contains guidelines and strategic objectives in the energy field over a ten-year time horizon. The PEAR therefore contributes to constituting the reference framework for public and private subjects who, in this field, have taken and are taking initiatives in the territory of the Puglia Region. In a further resolution of the Regional Council of 28 March 2012, n. 602, the methods used to update the Regional Environmental Energy Plan were identified, entrusting the activities to a technical structure made up of the Ecology, Territorial Structure, Energy, Networks and Material Infrastructure services for development and agriculture. The plan focuses on identifying the lines characterizing regional energy planning which is developed on considerations concerning both the demand aspect and the energy supply aspect. As far as energy demand is concerned, the Plan focuses on the needs related to the users of the various sectors: residential, tertiary, industry, and transport. Important are the initiatives aimed at defining the measures and actions necessary to achieve the improvement of the environmental energy performance of urban settlements, as well as measures and actions useful for promoting energy saving. Instead, from the point of view of the offer, the plan aims to define a differentiated energy mix to produce electricity, also focusing on renewable sources, capable of guaranteeing environmental protection by reducing the impacts related to the production itself of energy. Through the planning process outlined, it is possible to assume that the contribution of renewable sources will be able to cover a large part of the consumption of the entire civil sector. In turn, the PEAR regulation governs the authorizations for the installation of wind farms and ancillary works in the Puglia region. The regulation defines two macro-categories of wind farms: those of "large size", if consisting of a single dispenser whose power is greater than 1 MW, and those of small size consisting of a maximum total power of 60 kW with a maximum unit power of 30 kW, rotor diameter not exceeding 10 meters and height of the support pole not exceeding 24 meters. The authorization process for large and small wind farms follows two different procedures. Large-scale plants refer to Legislative Decree 387/03 (environmental law) which requires municipal administrations to equip themselves with Regulatory Plans relating to the installation of Wind Power Plants (PRIE). These plans are drawn up by the municipal administrations individually or jointly between neighboring municipalities (inter-municipal PRIEs). All the Administrations with expertise in the construction and management of RES plants participate in the technical table. In turn, the Environmental Impact Study is mandatory only if the plants fall within 1 km (for large-scale farms) and 500 m (for small-scale farms) from the sites of the Natura 2000 network. This entails the implementation of an

administrative simplification tool aimed at guaranteeing environmental protection and reducing the bureaucratic burden for private and public operators. The plan, in turn, must be consistent with the projects and with the overall framework of planning and programming on the territory of both the vast area and the municipality.

If on the one hand for large-scale plants the interventions are implemented through indirect implementation, for interventions related to small-sized plants the implementation is direct through authorizations. Small farms are subject to having to request Certified Notification of Start of Activity (SCIA): it is a declaration that allows private operators to start, modify or stop a production activity (craft, commercial, industrial), without having to wait for the duration and the implementation of preliminary checks and inspections by the competent authorities, but in turn the private individual will have to have the financial capacity for the complete realization of the project for plants between 200 kW and 1 MW.

As far as the authorization aspects are concerned, it is envisaged that, in general, no authorization is required for wind farms with power lower than or equal to 10 kW if inserted in rural or industrial areas and with power lower than or equal to 5 kW in the other cases. The small wind power technology finds an interesting application at a rural level, at the service of farms since it constitutes a peculiarity of the area of interest in the Apulian territory. An appropriate application of this technology would lead to the creation of integrated energy supply chains from renewable sources. In Italy, electricity from RES is promoted through deductions from value added tax (VAT) and property tax and can be sold on the free market or to the Energy Manager at a guaranteed minimum price. Alternatively, renewable energy producers can opt for on-the-spot metering which provides for economic compensation for the electricity fed into the grid. Instead, small-scale plants can already take advantage of the incentives deriving from the sale of green certificates.

The framework of rules for the definition and construction of large and medium-sized wind farms has been outlined. The second step of the work was aimed at defining the dataset useful for defining the wind farm. In addition, surveys were conducted through satellite images obtained from drones through constant surveys on the area under study also supported by Google Earth images. This dataset was used as a basis for defining where to build a wind farm in accordance with the provisions of the Biccari plan choices developed through territorial geographic tools such as GIS.

The database had the functionality to collect both spatial data from large area and municipal planning. The dataset was structured starting from the Regional Technical Cartography (TRC) produced by the Puglia Region to build the entire database. The basic database has been divided into macro-categories.

