Energy Research & Social Science 119 (2025) 103918

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

What does Agrivoltaics means? A study on social representations shared by experts and the press in Italy

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ARTICLE INFO

Keywords:
Agrivoltaics
Social representations theory
Sustainability
Social acceptance
Innovation

ABSTRACT

Our study delves into the evolving landscape of Agrivoltaics (APV) diffusion in Italy, where this innovative application of photovoltaics encounters multifaceted challenges. Through an analysis of press reports and experts' interviews, we aim to elucidate the Social Representations of APV, considering the nuanced perspectives of both expert and non-expert stakeholders. Within these viewpoints, a complex interplay emerges, marked by four major themes: ambiguity, justice, (agronomic) risk, and exploitation. By analysing the representational processes behind the construction of each theme, we posit the need for a more comprehensive understanding of sustainability in the context of APV diffusion, highlighting the importance of clear definitions and guidelines within regulations and policies.

1. Introduction

The European Union has raised its renewable energy target to 42.5 % by 2030, with Member States encouraged to aim for 45 % [1]. Solar energy, contributing 18.2 % of Europe's renewable energy production, is expected to double by 2028. However, in Italy, after a rapid increase of 15 gigawatts in solar capacity between 2010 and 2013, deployment slowed significantly due to diminished incentives and permitting challenges, resulting in just 5.6 GW added between 2014 and 2022 [2]. Land-use conflicts have also intensified as solar development increasingly overlaps with croplands, raising concerns about the displacement of agricultural activities [3,4].

Agrivoltaics -alternatively referred to as agriphotovoltaics [5], agrovoltaics [6] or dual-use solar [7] - has emerged as a viable solution to these challenges by facilitating dual land use. Technical solutions differ through elevated or spaced-out solar modules, with configurations varying based on site-specific needs. In this paper, we adopt the overarching term “agrivoltaics” (APV), as it aligns with EU policy terminology and corresponds closely to the Italian term “agrivoltaico”.

APV holds significant promise for harmonizing energy production with agriculture, including providing shade for crops and livestock, supporting water collection for irrigation, and generating supplementary income for farmers [8–10]. Despite these advantages, APV projects present new challenges and often encounter significant resistance [11,12]. APV remains an emerging option, policies vary across regions, and its role in the current socio-technical system is not clear. For instance, Japan and Massachusetts have established clear standards, whereas Europe still lacks a cohesive framework [13,14].

As with other Renewable Energy Technologies (RETs) the diffusion of APV will depend on legal, technical and economic feasibility; however, social acceptance is equally crucial. Social acceptance has been defined as a set of responses ranging from apathy to favourable attitudes toward a technology within specific social and political contexts [15,16]. We agree with authors that suggest considering acceptance as a dynamic, multi-level interaction encompassing socio-political, community, and market dimensions, all embedded within processes of institutional change [17]. In this sense, RETs acceptance involves various levels -societal, community, and individual- and refer to specific technologies, infrastructures, or applications. Acceptance unfolds over time in three main steps: attitudes toward a given technology (“acceptability”) lead to behavioural responses, including intention to support a technology, use it, and eventually adopt it (“acceptance”), and ultimately results in actual use and diffusion (“adoption”) [18].

Namely, solar energy enjoys high socio-political acceptance, being widely perceived as a preferred renewable energy source [19]. However, this broad approval does not necessarily translate to local acceptance, particularly when scaling up installations [20]. Research highlights that community concerns often revolve around economic factors, such as

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https://doi.org/10.1016/j.erss.2024.103918
Received 21 May 2024; Received in revised form 17 December 2024; Accepted 23 December 2024
Available online 28 December 2024

initial costs, payback periods, subsidies, maintenance expenses, access to financing, and potential impacts on property values [21]. Technical considerations, including the complexity, reliability, quality, and efficiency of systems, are also significant barriers. Finally, key elements consistently highlighted in energy acceptance research are information availability, awareness, market perceptions of transparency and trustworthiness [15].

Studies on social acceptance of APV have explored its development in the USA [3,9,12,13], France [22], Netherlands [23,24], and compared stakeholder perceptions across Germany, Belgium, Denmark [25] and Türkiye [10]. Overall, research suggests that despite APV's potential, conflicting interests hinder its acceptability and adoption. Incentives are still perceived as key, as photovoltaics systems are currently cheaper due to their simpler mounting structures. Torma and Ashemann-Witzel [25], in their thorough analysis, collect mixed opinions on APV's practicality and effectiveness, and conclude that APV is not just a technological innovation but a new socio-technical system which require changes in social and economic practices, and extensive cross-sector collaboration. However, it might be hard to achieve this collaboration as long as the policy landscape offers a plethora of options to install APV, yet no shared understanding of what these systems should entail [13].

