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EDITORIAL #26

Humanizing Energy
Design and Art for Energy Transition

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The energy transition represents today an unavoidable challenge, a necessity and an environmental, social and economic urgency that can no longer be postponed. Institutional actors, governmental and non-governmental bodies have defined strategic objectives to pursue it, yet they have undertaken actions that are still too often of limited impact. International programmes include, for instance, the 7th SDGs of the 2030 Agenda and, in the European sphere, the European Green Deal and the most recent REPowerEU, with which the European Union has set the target of using 42.5 percent renewable energy in its energy mix by 2030 (European Commission, 2022). The plan calls for parallel efforts to reduce consumption, improve the energy efficiency of buildings and production cycles, and invest in energy storage infrastructure.

The climate crisis also prompts a rethink of fossil fuels' environmental and social impact. The transition to more sustainable sources, instrumental in a serious reduction of greenhouse gas emissions, is indeed an important step in the fight against climate change. An increment in energy sustainability also goes in the direction of countering the emergency of energy poverty: whereas in developing countries the latter manifests itself in the inaccessibility to the electricity grid for about 1 billion people, Italy alone in 2021 accounted for more than 2.1 million households experiencing difficulties in acquiring a minimum basket of energy goods and services (8.5% of total households) and in 2023 10% of minors still

Opening photo: Luminous installation *Verso un Lettering Civile* by Davide Crippa and Repubblica del Design. Realised for the Milano Design Week 2022, Bovisa district (photo by Design Differente).

lived in unhealthy, poorly heated and/or cooled, or poorly lit environments (Castellini et al., 2023).

As a matter of fact, the energy transition concerns all fundamental aspects of societal life: health, work, the quality of everyday spaces, mobility, as well as cultural production and the fight against inequality and discrimination. Community, care, technology, culture, identity, education, neighbourhood welfare, behavioural change, urban biodiversity, social and ecological networks, soft mobility and urban resilience are but a few of the themes that converge in a truly sustainable and inclusive energy transition.

With this in mind, it is surely a collective responsibility to identify processes and methods to implement a rapid and effective energy transition. In this process, design and the arts represent strategic levers of action and innovation, for they may stimulate paradigmatic changes in the ways energy is produced and consumed, in the ways it is used and in the behaviour of individuals and communities around it, to experiment with new conceptual and operational models and, in short, to propose paths towards a more sustainable future.

In this vision, design disciplines intervene on the "hard" components of the energy transition but also on its "soft," more relational, and qualitative components. This dimension is "close" to the people and calls upon the responsibility of individuals without leaving the solutions solely to institutions, companies, and international bodies. Instead, the energy transition is based on the collective participation of all social

bodies, formal and informal, and requires sharing themes, scales, and project intentions. Indeed, the transition requires systemic, structural, technological, political, economic, and cultural changes involving individuals, communities, and all local and global actors. It is, therefore, necessary to implement a revolution of the current models, starting from a more widespread energy education towards scenarios – some of which are already visible – of co-creation, co-production, and co-management, of short and circular supply chains, of self-production and digitised and smart processes, to secure a safe, ethical and welcoming future.

Innovative models such as those of Renewable Energy Communities (Bolognesi & Magnaghi, 2020), so-called circular neighbourhoods, and "proximity" energies aim to engage individuals and businesses in the creation of a local energy system, re-establishing a direct relationship between users and production, while creating new jobs, stimulating community cohesion and reducing greenhouse gas emissions, are heading in this direction. Ultimately, it will enhance territorial specificities and promote opportunities for social innovation and new forms of energy democracy (Liberti, 2022).