As regards the planning of a vast area, the areas subject to restrictions were firstly identified: hydro geological, of archaeological interest, of community importance and deriving from the landscape plan. Secondly, the areas governed by the Territorial plan of provincial coordination (PTCP) in relation to rural contexts, urban fabrics, production centers and special types. From the rules governed by the planning of a vast area, we have moved on to the municipal scale.

In particular, all land use/land cover classes (LULC) have been identified starting from: (a) Residential buildings in compact urban centers; (b) Residential buildings in dispersed urban centers; c) buildings for industrial and commercial use; (d) roads and railways; (e) caves and dumps; (f) gardens and urban green areas; (g) orchards; h) gardens; i) arable land; l) olive groves; m) vineyards; (n) pasture or fallow areas; (o) mixed forests; (p) coniferous woods; (q) hardwood forests; (r) Watercourses. Some geoprocessing operations have been applied which are useful for defining the area to be occupied for the installation of RES plants in relation also to the urban planning instruments in force and already present in the field of renewable energy in relation to the environmental feasibility study. The next step was to define the wind farm categories according to the 'installed capacity' and the relative radius of influence in terms of land use linked to the wind farm, including fields, access road and technical services. In detail, the type of wind power plant that has defined itself in the area, also due to the current technological innovations in the sector, are the Vortex devices. These cutting-

edge devices are born thanks to a Spanish startup that created Vortex Tacoma, capable of capturing wind energy through vibration and transforming it into electricity. The result is a vertical, thin, and cylindrical wind turbine: a fixed base in which the device is anchored to the ground and an upward flexible part that interacts with the air creating an oscillating movement. The internal parts never collide with each other but interact to generate electricity. This plant, designed as a "small wind" generator, is aimed at a residential or rural market with low energy consumption systems and has only an alternator that transforms energy into electricity. The height of each device is approximately 2.75 meters, making it capable of being easily integrated into urban environments. Furthermore, having heights of 3-4 meters they do not create major problems from a landscape point of view in rural areas. Tests show that the turbine can store 40% of the wind and outputting a power of 100W. Thanks to their simplified structure, they are able to significantly reduce production, installation, and maintenance costs, ensuring the production of clean energy at a cost 30% lower than that obtainable with traditional wind turbines. A comparison in terms of efficiency of the two technologies shows that traditional wind turbines have a higher net efficiency value, however, with the same surface area, it is possible to obtain more energy from a Vortex Bladeless field, since the latter can be installed at a smaller distance (Fig.5).

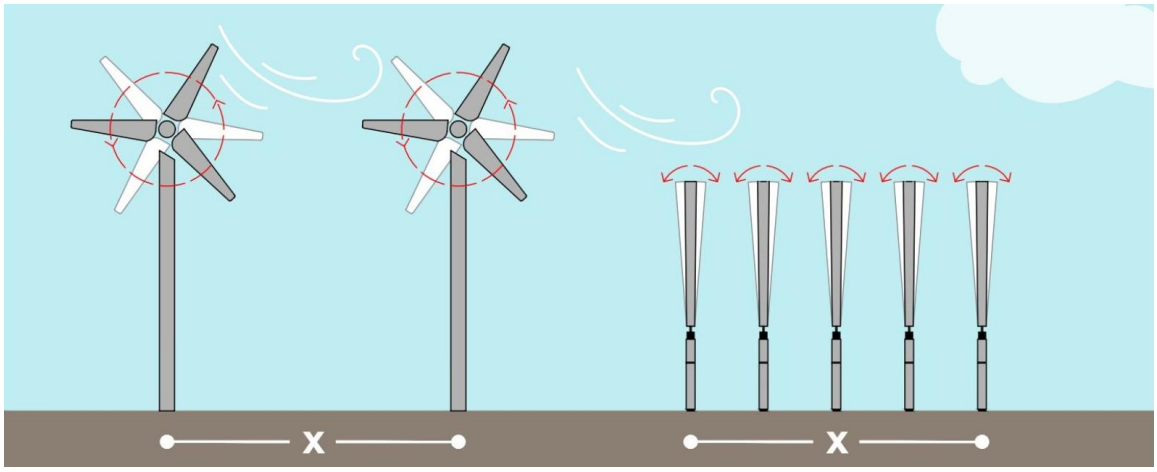

Fig.5 Comparison of technology on wind turbines and Vortex devices

An economic aspect is that, having no gears or moving parts in contact, it does not require lubricants. Implying a reduction in costs and on maintenance hours. The estimated maintenance cost savings are 80% less than existing wind energy systems. In this direction, it was decided to use this technology for the municipality of Biccari with the aim of carrying forward cutting-edge aspects useful for the creation of an organized and planned energy community.