In Italy, as in other EU countries, APV is more debated than implemented, and legislation remains in development. In these early stages, it is crucial to examine how experts and media attribute meaning to APV, as its acceptance will largely depend on meaning-making processes currently ongoing. To explore these dynamics, we draw on Social Representations Theory (SRT), which has been effectively used to study shared meanings shaping key aspects of the energy transition, such as the energy grid, hydroelectric, solar, and wind systems [26–30]. However, no studies have explored the social representations (SRs) of APV.

SRT is indeed well suited to explore how diverse social groups interpret and navigate polarizing changes, as the ones brought on by the energy transition. In this perspective social acceptance can be framed as a collective process involving negotiation, contestation, and the integration of new technologies into shared meanings. While the concept of acceptance includes both attitudes and behavioural practices, SRT suggests that representations hold a higher-level role, encompassing both. Indeed, attitudes are considered a connotative element of representations, and by co-constructing these representations, groups can meaningfully coordinate their actions [29]. Furthermore, integrating social acceptance research with SRT highlights the symbolic and communicative roles of so-called “middle actors”, who act as intermediaries in the dissemination of knowledge and legitimization of specific agendas [31]. These actors, including the press and techno-scientific experts, play a pivotal role in shaping public perceptions and fostering (or hindering) the acceptance of innovative technologies.

Therefore, by analysing SRs of APV circulating in expert and media narratives, we aim to understand meaning-making processes potentially influencing its acceptance. This approach allows us to move beyond simplistic acceptance-rejection dichotomies and instead illuminate the diverse, context-specific ways in which APV is conceptualized and evaluated.

2. Background: APV in Italy

In examining the degree of acceptance and the factors contributing to it, it is important to recognise that they are interrelated [15,16]. However, for analytical purposes, they can be distinguished according to the level at which they operate, and the type of actors involved. The tripartite framework provides a structured framework in this regard. Socio-political level includes robust institutional capacity, political will, and supportive regulatory environments. Market acceptance is influenced by factors like cost-competitiveness, effective information-sharing mechanisms, and access to financial resources. Community acceptance hinges on elements such as community participation, opportunities for ownership, and acknowledgment of external benefits or positive public perception.

In the next section, we specifically use this categorization to frame the Italian context at the time of the study.

2.1. Sociopolitical

APV plants in Italy are few and relatively small, with a maximum capacity of 1 Megawatt. During their development Italian regulatory bodies imposed significant constraints: initially, a ban on incentives for ground-mounted PV systems, followed by a complete prohibition on the implementation of PV systems on agricultural land.

The legislative journey for APV in Italy began with Legislative Decree No. 28 on March 2, 2011, aligning with EU Directive 2009/28/CE. This directive, addressing global agricultural demands, highlighted the need for energy sector cooperation to expand agricultural land and restore contaminated areas. This regulatory environment spurred the development of innovative solutions, leading to the early implementation of APV systems in Italy. Notable early adopters include RemTec, with three plants in Northern Italy [Figs. 1, 2, 3], and La Svolta, with one plant in Southern Italy [Fig. 4].

In June 2022, guidelines were established to define APV systems eligible for state incentives. ([32], Table 1). While these guidelines reflect political commitment, they were not legally binding during our study. Instead, Italian regions hold the authority to assess appropriate solar developments, also due to proliferation of large ground-mounted PV plants over the past two decades [4]. Approval processes vary by size and type: installations over 10 MW require an Environmental Impact Assessment (EIA) by State or Regional authorities, assessing environmental, health, and well-being impacts, and mitigation measures. During 2022, the EIA threshold was raised to 20 MW for “innovative” APV plants within 3 km of industrial or commercial areas, unless the site is culturally, environmentally, or architecturally protected. Regions often manage both the EIA and final authorization via a Regional Single Authorization Procedure [33].

Today, Italy's legal and regulatory framework for APV is a patchwork of regional guidelines, institutional reports, and energy company directives. APV is incentivized by the Italian Ministry of Environment and Energy Security (MASE) through the National Recovery and Resilience Plan (PNRR), aiming to install at least 1.04 GW of APV by June 2026. A budget of 1.1 billion euros includes a capital grant of up to 40 % and an incentive tariff for net electricity fed into the grid.

