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0. EDITORIAL #26

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II

MODELS

ENERGY COMMUNITIES & COLLABORATIVE LANDSCAPES

Energy to Design Communities
Energy Communities and Communities of Practice to Support Marginal Areas in Abruzzo

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Abstract
This contribution reports on an ongoing analytical experiment aimed at establishing a Renewable Energy Community in Taranta Peligna (CH), a highly marginalised municipality in the Italian Abruzzo region. The aim is to activate a Community of Practice to support local artisanal resources of high quality for the enhancement of energy and productive resources and thus to counteract the worrying depopulation that is taking place. With a systemic multi-objective approach to research, it is planned to define a distributed and collaborative model based on proximity, where the Municipality, with the participation of the community and the patronage of the Maiella Park Authority, can guide the creation of Energy Communities to obtain environmental, social, and economic benefits. In this perspective, a feasibility study based on an open-access geographic information system will provide an overview of the current energy situation, recovering the industrial and environmental heritage to define clean energy design scenarios, overcome energy poverty, generate economic improvements, and promote social awareness. Thanks to the holistic lever of systemic design, the proposed model faces difficulties in overcoming the classical economic approach and the deeply rooted individual culture, designing inclusive community-centered scenarios for social, cultural, economic, and, not least, energetic innovation.
However, the research can only benefit from a local production model within the Maiella National Park, a UNESCO Geopark since 2021, rich in clean energy and authentic communities, witness of a strong manufacturing and industrial history characterized by excellence and authenticity.

1. Introduction. The Centrality of Systemic Design in the Current Polycrisis

In times of polycrisis (Tooze, 2021; Davies & Hobson, 2022), where difficulties intertwine and influence each other at a global level, generating complex effects that amplify existing vulnerabilities, it becomes imperative to adopt innovative solutions that transcend traditional approaches (Lawrence, 2024). These approaches often manage crises in isolation, unable to address their growing interconnections (clearly evidenced by the correlation between the 2030 Sustainable Development Goals).

Despite today's well-defined international regulatory context (Green Deal Plan, UNSDGs 2030, ESG indicators), transversal and unconventional approaches are needed to manage complexity. These approaches challenge cause-and-effect dynamics, shift cultural paradigms, and experiment with community models for sharing technical and social resources within everyday habitats.

To protect environmental complexity and promote economic and community growth towards sustainable, robust, and resilient systems (Norman, 2023), the systemic and unconventional approach of Design can outline new conceptual models and operational processes (Manzini, 2015). It can explore more sustainable future scenarios, enable collective participation involving all social entities (both formal and informal), and engage in common themes, scales, and design intentions through a circular process (Gaddi, Mastrolonardo, 2023). This approach resonates with literature on systemic and transition design (Bistagnino, 2009; Irwin, 2019; Barbero and Ferulli, 2023), where the designer serves as a connecting figure

supporting the understanding of complexity dynamics. This includes analysing connections between parts and consequent reconfiguration of the production system, considering both community and local needs alongside global aspects. It involves narrating planning and future scenarios to create leadership around consensus based on active participation, envisioning possible innovation scenarios through mastery of design tools and technical and creative skills, and promoting the enhancement of the territory through services, products, and communication with a strong relational characterization (Magnaghi, 2020). It also entails connecting stakeholders to broaden the debate beyond the project itself (Design Council, 2021).
The research is about an experiment for the creation of an Energy Community in Taranta Peligna (CH), a very marginal municipality in the Abruzzo region, designated by 9 positive parameters according to the Prime Ministerial Decree 07.23.21. Additionally, it explores the possibility of activating a Community of Practice (Wenger, 2002) to support the enhancement of local environmental and artisanal resources.
The premise of the research stems from an existing agreement between the Municipality and the Department of Architecture of "G. d'Annunzio" University of Chieti-Pescara, aimed at studying design solutions for the enhancement of energy and production resources to counteract the worrying depopulation underway. The first analytical phase, here described, will spot the opportunities offered by the territory and will be followed in the future by an operational phase aimed at the definition of inclusive design solutions to support the local community and foster economic development and energy transition.