6. Results

In accordance with the previous section, to define the guidelines for drafting the P.U.G. it appears necessary to identify the "territorial invariants". By territorial invariants we mean all those municipal areas which appear to be non-transformable at an urban level linked to the intrinsic characteristics of the context.

The areas subject to restrictions due to the combined provisions of the restrictions and protections deriving from the superordinate planning such as the Basin Excerpt Plan for the Hydrogeological Structure and the regulations of the Provincial Territorial Plan and the Landscape Plan have been identified.

In detail, the municipality of Biccari presents the hydrogeological instability that surrounds the historic and recently formed inhabited center of the Municipality of Biccari throughout the municipal area. In turn, in the hamlet of Tertiveri there is an area of archaeological interest within which, especially in recent years, various artifacts and finds have been found, testifying to the historical importance of the area. In addition, in the south-west part of the Municipality there is a SIC area (Site of Community Importance). The mountainous part

of the municipality of Biccari falls almost entirely within the SCI area called "Monte Cornacchia-Bosco di Faeto". Inside there are also various areas of natural pasture, as identified by the Territorial Landscape Plan of the Puglia Region. The areas subject to this constraint severely limits any type of intervention, considered natural heritage to be protected, resulting in areas that must be subjected to Environmental Impact Assessment (VINCA) for the implementation of such interventions in that area.

As regards, the Territorial Coordination Plan of the Province of Foggia (PTCP) constitutes that act of general planning of the territory defining the strategic guidelines and the physical-functional structure of the territory with reference to the supra-municipal interests.

The municipality of Biccari has a large part of the built-up center of a historic urban fabric, only in the part near S. Lucia and S. Quirico a recently formed urban fabric. In the area above S. Quirico there is a productive urban fabric. The entire area adjacent to it up to the boundaries of the municipal territory appears to be an environmental area with a predominantly traditional forestry and agricultural structure. Fig.6 shows the areas governed by superordinate planning.