Issue #26 of PAD, therefore, gathers reflections, studies, and research proposals that highlight the role of design and the arts in promoting systemic innovation, both in terms of practice and cultural and social meaning, to provide new models of sustainable energy production, use and consumption. In particular, the issue explores how art and design actions can lead to a transition toward innovation in values, models, and

tools. These three categories also articulate the structure of the journal. Innovation in values leverages culture and knowledge about energy-related phenomena and transforms everyday behavior. On the other hand, an innovation involving models ignites the development of increasingly participatory and collaborative processes in energy production and consumption systems. Finally, sustainability undoubtedly passes through innovation in tools, which are intended as devices and technologies for sustainable energy production but also understood as those supports aimed at increasing awareness about the role of data and information in the overall energy balance.

1. Values: Energy Cultures & Behavioural Change

The first section, *Values: Energy Cultures & Behavioural Change* is dedicated to pieces that explore the role of design in promoting energy sustainability through cultural and behavioural change. This involves spreading new value systems and increasing the knowledge and awareness of individuals and communities. In this context, design, with its interdisciplinary connections, emerges as a powerful ally for individual and collective education. It can generate support for change, raise awareness, engage people and broaden participation in transition processes. Furthermore, design can outline new future scenarios for energy production and consumption, create new formats for managing daily actions, and envision energy-efficient goods and services. It can also promote using sustainable energy sources by adopting technologies and materials with reduced environmental impact.

The essay *Re-Crafting Energy-Related Household Routines: The Integration of Design Methods in Behavioural Change Theory to Foster More Sustainable Routines* by Giovanni Profeta, Francesca Cellina, Desirée Veschetti, Evelyn Lobsiger-Kägi, Devon Wemyss and Pasquale Granato focuses on the promotion of more sustainable household routines in terms of energy consumption using design methods integrated with behavioural change theories. The authors describe the development and implementation of the Social Power Plus (SPP) mobile app, which aims to promote energy-efficient behaviour. The app is based on the Model of Action Phases (MAP), which identifies four stages of behaviour change. It uses data visualisation techniques to provide feedback to users according to their level of data literacy. In addition, the app provides social networking features to facilitate the sharing of energy saving experiences and knowledge.

The contribution by Gijs van Leeuwen and Abhigyan Singh, *Exploring Design Fictions as Tools for Transformation Towards a Human-Centered Energy Transition*, explores how design fiction can be used to support people-centred energy transitions. The authors propose using design fiction as a method of world-building to imagine alternative realities and intervene in the development of energy infrastructures. The emphasis is placed on using design fiction to influence values, mindsets and practices across the distributed networks that shape energy transitions. The authors present seven speculative scenarios to illustrate possible futures of energy infrastructures, aiming to create a comprehensive approach that can influence systemic energy transitions while maintaining a human-centered focus.

The essay *Environment/Data/People: [Eco] Participation Through Data Visualisation as Design Strategic Approach for Engaging, Sensitising, and Educating the Community to Energy Transition,* by Alessio Caccamo and Anna Turco, explores the role of data visualisation in promoting energy literacy and participation in the energy transition. The article highlights the importance of engaging citizens through visual and participatory methods to foster a deeper understanding and commitment to sustainable energy practices. The article discusses different design strategies to make abstract data more tangible and engaging, including visual metaphors, data art, and data physicalisation. It presents several case studies and examples of effective data visualisation projects. By involving individuals and communities in participatory data visualisation, it is possible to create a more emotionally engaging and accessible understanding of complex energy data.

Marco Manfra and Grazia Quercia, in the essay *Design for Temporary and Sustainable Music Festivals: New Values and Informal Educational Systems for Humanising the Energy Transition*, explore the role of temporary and sustainable music festivals as vehicles for promoting new environmental, "energetic" and social behaviours. These festivals can typically address environmental impacts such as energy consumption, fossil fuel use, biodiversity loss, CO2 emissions and waste generation. The authors argue that these festivals can inspire personal responsibility and promote practices of sustainability and circularity. They examine several European music festivals, detailing their sustainability strategies and encouraging responsible behaviour through interactive and engaging methods.