2. Energy Communities and Communities of Practice in Support of Abruzzo Fragile Areas and Local Communities

The mountainous regions of Abruzzo are experiencing significant depopulation: from 2015 to 2022, the population in mountain municipalities decreased by 6.2%, surpassing both the regional (3.8%) and national average decline in mountainous areas (4%) (ISTAT, 2022). While not recent, this depopulation trend (OECD, 2020) has direct implications for residents' economy and social well-being (European Network for Rural Development, 2020). This situation is particularly pronounced in Central-Southern Italy, especially in Abruzzo, where the pandemic has further exacerbated the situation, resulting in a 2.4% decline between 2020 and 2022 solely in the mountainous areas of Abruzzo (de Renzis et al., 2022).

Despite this, depopulation is not inevitable. Certain factors can effectively counteract depopulation and facilitate a fair transition (European Commission, 2021; European Commission, 2022), socioeconomic diversification, high female employment, low risk of social vulnerability, preservation of historical-architectural heritage, and the availability of natural resources, including those for renewable energy production (De Santoli, 2024). Establishing energy communities in marginal and rural contexts promotes energy self-sufficiency, reduces CO2 emissions, fosters local innovation, supports local production chains, and encourages entrepreneurship (Bussone, 2024). Consequently, renewable energies and sustainable technologies become instruments for fostering new models of territorial economic development, where participating entities, such as producers/consumers or prosumers (Perger, 2020),

actively engage in creating and developing renewable projects, thereby exercising control over the process and benefiting from the outcomes. This vision aligns with the energy and cohesion policies of the European Union, such as the Circular Economy Action Plan (2020), which aims to reduce disparities among regions by promoting smart specialization, a green economy, and social inclusion. This involves transitioning from a linear production model based on resource exploitation to a circular and regenerative one (Ellen MacArthur Foundation, 2015), promoting short supply chains, investing in renewable energy and the green economy, enhancing heritage to develop sustainable tourism models, fostering digitalization, and strengthening collaboration between institutions, organizations, and citizens (Bolognesi & Magnaghi, 2020).
The integration of Energy Communities and Communities of Practice represents a particularly compelling strategy: by utilizing clean energy and low-impact technologies, virtuous cycles can be initiated to revitalize local economies with high added value, within a circular and sustainable framework. Achieving this requires a systemic approach that integrates energy planning with territories' social, economic, and cultural needs, leveraging extensive collaboration between public and private entities, academic institutions, and the local population (Manhique, 2021).

3. Analysis and Design Methodology. A Design-Driven Approach for Enhancing Energy Resources

The analytical methodology employed a combination of quantitative and qualitative analyses (data and best practices) to compare integrated environmental themes and industrial

symbiosis (Raggi et al., 2018), to define the most suitable processes and technologies for constructing a Renewable Energy Community (REC) in Taranta Peligna. In this context, the environment concept was perceived as a complex and comprehensive system (Butera, 2021) with its own rules and boundaries to which economic and social systems must adhere. This compelled to consider safeguarding the complexity of the environment while promoting the growth of local economies and communities through a circular process in which design, communication, and technology support development, rather than merely serving as tools for development.
Within this application context, the energy transition is based on the collective participation of all social entities, both formal and informal, necessitating the sharing of themes, scales, and design intentions. This offers a perspective on how design can act as a driver of change, promoting creating communities that are aware, resilient, and rooted in their territorial context.

The analytical methodology and design process, which embody the synergy of divergent and convergent thinking, adhere to principles outlined by the Design Council (2021) to develop new design methods and tools:

- Focus on the shared benefits of all living beings (placing people and the planet at the centre).
- Plan from the root cause to the broad vision, from micro to macro, from present to future.
- Create prototypes to understand the functionality and foster further innovation (through continuous testing and iterative verification in the field).