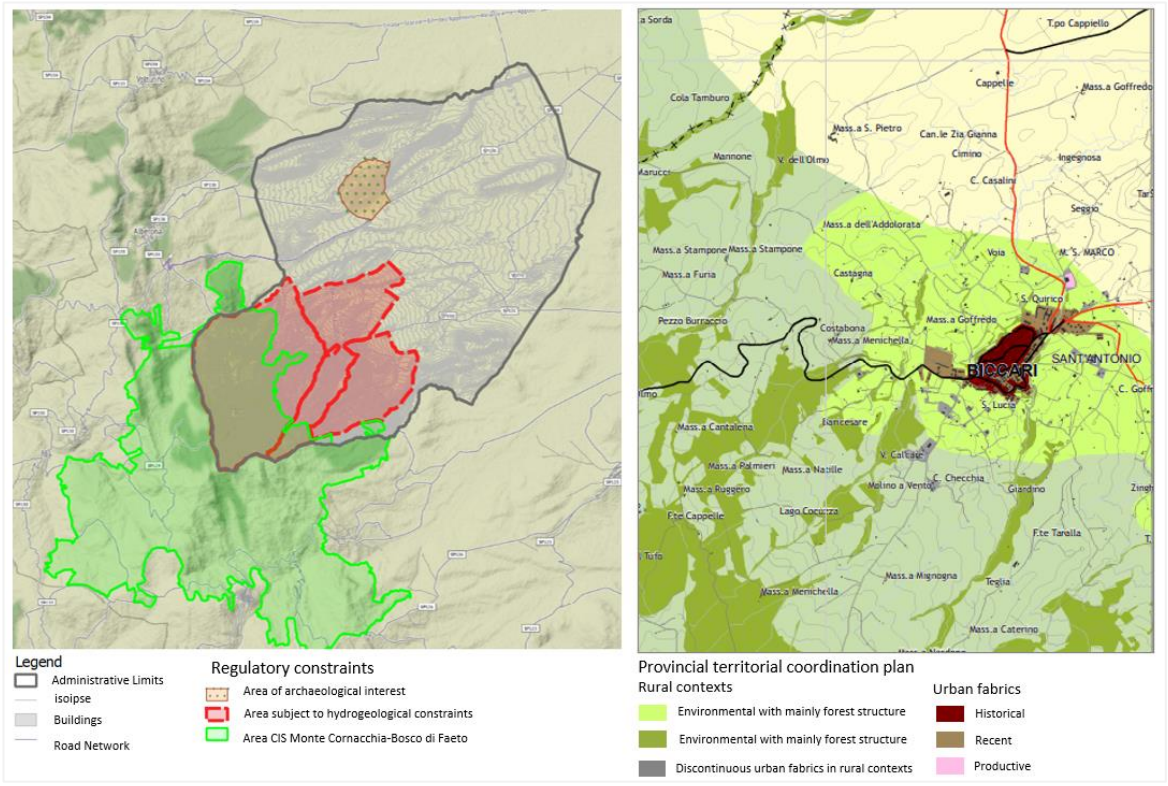

Fig.6 Cognitive framework of superordinate planning

The second step of this work was in the identification of the land use/cover classes (LULC), proving to be a territory mainly of agricultural vocation as shown in Fig.7.

The entire area that goes from the south-west to the south-east of the Tertiveri area falls within those "arable areas in non-irrigated areas" which differ from each other in terms of intensive and extensive agriculture. In the area adjacent to the inhabited center of the municipality of Biccari and on the border of the municipality precisely in the Berdinone area, they have a high value linked both to the characteristics of the agricultural land linked to profitability given the presence of vineyards, orchards and olive groves. Finally, the area of Daunia and Lake Pescara is presented as an area of high landscape and naturalistic value given that they appear to be a "unique settlement" of an environmental type, confirming the high presence of deciduous and coniferous wooded areas.

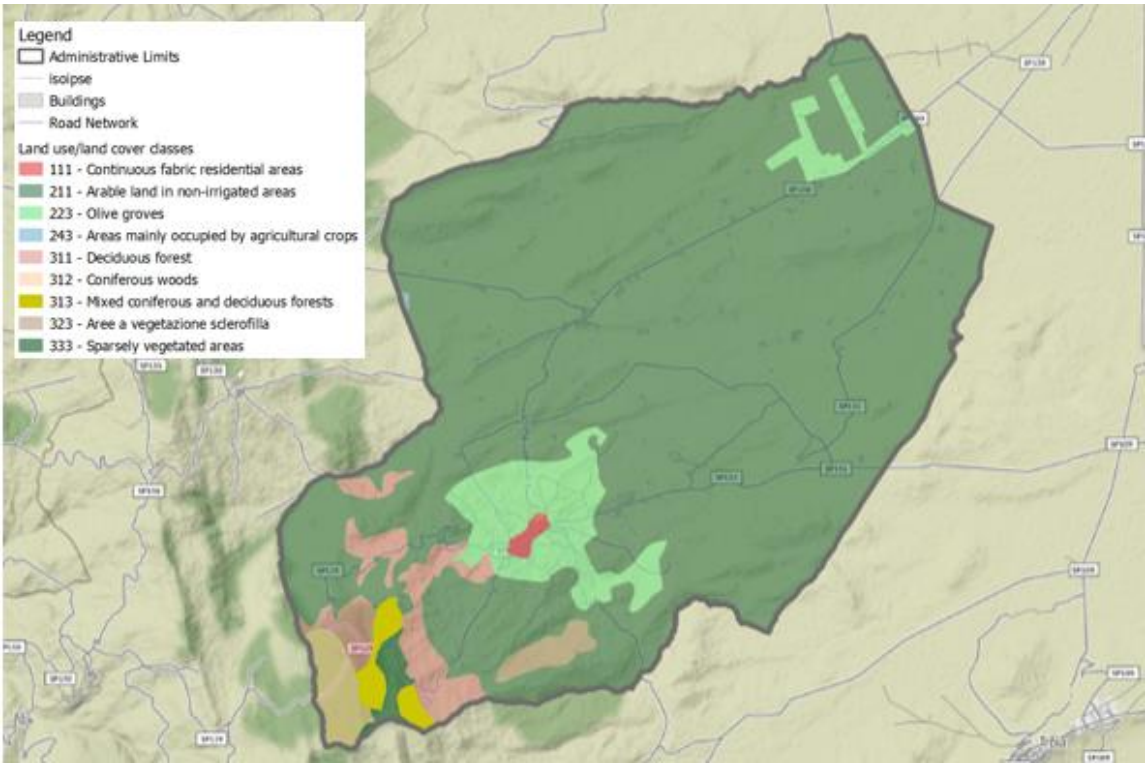

Fig.7 Land use/ Land cover (LULC)

The Biccarese inhabited center was born around that a small community developed around that historical element of the city such as the Byzantine Tower. The cognitive framework of the Municipality of Biccari has made it possible to define the non-transformable areas and the possible transformation areas. In particular, the work is identified in the identification of an area where to insert wind generators in accordance with the mandatory urban planning.