2.2. Market

The market acceptance of APV systems in Italy is shaped by several factors, including construction costs, regulations, and information dissemination. Construction costs vary widely due to plant size, technology, land conditions, grid connection, and permit expenses. Large-scale systems benefit from economies of scale, but regional regulations can influence final costs. Tailored approaches and professional consultations are needed for accurate cost estimates, and potential revenues depend on site sunlight exposure.

Preliminary estimates by MASE [32] suggest that APV systems over 10 MW cost below €800 per kW, with variations mainly due to mounting structures: €65 per kW for ground-mounted, €320–600 per kW for systems over cropland, and €130–220 per kW for those over permanent crops. Additional costs include site preparation and installation, such as foundation work, cable laying, and road construction. PV module costs range from €220 per kW for traditional modules to €350 per kW for bifacial glass-glass modules, which help maintain ground irradiation. Maintenance costs for APV are estimated to be 13 % lower than for ground-mounted PV systems.

Regarding the availability of information and feedback, the Italian Association for Sustainable Agrivoltaics (AIAS) plays an active role in updating its associates on laws, procedures, and good practices related

Fig. 1. APV plant in Castelvetro (Emilia-Romagna region) © 2020 REM TEC s.r.l.

Fig. 2. APV plant in Monticelli d'Ongina (Emilia-Romagna region) © 2020 REM TEC s.r.l.

Fig. 3. APV plant in Borgo Virgilo (Lombardia region) © 2020 REM TEC s.r.l.

to APV. However, actual access to financing remains problematic due to slow bureaucracy.

2.3. Community

Systematic data on community acceptance in Italy is unavailable. The topic of land consumption by renewables appears occasionally in local newspapers, with sporadic mentions of APV. Studies conducted in other countries show the importance of prior experiences with similar projects [34] and have highlighted how this dimension is particularly influenced by trust, equity, and procedural fairness [17]. While AIAS organizes webinars, podcasts, and events to update its associates, there is a lack of systematic research on how experts, the media, or different communities perceive APV.

In the next section we will introduce SRT as a suitable framework to explore meaning-making processes which are intertwined with community and socio-political acceptance. Indeed identifying the SRs of APV is a critical step toward addressing this gap and understanding its nuanced reception at the local level.

3. Social representations theory

According to SRT, SRs are formed through collective processes within social groups, primarily through everyday communication [35]. SRs provide common sense theories for explaining and discussing polarizing social object, such as new contested technologies. This is achieved by connecting unfamiliar concepts to previously accepted sets of opinions, images, and beliefs (anchoring process), and then transforming the abstract novelty into a tangible object (objectification process) [36]. In anchoring and objectification, some elements are selected, others lost and still others transformed so that the new object becomes comprehensible and manageable. Overall, emerging representations are characterised by a so-called *decalage*, a distance between the initial knowledge about the object and the form that the representations finally take.

This distance, however, is not due to mere individual cognitive limitations, but rather highlights different systems of thought belonging to two ideal-type universes. The reified universe is based on authority, rules and procedures, and scientific knowledge subject to control (e.g. through experiments and logic); its representations are independent of

Fig. 4. APV Plant in Gioia del Colle (Puglia region) @2021 Prosvolta SRL.

Table 1
Guidelines established for APV promotion in Italy.

Definition (A)	Synergy (B)	Configurations (C)	Monitoring (D)	Monitoring (E)
Agricultural area: ≥ 70 % of the total area. PV module coverage: ≤ 40 % of the total area	Agricultural activities must continue without interruption. Electricity production: ≥60 % of a standard PV system.	Type 1: Inclined PV modules above crops. Type 2: Inclined PV modules integrated among crops. Type 3: Vertical PV modules integrated among crops.	Monitoring for water conservation and agricultural continuity.	Monitoring for soil fertility recovery, microclimate, and resilience to climate change

our desires. The consensual universe is based, instead, on relative competence and knowledge is a shared process that corresponds to immediate interests, first and foremost enabling communication between members of the social group and maintaining the group itself.