- Establish safe and shared spaces and languages to introduce multiple perspectives.
- Consider a specific project as an element of a broader process of change.
- Focus on existing physical and social resources and explore methods to reuse and enhance them.

The territory of Taranta Peligna (Fig. 1) not only possesses energy resources but also environmental and historical/cultural assets. It is situated mainly within the Maiella National Park (UNESCO Geopark since 2021). It features resources such as the Acquevive River Park (Fig. 2) and the Cavallone Caves (Fig. 3), which houses a multimedia museum and a medieval path carved into the Maiella rock.

Figure 1. Taranta Peligna. Source: Municipality of Taranta Peligna, 2023.

Figure 2. Acquevive River Park, Taranta Peligna. Source: Municipality of Taranta Peligna, 2023.

These historical and cultural assets are intertwined with the economic and social history of the upper Aventine Valley, particularly in relation to the wool processing industry, for which Taranta Peligna was the economic hub. Evidence of this industrial tradition can be found in landmarks such as the Church of San Biagio, the church of the wool workers dating back to the 16th century, and the historic core of the abandoned medieval village overlooking the river. The remnants of pre-industrial machinery from wool mills, which produced traditional Abruzzo blankets and fabrics, further attest to this industrial heritage.

Figure 3. Cavallone Caves, Taranta Peligna. Source: Municipality of Taranta Peligna, 2023.

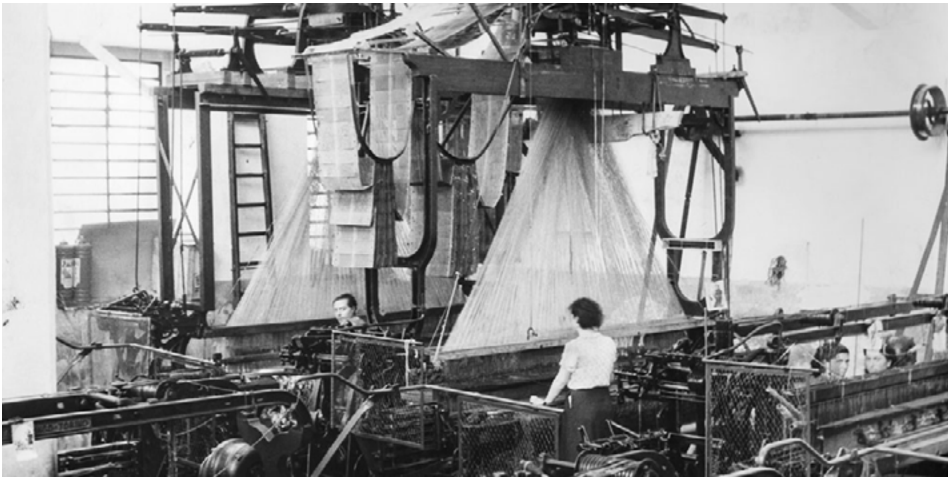

Figure 4. Ancient weaving, Lanificio Merlino. The movement of the warp threads of the Abruzzese Blanket is managed by jacquard machines, the first machines to be driven by a binary system. Source: Lanificio Vincenzo Merlino, www.copertemerlinotaranta.it, 2024.

Figure 5. Jacquard pattern of a traditional Abruzzo blanket, Lanificio Merlino. Source: Lanificio Vincenzo Merlino, www.copertemerlinotaranta.it, 2024.

Despite the textile industry crisis in the 1980s, only one wool plant survived: the Lanificio Merlino, a historic brand with a 150-year legacy (Fig. 4), which remains active, albeit with only one production unit, in the production of blankets and fabrics, including the Traditional Abruzzo blanket made with 3600 threads of twisted wool (Fig. 5). Merlino has historically been attentive to renewable energy dynamics (photovoltaic and hydroelectric), as depicted in Table 2, which will be discussed further in the subsequent paragraph of this contribution.
In the following paragraphs (4 and 5), the analytical methodology will be illustrated as a quantitative analysis of local constraints and opportunities, which indicate the consequent most suitable technologies and tools to support the development of qualitative scenarios based on community advantage, allowing the hypothesis of inclusive design solutions.