In accordance with the entire previous work, in defining the guidelines for the preparation of the Municipal Urban Plan, the plan itself took into account this aspect and interest in the field of renewable energy, wanting to implement this proposal already in the same area given that the area meets certain requirements such as: (i) Analysis of the inclusion in the landscape; (ii) Visual impact and impact on cultural heritage and landscape; (iii) Analysis and insertion of the project into the environment; (iv) Analysis of geomorphological interactions (v) Landscape impact mitigation measures. The intervention in question envisages for the Municipality of Biccari the installation of a wind turbine east of Biccari in the part below T. Vulgano.

In accordance with the entire previous work, in drafting the Municipal Urban Plan, the plan itself took into account this aspect and interest in the field of renewable energy, wanting to implement this proposal already in accordance with Fig.8. With respect to these analyses, the work defined the number of wind turbines with respect to the average annual and daily energy consumption of families. Biccari estimates several families equal to 1,134.

The average annual energy consumption is approximately 2,700 kWh and the corresponding daily consumption of 8-9.5 kWh per day. To meet the energy demand, it was decided to insert three wind turbines of a height of 150 meters, each with a power of 1 MW, in one of the hamlets of Biccari precisely in the north-west area or Tertiveri and at a distance from the inhabited center of about 2.8 km. Each wind turbine has the capacity and scope to satisfy around 400 homes, defining an overall area of around 168 hectares. The new mini wind farm of Biccari can also be built in the Tertiveri area, for which the wind capacity is satisfactory (https://atlanteeolico.rse-web.it/start.phtml) and will involve the installation of n. 3 Vortex generators capable of producing 1 Mwh of electricity useful for the energy needs of the urban system. The technology adopted will also allow the simultaneous use of the generator installation area, which could be used for the construction

of a Mountain Bike Park capable of representing a further element of sustainable tourist attraction in the city center.