There is no strict separation between lay and expert thinking, as both influence each other [37]. While expert knowledge stems from specialized roles and education, experts remain part of society, bridging exclusive expertise and everyday life [38]. Thus, expert discourse also involves consensual processes. This has two implications: (1) SRs are not neutral but reflect power dynamics, social conflicts, and biases [34]; individuals and groups engage in *polyphasic thinking*, holding multiple, sometimes conflicting, representations simultaneously. This polyphasic thinking enables adaptation to change, as individuals navigate competing representations that reflect broader cultural, institutional, and contextual influences.

SRT has been largely employed to examine technological innovation and environmental issues, including novelties related to energy transition [28]. Several authors suggest that exploring SRs shared by experts and circulating in the public arena, and the dynamic between the two, is pivotal to identify areas of conflict and, ideally, to better communicate techno-scientific innovations and foster community engagement [31,38]. SRT has thus been used to explore shared meanings attributed by diverse communities to energy projects and to avoid a normative and top-down approach to the energy transition. The investigation of representations circulating among experts, policy makers and in the media proved relevant to define the denotative and connotative components of renewables technologies and to identify SRs underlying local opposition, and potential instances of energy injustices. The present study adds to this literature by addressing APV as a new social object and starts by exploring whether and what representation is emerging among experts and in the media.

4. Aims

The primary objective of this paper is to delve into SRs surrounding APV in Italy. Our focus is on experts and media, as we aim to decipher how both symbolically denote and connote this socio-technological innovation.

Namely, we expect experts to draw on both reified knowledge and consensual elements in their discourse. This is because different repertoires can be used to make sense of novel technology and its associated values.

We expect media to play a significant role in shaping representations of APV, particularly when it becomes a relevant object for the communities. Therefore, we have focused our attention on news about conflicts and oppositions, which should manifest anchoring and reification processes, and the typical decalage of information that accompanies the emergence of new SRs.

By investigating the heterogeneity of representations across experts and media we aim to understand whether and to which extent expert opinions shape public representations and vice versa. We hypothesise the existence of a common ground for SRs elaborated in both expert and media discourse, informing communication on the same socio-cognitive basis for taking sides on APV.

5. Material and methods

This study explored the SRs of APV through two datasets: 15 interviews conducted with APV experts and 40 Italian news articles reporting protests against APV projects.

For the news articles, an extensive search was conducted using Google, employing Italian equivalents of keywords such as “opposition”, “agrivoltaics”, “no agrivoltaics”, “protest agrivoltaics”, and “stop agrivoltaics”. Synonyms, like “agrophotovoltaics”, were included to ensure the broadest sample possible. Outputs were manually screened to include only news articles explicitly addressing APV, excluding texts that merely mentioned the keywords to advance normative positions supporting APV. The final sample consisted of 40 Italian news articles spanning from December 15, 2021, to August 15, 2023. This period coincides with APV's increased prominence following its formal

normative definition and the announcement of a €1 billion investment under the PNRR funding program, which drew public attention. Articles originated from online newspapers (67.5 %), digital versions of print newspapers (25 %), and thematic news websites (7.5 %). Most were local (64 %), while 18 % addressed national news and 18 % regional events. Their political orientations were assessed preliminarily: 52.5 % came from independent local newspapers, 10 % from church-affiliated sites, 12.5 % from right-leaning publications, 2.5 % from centrist sources, and 20 % from thematic sites focused on ecology, technology, legal issues, or agriculture. Geographically, disputes over APV projects were most frequent in the Marche region, followed by Piedmont and Tuscany.

Discursive interviews [39] were chosen as a tool for collecting experts' shared SRs, due to their open-ended and conversational nature. Unlike structured interviews, discursive interviews encourage participants to freely express their thoughts, feelings, and experiences related to the subject under study. The interviews, conducted online and video-recorded with consent, began with participants affiliated with AIAS -assumed to have favourable views toward APV- and expanded via snowball sampling to encompass diverse perspectives. Participants included agricultural entrepreneurs, energy entrepreneurs, policy-makers, activists, and researchers, categorized as "insiders" or "outsiders" per Von Soest's recommendations [40]. Of the 25 experts contacted, 15 participated, comprising 6 agricultural entrepreneurs, 6 energy entrepreneurs, 1 farmers' association representative, 1 environmental activist, and 1 legal expert (Fig. 5). These participants came from Northern Italy (4), Central Italy (5), and Southern Italy (6).