The essay *Talking about Energy: Design and Language for the Energy Transition* written by the editors (Barbara Di Prete, Agnese Rebaglio, Lucia Ratti) concludes the first part. It emphasises the critical role of communication in the energy transition. It argues that design can play a key role in engaging people both cognitively and emotionally in discussions about energy sustainability. By creating a new language around energy, design can, in fact, promote knowledge and awareness to combat the "energy illiteracy" that is currently making the majority seem disinterested in transition-related issues. Starting from the observation that the technical and specialised language currently used in the energy discourse often has an alienating effect on people, the authors suggest that the development of a new everyday vocabulary could help to bridge this gap, making sustainability a more integral part of everyday life and thus encouraging behavioural change. The article outlines different design approaches to help cultivate a culture of sustainability, making energy issues more understandable and actionable for a wider audience.

2. Models: Energy Communities & Collaborative Landscapes

The second section, entitled *Models: Energy Communities & Collaborative Landscapes*, examines alternative and innovative collaborative models of production, management and consumption, mainly characterised by participatory dynamics, community practices and collective empowerment in constructing new economic and social visions. The five contributions offer complementary points of view on methods and tools for raising citizens' awareness, but also on new forms of "proximity" energy co-production and co-management aimed

at combating energy poverty (energy communities, short supply chains, self-production models, local renewable sources).

All these analyses point to the strategic role that design can play in promoting the containment of energy demand, guaranteeing access to energy for all, promoting increasingly inclusive, democratic, and conscious processes of community welfare, but also in outlining new scenarios of more sustainable consumption, redefining both individual behavior and collective aspirations.

Debora Giorgi, Claudia Morea, Chiara Rutigliano, Letizia Giannelli and Luca Incrocci, in the essay entitled *Services to Design Change: Gamification Opportunities to Generate Virtuous Behaviours and Design Sustainability Pathways*, explores Design for Behaviour Change (DfBC) practices capable of promoting an energy transition based on more sustainable consumption, more conscious behaviour, the ability to embrace technological advances and the application of user-centered design strategies. The contribution aims to provide a theoretical and methodological framework that combines the skills of design with those of social psychology to make sustainable energy choices and personal desires and not merely social or regulatory constraints perceived as distant and suffered as imposed. The essay presents case studies that testify to the effectiveness of the proposed practices in raising awareness and stimulating a collective commitment capable of determining impacts in terms of energy, environmental, and climate sustainability, even in the long term.

The essay *Energy to Design Communities: Energy Communities and Communities of Practice to Support Marginal Areas in Abruzzo*, written by Rossana Gaddi, Raffaella Massacesi, Luciana Mastrolonardo and Davide Stefano, illustrates a systemic and multiscale design experiment carried out in Taranta Peligna (CH). Here, the construction of a Renewable Energy Community provides an opportunity to support high-quality artisanal resources, recover the excellence of the local industrial history, valorise the great environmental heritage of the area and counteract the growing depopulation. The aim is to define a production model based on proximity, public-private collaboration and the use of an open-access Geographical Information System, in order to develop inclusive, community-centred scenarios for clean energy production that combat energy poverty and, in the long run, generate economic, cultural, social and environmental benefits, starting from the energy lever itself.

Carla Sedini, Francesco Zurlo, Stefania Palmieri, Mario Bisson and Silvia Peluzzi, in their essay *Enhancing Wind Farm Projects: A Systemic and Strategic Design Approach to Community Acceptance and Engagement*, investigate how to increase local acceptance of wind farm projects by integrating landscape knowledge and cultural significance through a systemic and strategic design approach. A case study analysis of fifty energy transition projects was undertaken and a matrix was filled to map the case studies based on user involvement and their relationship to the environment. The study highlights the need for community engagement at both the design and implementation stages to achieve local acceptance. The discusses strategies in-

clude educational activities, visualisation of abstract concepts of sustainability and co-design workshops.