4. The Energy Resources of Taranta Peligna. Analysis of Existing Consumption and Potential for Energy Development

For quantitative analysis, Taranta Peligna is estimated to be a small village with a resident population of 291 units and slightly more than 170 families (ISTAT 2022).
Ministerial Decree no. 414 of December 7th 2023 (MASE, 2023), aimed at stimulating the birth and development of renewable energy communities and widespread self-consumption in Italy to pursue the 2030 decarbonization objectives (Goal 7, UNSDG), regulates the incentive methods to support electricity produced by RES (Renewable Energy Sources) plants. These incentives apply to self-consumption and the sharing or sale of surplus renewable energy under market

conditions or through dedicated withdrawal, with economic conditions guaranteed by the Energy Services Manager (Italian GSE). Furthermore, in municipalities with a population of less than 5,000 inhabitants, if the Administration can participate in the REC as a producer or consumer, it could receive a contribution of 40% of the investment cost.
However, an estimate of the village's consumption can be made based on the 2012 Sustainable Energy Action Plan, developed by the Local Agency for Energy and Environmental Development of the Province of Chieti as part of the European Commission's Covenant of Mayors program (2008). According to this study, the Municipality of Taranta Peligna's overall electricity consumption is approximately 1,017 GWh/year.

TYPE OF CONSUMPTION	POWER CONSUMPTIONS (MWH/YEAR)	
MUNICIPAL SECTOR	18,65	1,83%
SERVICE INDUSTRY	221	21,72%
RESIDENTIAL SECTOR	612	60,14%
PUBLIC LIGHTING	166	16,31%
	1.017,65	**100%**

Table 1. Type of electricity consumption in the Municipality of Taranta Peligna. Source: Sustainable Energy Action Plan, 2012.

As seen in Table 1, the most significant element is represented by the consumption of the residential sector. Since estimating this value is fundamental in the context of energy consumption control and verification, it is necessary to carry out real-time monitoring of residential consumption. This activity can be easily carried out by installing electricity consumption meters (smart meters), which, with the assistance of IoT sensors, allow precise monitoring of each household electrical device, collecting data from each appliance, transmitting it to a unified platform with a specific communication protocol (e.g., *Modbus*, *LoRaWAN*, *OpenThread*). These systems, accessible in terms of costs and installation procedures, enable monitoring not only the energy consumed by buildings but also that produced by individual installed systems.

TYPOLOGY RES PLANT		POWER INSTALLED (KW)	ANNUAL PRODUCTION (KWH/YEAR)
PHOTOVOLTAIC	Municipality of Taranta Peligna	20,00	25.600,00
PHOTOVOLTAIC	I.L.A. - Industria Laniera Abruzzese di Vincenzo Merlino & Figli S.n.c.	75,90	97.227,90
HYDROELECTRIC	I.L.A. - Industria Laniera Abruzzese di Vincenzo Merlino & Figli S.n.c.	600,00	
HYDROELECTRIC	Verlengia & De Cecco S.r.l.	9.000,00	1.054.897,70
HYDROELECTRIC	Enel Green Power S.p.A. Centrale ENEL Aventino 1	10.000,00	
			1.177.725,60

Table 2. RES plants in the Municipality of Taranta Peligna. Source: Sustainable Energy Action Plan, 2012.