We applied thematic analysis, guided by constructivist grounded theory [41], to both datasets. The first author developed a bottom-up coding system by thoroughly familiarizing herself with the data, initially coding sentence by sentence. These codes were grouped into broader themes, which were reviewed twice with co-authors to ensure reliability and consensus. Finally, connections between codes were examined (considering Boolean operators), to explore how meanings were connected, constructed and contested by experts and the media. Representational processes were examined as follows. Anchoring was studied by examining how APV was named, categorized, and connected to familiar cultural frames, and existing beliefs and attitudes, this included identifying statements that maintained stability in perceptions while incorporating new information. Objectification was studied by observing how abstract ideas about APV were transformed into tangible practices or images, solidifying it into a concrete representation [27].

6. Results

In the press, the discussion on protest to APV is on potential installations (as the projects are still under approval). What is debated, in other words, is the technology's presence in specific places, suggesting representational processes were still in their infancy during the period considered. While this may bias our analysis due to the journalists' preconceptions or interpretations based on social or local identities, it also encourages us to assess the presence of anchoring and objectification phenomena in SRs, which tend to emerge when something significant and unfamiliar is introduced.

Regarding the size of the plants, every time a protest is documented the systems are described as "large", "huge expanses of modules" or "maxi-plants". The smallest plant mentioned in corpus examined would -if realised- occupy 7.5 ha; the largest, 140. This seems to tie in with Cousse's [20] observation about the link between size of plants and their acceptability: the larger the scale of the plant, the greater the perceived damage in terms of landscape quality.

Adopting an iterative process enabled the development of themes reflecting key tensions and dimensions, including ambiguity (e.g., "vagueness of the institutional framework"), justice (e.g., "threatened landscape"), risk (e.g., "insufficient agronomic experimentation"), and exploitation (e.g., "wounded territory"). Each overarching theme appeared to reflect tensions encapsulated by oppositional concepts such as true-false (ambiguity), inclusion-exclusion (justice), repetition-innovation (risk), and common-commodity (exploitation).

- Ambiguity: True-False
- Justice: Inclusion-Exclusion
- (Agronomic) Risk: Repetition-Innovation
- Exploitation: Common-Commodity

ID	Job	Region	Sex
1	Energy entrepreneur	Emilia-Romagna	M
2	Energy entrepreneur	Lazio	M
3	Agricultural entrepreneur	Lombardia	M
4	Agricultural entrepreneur	Friuli-Venezia Giulia	M
5	Agricultural entrepreneur	Lazio	F
6	Energy entrepreneur	Campania	M
7	Farmers' association representative	Campania	M
8	Energy entrepreneur	Abruzzo	M
9	Agricultural entrepreneur	Lombardia	M
10	Agricultural entrepreneur	Campania	M
11	Energy entrepreneur	Sicilia	M
12	Agricultural entrepreneur	Sicilia	M
13	Energy entrepreneur	Campania	M
14	Environmental activist	Campania	F
15	Legal expert	Lazio	M

Fig. 5. Data distribution and documented APV plants per region.
Note: News articles: distribution and sources coverage; Interviewees: employment, region of working activity and gender.

These tensions across the scientific-common sense continuum are explored in the following paragraphs and are exemplified by the chosen extracts.

6.1. Ambiguity

Ambiguity permeates news coverage. Occasionally, APV is conflated with ground-mounted photovoltaics systems as well; even when the term "agrivoltaics" is adopted, the technology it refers to is still understood as traditional photovoltaics. Indeed, quoting the voice of an influential farmers' associations, the press reports that "With the lie of solving energy problems and the illusion of agrivoltaics, [they] create new arguments to install photovoltaics" [Art.30] and "doubts are not lacking either regarding the very concept of agrivoltaics" [Art.1]. This ambiguity within the institutional paradigms of APV and its definitional uncertainty is frequently exploited within journalistic discourse, framing this technology as a potential hazard (overlapping with the risk theme, described below). Similarly, the adoption of APV is characterised by regional authorities as "hasty and illogical [...] in an area where there are more doubts than certainties" [Art.24].

This apprehension intensifies when projects take place in highly symbolic sites; for instance, talking about proximity of an APV system to an archaeological site, the press reports that "[institutional] objections may not be sufficient [to stop it]. In fact, Legislative Decree 199/2021 contains very general guidelines" [Art.17]. Interestingly, in the examined press, environmental groups contrast regional limitations through the evocation of ecological imperatives; a statement attributed to Legambiente Calabria, an environmental NGO, illustrates this conflict: "The idea that renewables are the solution to high energy bills and climate change is gaining ground at the national level, yet we are still experiencing great and inexplicable resistance at the regional level" [Art.39].