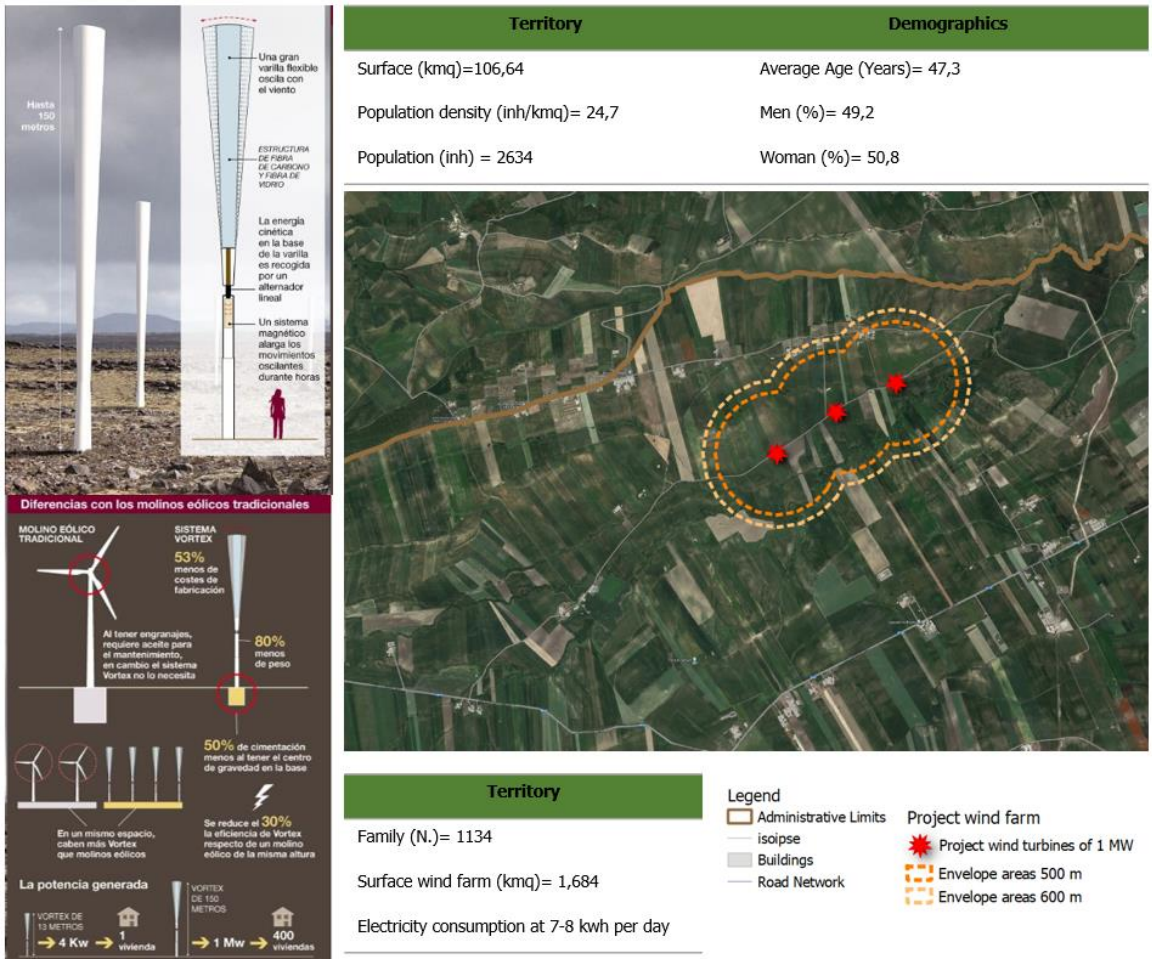

Fig.8 Mini wind farm project in the municipality of Biccari

7. Conclusions

The technical-scientific consultancy activity in support of the Municipality of Biccari has focused on two key objectives, on the one hand, the enhancement of the soil from a sustainable perspective and on the other, the issue of renewable energy. The main objective of this research work, but also innovation, is to propose a cutting-edge technology such as the Vortex Bladeless in the wind power field whose advantages are described within the operating procedure of this work, but at the same time to want to create a positive energy community. Recently, the European community has promoted research projects aimed at optimizing the local energy system through energy efficiency, flexibility, and local production of energy from renewable sources in actions directed towards the (urban) energy transition and climate neutrality, integrating these actions into urban planning processes. Unfortunately, today the real weaknesses can be seen in the reference regulatory framework both at the regional and urban scale. Most urban planning focuses on traditional urban functions (residential, commerce, industry, and services) and promotes a conventional approach. Today there is a strong need for a cultural reversal and a planning process that starts from the local administrations that have a key role in the management of energy and environmental issues, falling within the broader framework of urban planning discipline. This plan aims to take a step forward starting from the premise that urban systems and their processes are constantly evolving with each other, and rural areas change rapidly under unregulated settlement processes, based on different settlement categories. Therefore, the proposal aims to equip an area

like that of Tertiveri through innovative solutions to produce wind energy. The transformation of that urban area indirectly also aims at enhancing the value of the soil and at identifying the set of possible interventions on the territory to also support the farms adjacent to the area. The issue of renewable energy in the production of RES often clashes with political interests and those of small groups of operators. Energy and urban planning must be integrated from a multidisciplinary perspective on normative and methodological bases, supported by effective territorial evaluation tools directly connected with the current problems of land consumption useful for the innovation of environmental evaluation procedures. This work intended to propose a different vision regarding the need to equip urban and territorial systems with low-impact energy production plants, capable of allowing a contemporary functional mixité.

Author's Contributions

The work, although the result of a common reflection, was divided as follows: Fistola R. wrote paragraph 1; Gaglione F. wrote paragraph 2; Fistola R. wrote paragraph 3; Zingariello I. wrote paragraph 4; Gaglione F. wrote paragraph 5.; Fistola R.; Gaglione F and Zingariello I. wrote paragraph 6-7.

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Image Sources

Fig.1: Landscape from the municipality of Biccari;

Fig.2: Population trend between 2001 and 2021 (Source: National Statistical Institute);

Fig.3: Geographical location of the inhabited center and its period of construction (Source: National Statistical Institute);

Fig.4: Energy landscape from the Puglia region;

Fig.5: Comparison of technology on wind turbines and Vortex devices;

Fig.6: Cognitive framework of superordinate planning;

Fig.7: Land use/ Land cover (LULC);

Fig.8: Mini wind farm project in the municipality of Biccari.

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