Table 2 reveals that several RES plants currently exist within the entire municipal territory of Taranta Peligna, producing a total of approximately 1.17 GWh/year: existing and operational plants within the municipal territory cannot become part of the REC (D.M. 414/2023). Therefore, new forms of development must be identified.
Given the characteristics of the area and the availability of water resources, it is possible to consider the reactivation of the old power plant located along the Acquevive River Park; as depicted in Figure 1, the river stretch is indeed suitable for harnessing the water resource for hydroelectric purposes,[1] with a potential withdrawal of 3,455 l/s.

1 Abruzzo Region, Study to support regional planning regarding water resources intended for hydroelectric energy production, 2008. https://www.regione.abruzzo.it/content/risorse-idriche

However, this value is purely theoretical and requires an in-depth hydrological study to verify its validity; therefore, in the hypothesis of a flowing water system with a withdrawal of 1,000 l/s and a geodetic head of 5 meters (within the same structure), a production of approximately 384,018 kWh/year would be achieved. This entirely precautionary estimate does not consider the possibility of greater withdrawal and a larger geodetic drop, which would allow for increased production.

Regarding the development of photovoltaic systems, it will first be necessary to conduct a census (Carbonara & Stefano, 2016) of all municipal real estate assets to identify properties and areas suitable for constructing photovoltaic systems. However, following the census activity, a “real estate due diligence” (Carbonara & Stefano, 2020) will be required to verify said assets to provide an accurate description and evaluation of the assets under analysis.
In addition to the public potential, it is possible to estimate the potential that can be installed on individual private residential homes by assuming that each resident family (173 families according to ISTAT 2022) creates a modest-sized system equal to 3 KWp. From this perspective, a production of approximately 648,750 kWh/year could be achieved.

As for RES plants deriving from the exploitation of wind resources, the municipal territory falls within a multi-restricted area (as shown in Figure 7: Site of Community Interest - SCI, Special Protection Area - ZPS, Maiella National Park, Zones A1 and A2 of the Regional Landscape Plan), effectively inhibiting the installation of large-scale wind turbines.

The greatest energy potential of the area, with production greater than 2500 MWh/MW, as shown in Figure 8, is located only in the mountainous part of the municipality of Taranta Peligna. This makes the realization of any project unsustainable (both financially and in terms of landscape) due to the steepness of the area and the presence of highly protected areas. Nevertheless, there remains the possibility of installing small-scale wind power systems with reduced power up to 3 KW on the premises of buildings, which, albeit with a minimal contribution, still represent a form of renewable energy with low impact.
In summary, the hypothesis of establishing and developing a REC in Taranta Peligna envisages that the proposed RES plants (hydroelectric for 384,018 kWh/year (Fig. 6) and photovoltaic for 648,750 kWh/year) could ensure, with the aid of storage systems, the energy balance of the entire municipality, providing production of 1.033 GWh/year, compared to a consumption of 1.017 GWh/year.

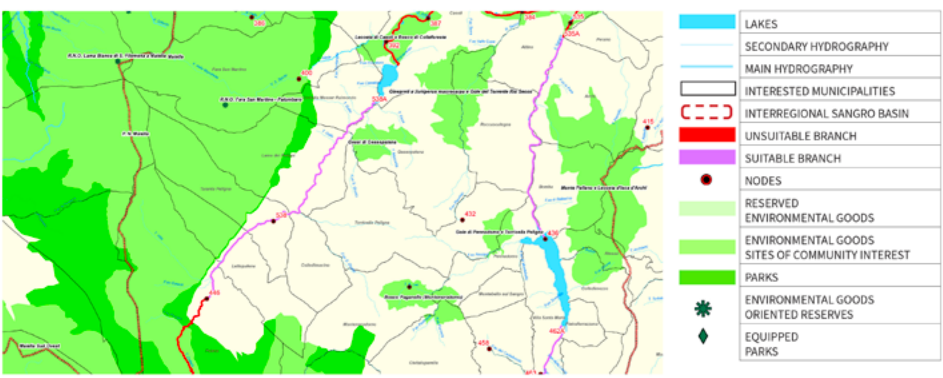

Figure 6. Section suitable for the exploitation of the hydroelectric resource. Source: Abruzzo Region, *Study to support regional planning regarding water resources intended for the production of hydroelectric energy*. 2008, available online.