The essay by Andreas Sicklinger and Adrian Peach, *Powered by the People: Human-Powered Energy Generation as a Lifestyle Choice*, addresses a crucial issue that is both a constraint and a lever for the energy transition in a society dominated by consumerism and the pursuit of well-being: the need to replace the dominance of waste with a different social vision that does not conflict with the expectations of citizen-consumers, but is capable of asserting itself as a new, desirable, more ethical and also more attractive lifestyle. With this in mind, the essay illustrates an experiment carried out in two university workshops and invites to take advantage of people's growing interest in health and sport as an opportunity for design, using the energy of physical movement to power household appliances and proposing new products to generate decentralised energy, mainly at home or at work. Starting from concrete solutions, the text thus pursues an ambitious and far-reaching goal: to act in the sphere of awareness, responsibility and individual freedom, and to induce a collective change in behaviour for the benefit of society as a whole.

The contribution *Designing Community-Driven Energy Solutions*, written by Valentina Auricchio, Marta Corubolo, Stefana Broadbent, Beatriz Bonilla Berrocal and Chenfan Zhang, proposes a wide-ranging critical and design reflection, developed in the academic sphere, which identifies renewable energies (solar, wind, biogas and other green sources) as the challenge and opportunity for a future capable of reducing CO2

emissions in the most congested areas of the world, while at the same time reducing energy poverty in the most remote areas or among the most vulnerable populations. Electrification is therefore a prerequisite, strategy and objective for the realisation of this inclusive scenario. In particular, the essay examines a number of community energy solutions that allow citizens to become protagonists of change, sharing resources with their neighbours through networks, often autonomous, that envisage different possible infrastructural distribution models. The results of these experiments are the strengthening of the sense of belonging to the community, the construction of social capital and the transition towards an increasingly necessary local empowerment.

3. Tools: Energy Technologies & Digital Awareness

In the third and final section, centred on *Tools: Energy Technologies and Digital Awareness*, the focus shifts to the more "hard" component of the energy transition. The four contributions collected here are concerned with analysing and proposing directions for an infrastructure, process or service innovation that is brought back to the human scale, suggesting reflections on the introduction of new techno-ecological approaches to energy production, horizontal models for its distribution, recalibrated habits around the use of the web and a renewed awareness of the impact of digital behaviours.

Projects and field experiments aimed at investigating the role of design and art in defining a new productive, commercial, distributive, but also conceptual paradigm – reported first-hand or taken from the literature and critically analysed

here – find space in this section, along with data-based reflections on the impact of current technological and digital solutions, to stimulate further discussion on the existing need for the use of "better" tools, and at the same time a "better" use of the ones that already exist. The role of art and design here becomes that of "contaminators", capable of identifying alternative strategies to the current ones, gathering clues from different domains of knowledge and grafting between the meshes of technical-technological knowledge the human need to understand and the collective need to be aware of the change we are living.

Suzanna Törnroth, in her essay *Solar Biota: Co-Living with Solar Ecologies*, presents a personal experience of field experimentation in the sphere of alternative solutions for energy production. Challenging the prevailing perception that associates solar energy with the image of large photovoltaic panels located in places that are inaccessible or otherwise distant from the experience of everyday life, the author reports on the results of a five-month multi-species ethnographic study during which she observed her SunSpider – a small prototype of a photovoltaic "organism" – interacting with the ecosystem and other living and non-living entities. Exploring the possibilities opened up by a relational approach to photovoltaic technologies, the essay offers points of departure for a reflection on the complexities and possibilities inherent in the increasingly necessary act of co-living with solar energy-producing devices. Combining an interpretive lens derived from artistic practice and research with a new materialist perspective, Törnroth proposes an original narrative of the

ecosystemic, climatic, and relational entanglements that are triggered in these "solar ecologies" by the conscious coexistence with the technology they bring forth.