The pervasive theme of ambiguity surrounding APV is widely evident across interviews with experts as well, with an accent on procedural justice. As articulated by one agricultural entrepreneur: "In the Ministry's criteria, disastrously, […] even ground panels are called 'agrivoltaics', because they simply stand on the former 'agro'" [ID 9]. A particularly illuminating excerpt from an interview with an energy entrepreneur underscores this viewpoint:

"Three 'non-answers' […] explain why we do not see agrivoltaics diffusion. There is no official definition. There is no identification of an operational subject. There is, therefore, no vision of revenues associated with it. That is: what it is, who has to do it, and what's in it for them." [ID 6].

In other words, vagueness itself is perceived as a looming threat. Uncertainties are viewed as a direct consequence of hastiness, notwithstanding the acknowledged imperative for the diffusion of renewables. For instance, one entrepreneur affirms its fear of "not having time to do things right, to really present a well-thought project" [ID4].

Experts also delineate the disjunction between the regulatory frameworks intertwined by APV. Indeed, the struggle to reconcile energy and agriculture is epitomised by one interviewee through the analogy of an "oil company planting a field of tomatoes" [ID 6]. This disconnect has tangible repercussions on the daily operational practices necessitated by compliance with these divergent policies. This disparity is further compounded by the reluctance of small-scale agriculture entrepreneurs to adhere to industry standards and regulations, reflecting a broader systemic issue. Indeed, according to the experts interviewed, a new professional figure needs to be formed to overcome the (possible) injustices of the energy transition derived from this disconnection. Attempts to form such a figure, given the embryonic state of APV research, varies. An interviewee, for example, tells of training an agronomist for his own farm, so that "he will be ready when the time comes to manage the APV plant [...]. He will certainly take care of the agronomic part and, as far as his skills allow, also [...] the engineering maintenance of the plant" [ID4].

Finally, three interviewees [ID4, ID10, ID13] contrast ambiguity with the clear guidelines developed by the Campania region. Within these regional guidelines, the incorporation of advanced criteria for promoting APV is appreciated. The ability to elaborate these guidelines quickly is underscored, praising Campania's institutions for noticing early on "there was an […] invasion of farmland […] somehow trying to camouflage photovoltaics behind advanced agrivoltaics" [ID10].

6.2. Justice

One interesting result of the press analysis is the relevance given to "wounded territories", whose history is already characterised by energy project controversies. When there is a history of environmental conflicts, journalists underscore justice issues and attribute to the inhabitants the desire to preserve their territories from further harm: "After numerous controversies regarding the upcoming hydroelectric plant, now the agrivoltaics plant in Gracciano is under scrutiny [...]. Environmental sensitivity has always been a very delicate matter in Colle Val d'Elsa" [Art.21]. Or: "There's a limit to everything, and it is not certain that an already compromised territory can be continuously harmed. The reference is [...] to the ongoing expansion of the Carrara power plant, already a significant installation in itself." [Art.10]. Past energy projects thus serve as a negative reference point, shaping how the press present new projects.

Overall, newspaper articles are mainly concerned with transparency in infrastructure processes, and access to information from energy companies. Discontent is particularly directed at perceived land speculation, where lands are either overvalued or undervalued for energy investments, exacerbating tensions between agricultural and energy interests. For instance, the press reports that "just to carry out investments in energy companies, lands are paid for at 5-6 times their value" [Art.20], while "the construction of common connection cabins entails [...] the subtraction of land not through free market negotiations, but within procedures of public utility at lower economic values" [Art.34].

These examples all account for a democratic approach to energy decision-making processes; in the absence of a similar approach, the installation of APV is associated with speculation. This is also symptomatic of a fundamental distrust in institutions. The importance of engaging the community when proposing these projects is, therefore, underscored: "before depriving ourselves of a precious resource for 30 years, it would be worth conducting a careful analysis of the pros and cons and asking the citizens to express their views on how they would like the future of our country to be" [Art.23].