A B C

Figure 7. Constraints: A) Site of Community Interest (SCI); B) Special Protection Area (SPA); C) Landscape Plan. 2024, available online.

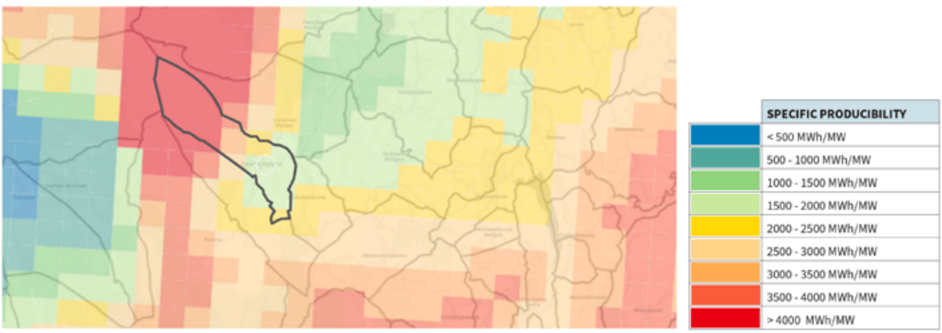

Figure 8. Specific onshore producibility at 100 m above sea level, expressed in MWh/MW – Source: RSE Italian Wind Atlas, available online.

5. Technologies and Tools to Support the Renewable Energy Community

To facilitate the creation of the REC and support its development, the project proposes the construction of a web-based digital platform integrated with a geographic information system and with functions capable of providing the energy analysis of the territory, facilitating interactions and the circulation of information between people and support the community in communication actions, energy management, and decision making.

The numerous projects aimed at creating energy communities constitute a point of reference for understanding good practices and acquiring a broad repertoire of information materials, technologies, and software specifically developed to support the development of communities (European Union, 2023). Citing examples, European projects such as H2020 *CREATORS*[2] provide software, applications, and services to help cities set up, plan, and manage community energy systems.
H2020 *BEcoop*,[3] allows the consultation and use of a toolkit of technical tools, business models and community models, and self-assessment tools. The H2020 *BENEFFICE* system[4] suggests technologies and incentives to improve home energy efficiency.

In the specific Italian context, the Legambiente Renewable Communities portal[5] reports on numerous case studies of energy communities that have been created, offering, through a WebGIS portal, a map of their location and a summary filing of each community's objectives and characteristics. From the study of the references and the preliminary analysis of the territory in question, the structure of the web platform emerges, and three main functions are outlined: the instrumental function, necessary for the measurement and monitoring of the energy balance; the dissemination function, for the

2 https://www.creators4you.energy/

3 https://www.becoop-project.eu/

4 https://cordis.europa.eu/project/id/768774/results

5 https://experience.arcgis.com/experience/40737f090e95471aa87a300a43700bec

growth of the energy community, and the collaborative one, which allows the development of ideas and favours the decision-making process. In Table 3 it is possible to schematically identify the expected results that applying these three functions to a WebGIS portal and web platform (detailed in the following paragraphs) could bring to Taranta Peligna, activating the advantages of building an energy community.