From the Cloud to the Ground: A Data-Driven Research to Build Informative Heritage on the Internet's Energy Footprint, written by Fabiola Papini, Francesca Valsecchi and Michele Mauri, moves the spotlight onto the impact of a technological area that is extremely close to our lives: the Internet. Contrary to the common understanding of the Internet as an intangible and lightweight "cloud" devoid of any physicality, the authors bring to the fore the significant resource consumption and contribution to global warming that the vast network of digital infrastructures involved in the functioning of the Web implies. To this end, the essay employs communication design, and in particular data visualisation, both as a method and as an output, to address the knowledge gap that currently exists around the energy footprint of digital activities, and of contextually identifying visual strategies suitable for effectively communicating such complex data. The interplay between human behavior, technology, and the environment is central to the authors' discussion, which ultimately aims to raise awareness of the unsustainability of our current relationship with the internet in order to act as a guide to a more responsible digital future.

The essay *Towards Energy Sustainability in the Digital Realm: A Compass of Strategies Between Natural and Artificial Intelligence*, written by Michele De Chirico, Raffaella Fagnoni, Carmelo Leonardi, Ami Licaj, Giuseppe Lotti, Manfredi Sottani and Annapaola Vacanti, also proposes a critical reflection on

the digital as a non-immaterial entity and suggests ways forward from the current predicament. In particular, the authors highlight how the use of digital does not automatically reduce the physical footprint of human activity but rather requires dedicated planning and design aimed at promoting sobriety and moderation, sustainability, accessibility, and inclusion. With this in mind, the essay examines several virtuous contemporary strategies aimed at minimising the energy consumption of the digital, analysing them through a dual reading criterion: practices that use artificial intelligence to improve system efficiency, on the one hand, and practices that rely instead on natural intelligence to redefine established consumption paradigms, on the other. Finally, by clustering these strategies according to further parameters, the essay proposes a significant set of actions aimed at promoting the energy transition within the digital realm, in line with an increasingly post-anthropocentric vision of design.

Lastly, Davide Crippa and Massimiliano Cason Villa, in their essay *Understanding the Energy Transition by Analysing the IT Revolution: An Infrastructural Reading to Direct Design Approaches Toward Energy Sustainability,* draw a connection between the more strictly instrumental field of energy production and distribution technologies and the digital world, weaving a parallel between the energy transition and the IT revolution. Using the IT metaphor as a critical-interpretive tool, the authors focus on the similarities between electrical energy transfer systems and data transfer systems, deriving from these observations a series of operational suggestions that could be transferred between the two domains.

Indeed, the issue of optimising the architecture of computer networks has been addressed before, and the lessons learned from its revision can serve as a guide for the reassessment of current energy policies. In particular, the paper explores the peer-to-peer model as a possible approach to horizontal and community-based energy management through the analysis of recent experiments in design and art and pilot projects carried out in European cities, with the aim of identifying design strategies and synergies that can inform present and future energy infrastructure planning.

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

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Marginal Areas, Renewable Energy Communities, Communities of Practice (CoP), Open Access Geographic Information Systems, Local Supply Chain.

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.

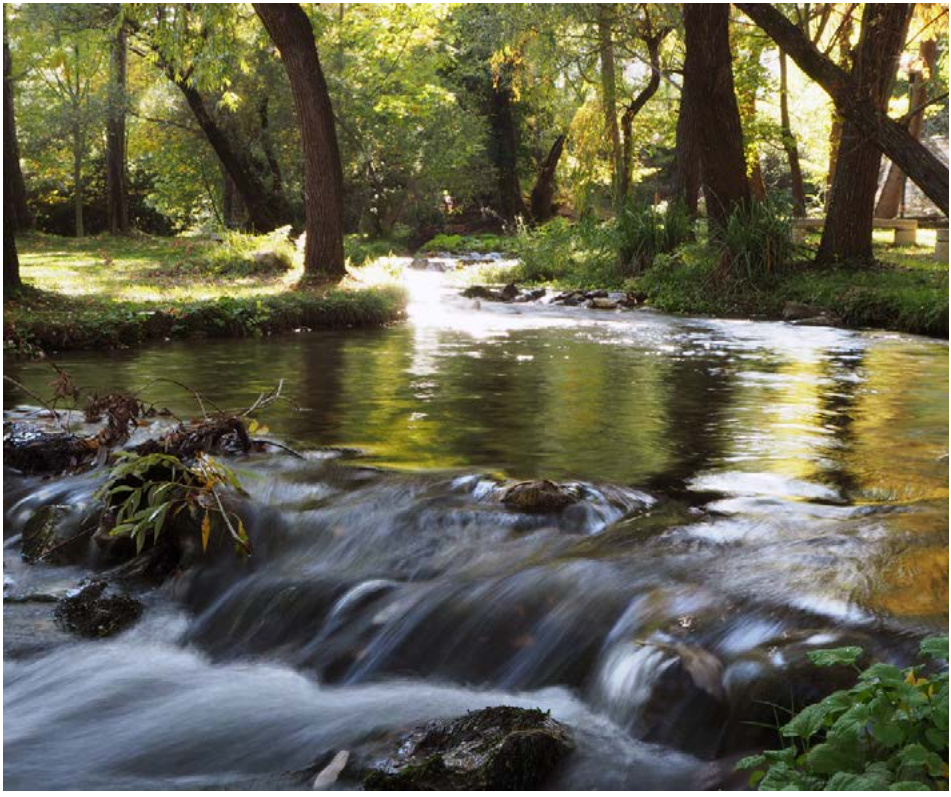

Figure 2. Acquevive River Park, Taranta Peligna. Source: Municipality of Taranta Peligna, 2023.

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.

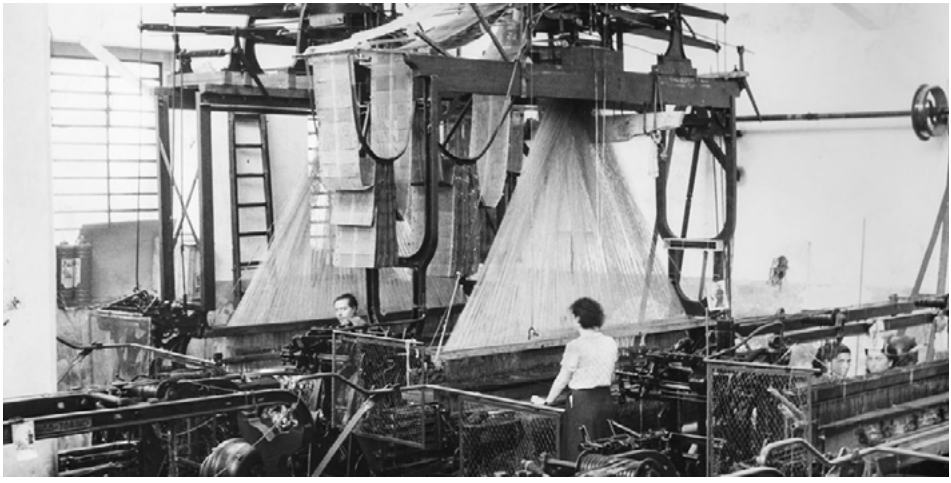

Figure 4. Ancient weaving, Lanificio Merlino. The movement of the warp threads of the Abruzzese Blanket is managed by jacquard machines, the first machines to be driven by a binary system. Source: Lanificio Vincenzo Merlino, www.copertemerlinotaranta.it, 2024.

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.