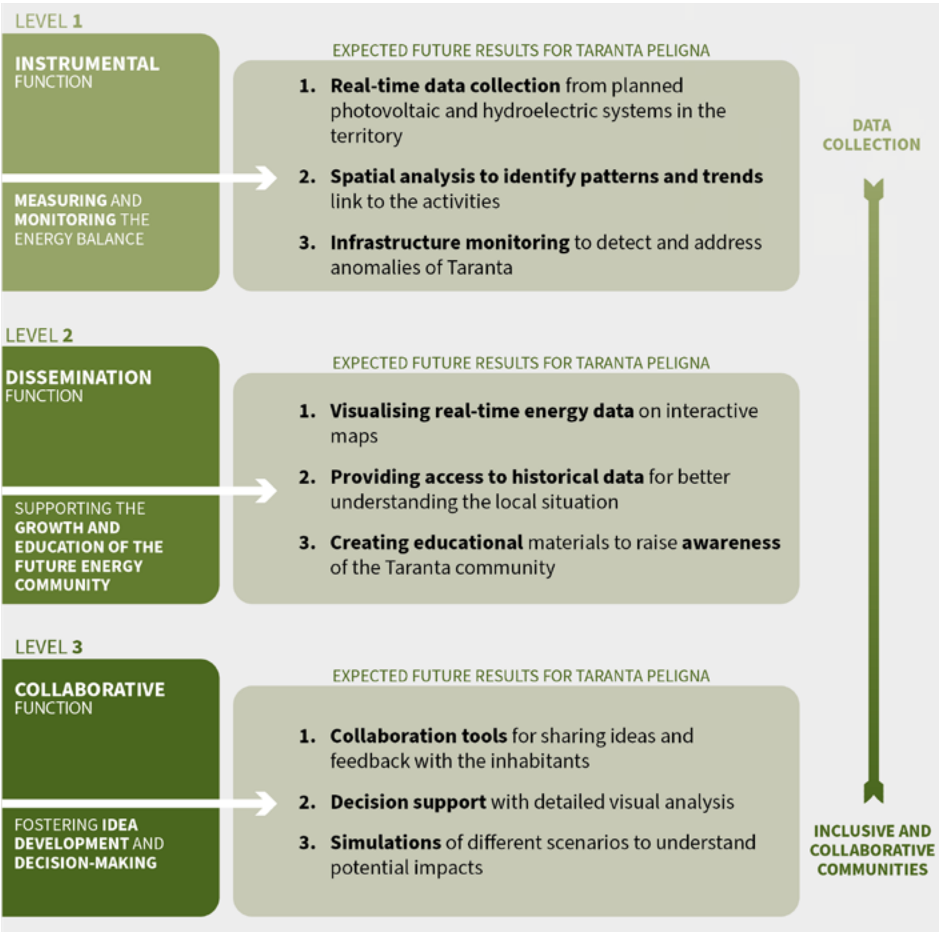

Table 3. Structure of the web platform: main functions and expected results for Taranta Peligna.

5.1. Communicating the Energy Balance to Communicate Opportunities: the Instrumental Function

A part of the web platform is dedicated to the visualisation and querying of geo-referenced virtual maps that provide precision monitoring (Fusero et al., 2018) through a WebGIS portal. The system allows real-time mapping of residential and non-residential energy consumption, storage, and localisation. The portal also allows to:

Monitor renewable energy production plants from renewable sources, allowing real-time intervention in case of anomalies.

Monitor residential and non-residential consumption and related CO_2 emissions to study the most suitable interventions and strategies for energy saving and emissions reduction. Collecting data such as radiation and exposure can help deduce the best siting opportunities for new RES plants (Canessa, Masini, Lanzetta, 2012).

Allow community members to geo-reference their activity and build collaborative networks by supporting the exchange of surplus or underutilized energy resources through a peer-to-peer mechanism.

The creation of periodic summary maps is envisaged to support the information system. Using Data Visualization tools, these maps describe the evolution of monitoring and the visual history of the energy community's quantitative data.

5.2. Making Data Understandable, Involving, Training: The Dissemination Function

An energy community is made up of groups of people with different skills and interests. Private citizens, technicians, and administrators of public entities must be able to access

the information; understanding its contents is a crucial aspect of the initiative's success and growth.
The community was created to optimize the use of energy resource but can "expand its attention also towards distribution, storage and electric mobility" (Boulanger et al., 2021), generating unexpected synergies and technological innovation. To foster these processes and encourage the involvement of residents in the community, there needs to be an exchange of knowledge, circulation of ideas, and explanation of the purposes, services, and reward systems provided for those who embrace renewables and commit to reducing CO_2 emissions. For this purpose, the web platform is the ideal tool to reach, through multimedia means such as videos, images, texts, social feeds, serious games, reports and downloadable guides, the plurality of subjects interested in the activity (Mastrolonardo & Clementi, 2024).

5.3. Promote the Organizational Structure and Decision-Making Process: The Collaborative Function

A collective energy project is based on collegial decisions, collective energy purchases at advantageous rates for use in common areas and choices relating to investments in RES plants in which private citizens and businesses participate, whose utilities fall within the same transformer substation (Robinson et al., 2022). These activities require collaborative and participatory forms of consultation and decision-making that the web platform can facilitate by implementing an open-source tool, such as *Your Priorities*[6], designed to enable community members to

6 https://yrpri.org/domain/3

collaborate on decision-making processes. It provides features for posing questions, proposing ideas and solutions, voting, moderating responses, conducting surveys, and linking to social media. This tool, hosted by the project's web platform, is a Progressive Web App (PWA), a software application used through a web browser and allows optimal operability on mobile and desktop computers.
In summary, the digital platform to be designed for the energy community of Taranta Peligna is a multimedia and collaborative WebGIS tool to support decision-making: it connects producers, consumers, and self-consumers towards the transition to renewable energies and encourages the development of specific skills and the enhancement of local resources with high added value. In this context, the web platform asserts itself as a crucial replicable model tool, not just for energy monitoring but also to promote active and educational participation, transforming every participant into a proactive element in the context of community management and environmental sustainability. This approach is important within a broader vision that enhances territorial resources as dynamic systems, capable of countering depopulation through technological innovation and the valorisation of local traditions, integrating zero-impact production processes and the redevelopment of local resources, with the goal of fostering a radical shift towards a circular and sustainable economy (Manzini, 2015).

6. Conclusions. Energy to Design Communities

Recognizing the importance of the territory in the processes of socio-economic and cultural development, and considering local resources as dynamic micro-systems capable of generating

value and resources (productive, but also cognitive, organizational and relational), the analysis has focused on the definition of a future vision for Taranta Peligna based on an authentic, local and innovative value system that can counteract depopulation with technological additions, for a community focused on local manufacturing with zero impact compared in wool-textile supply chain. This chain still showcases products with a strong identity tied to local tradition, contributing to the redevelopment of existing tourist and environmental resources. Indeed, delving into the root of a problem, whether hidden within governance structures, regulations, or deeply ingrained social assumptions or beliefs, an essential aspect of the design process considers connections, relationships, leadership, and narrative surrounding that require evolving resources and time. This process also needs to connect with other similar initiatives (local, national, community, etc.) to spark a movement for change. In this sense, the contribution of design discipline concerns both the methodological process and the product/service system: the web platform, designed not only to monitor but also to involve and connect users and stakeholders, is specifically designed to grasp possible growth opportunities, support the creation of a community of practice to establish, in a participatory manner and with a bottom-up approach, the skills that the territory of Taranta Peligna has seen arise and develop throughout history.
A pilot analytical experience like the one underway in Taranta Peligna (that will be tested in the future project phases) allows us to acknowledge the limits and obstacles to overcome, such as the classic economic model and prevalent individual culture, and to consider the ecological transition not as a linear passage

but as a true paradigm shift. The pursuit of limitless growth, whether applied to national GDP or individual profit, has led to exceeding the resource extraction limit. The consequences of this are becoming increasingly severe, including growing inequality. Conversely, reversing the energy transition negates the principle of limitless growth, replacing it with the circular economy. This is intrinsically at odds with the decoupling between economic growth and resource extraction, a myth that has never been demonstrated and is incompatible with the second law of thermodynamics (Butera, 2021).

Aknowledgments

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