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

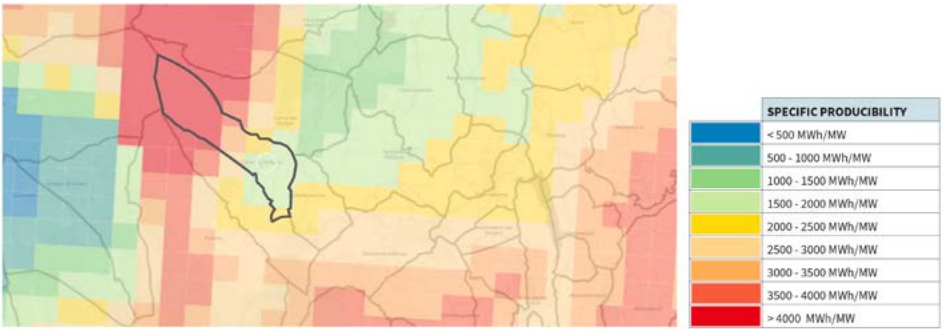

Figure 8. Specific onshore producibility at 100 m above sea level, expressed in MWh/MW – Source: RSE Italian Wind Atlas, available online.

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.

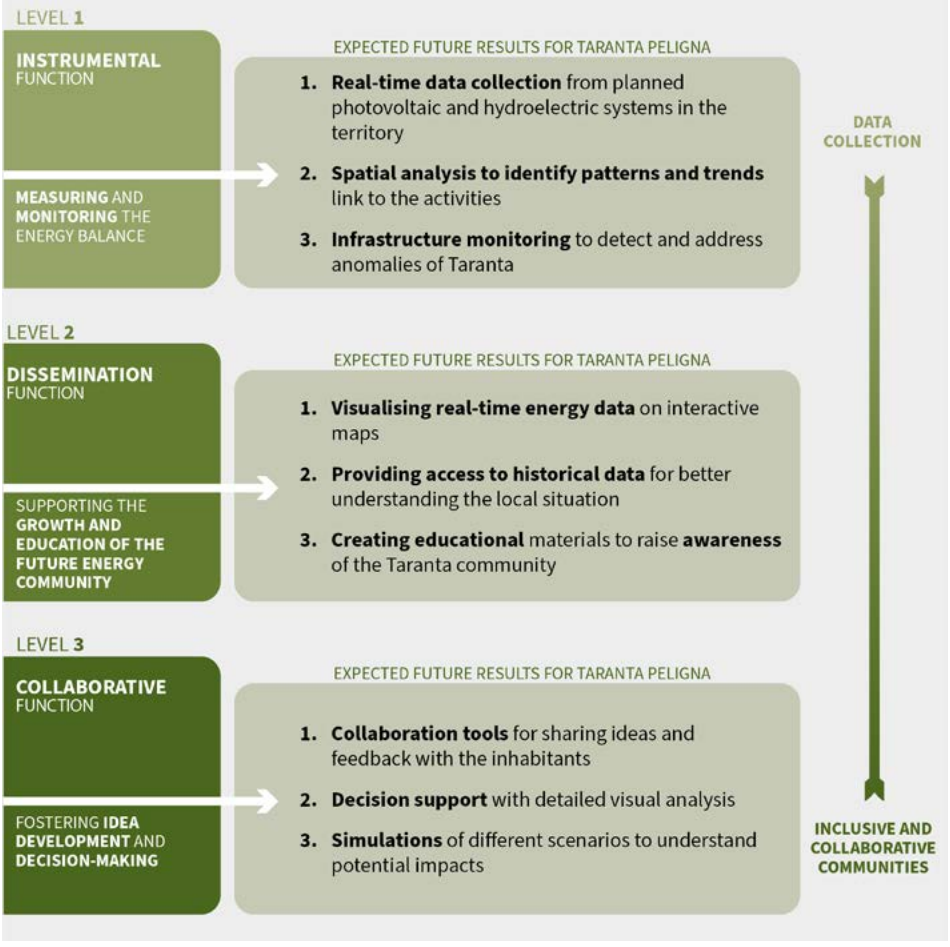

Table 3. Structure of the web platform: main functions and expected results for Taranta Peligna.

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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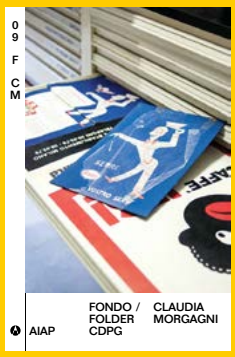

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