In experts' discourse, "wounded territories" emerge as an opportunity for presenting good practices. For instance, the "Terra del Sole" APV project ("Land of the Sun") is recalled by one expert as a chance to promote territorial redevelopment and quality agriculture despite the environmental challenges faced by the Campania region. Namely, the project takes place in Giugliano, a site affected since the 2000s by illegal dumps and fires for waste disposal:

> "Being surrounded by landfills, we put a sort of garrison, a symbol, for an area left to its own devices. If you go there, you find either rubbish on fire or garbage in the canals, and nomad camps as far as the eye can see. It is unmanned territory. But together we can enter a territory that has all these wounds and show that there is a new way." [ID 8]

Farmers and environmental activists endorsing the project especially aim to demonstrate the potential for sustainable reclamation of stigmatised territories; the importance of community engagement in transforming these areas for collective benefit is therefore emphasised:

"It's not a matter of doing photovoltaics where once you couldn't. […] Through agrivoltaics, one does not wonder whether it can or cannot be on a certain territory: one wonders how it can be on it. […] Changing the narrative of Giugliano from 'Land of Fires' to 'Land of Sun' is

something we can all agree is of the utmost importance" [ID 15].

Despite the prolonged timeline for project realisation, the absence of criticisms to the "Terra del Sole" project underscores the value of approaching stigmatised areas with an eye toward their potential, actively listening to the perspectives of local associations and entrepreneurs.

6.3. (Agronomic) risk

Insufficient data to guarantee the quality of crop yields in APV elicits concern both in news articles and in experts' discourse. For instance, one news article titles "Let's defend farmlands, the proposal on photovoltaics is premature and wrong" [Art.1]. In another case, the newspaper quotes a regional councillor contesting an APV project due to the "enormous and irreparable damage to agriculture" [Art.12]. Farmers' associations are given voice as well, expressing fear of losing control over their land and crops: "Underneath the panels, real, productive, and profitable agriculture must be carried out. We do not want to see expanses of installations where the 'agricultural component' is justified by productions that exist only on paper. Agrivoltaics must not make us lose even a hectare of real crops." [Art.27].

This apprehension is heightened in cases where crops hold certifications such as DOP (Protected Designation of Origin), IGP (Protected Geographical Indication), or STG (Traditional Speciality Guaranteed) marks. Illustratively, in the Piemonte region -where Italy's sole rice DOP is cultivated- both local institutions and farmers debated the siting of APV projects. Lack of assurances for the stability of rice crops led farmers to request the energy company a "guarantee that, over time, the agricultural function will be maintained" [Art.12]. Regional farmers organizations, like Coldiretti Veneto, are quoted in the local press for advancing their concerns on agronomic risks: "There isn't such an experience to know exactly what will happen. What is certain is that only some crops could be grown under the panels, and in any case, with a drastic reduction in productivity." [Art.2].

Insights from expert interviews further corroborate these concerns: "Farmers obviously want to know 'What crop do I put?' [...] 'Which one yields best?'" [ID5]. Moreover, they report landowners expressing a preference for spacious and elevated panels to accommodate agricultural machinery: "Landowners want these panels super spaced out and super high because they want to cultivate as much as possible. They say: the machines must pass." [ID 13]. However, fulfilling these requests is costly and time-consuming. One expert states it may be less environmentally friendly as well: "The higher you make the panels, the more complicated the anchoring will have to be, and in some way, it ends up disturbing the soil." [ID 9].

At the same time, experts perceive a growing environmental awareness among farmers and landowners. They express the importance of improving climate conditions by adopting novel technologies in agriculture. It emerges that in Northern Italy, this strategy may have been underway for several years. According to two interviewees, both from northern regions:

> "In the world of medium-sized transformation companies, I have seen roofs being transformed into photovoltaic systems for many years. Many of these companies do it. Some are more enlightened, some less [...], some have also understood that, probably, it would be useful in the future."
>
> [ID 3]

> "There is also a strong awareness that agriculture must participate in the decarbonization and ecological rebalancing of the environment. Consequently, there is a consciousness, now acquired by the more astute farmers, which leads them to believe that it is necessary to intervene in some way and contribute to improving climate conditions."
>
> [ID 4]

These extracts may indicate a growing readiness to embrace innovative solutions, which, at the time of this study, is evidenced by the majority of documented APV plants being concentrated in Northern Italy.

6.4. Land exploitation

The discourse surrounding APV underscores the nuanced interplay between land use and exploitation. We can trace this interplay back to the policy scenario, where the indication of suitable areas for PV diffusion by the State appears to be oriented at facilitating the governability of this transition:

> "Let's say that when we talk about suitable areas [...] these are areas that the State views favourably for photovoltaics, for example, near industrial zones, because they are areas where there is already a high level of pollution, [...] so installing a photovoltaic system wouldn't change things much."
>
> [ID 13]

However, according to the experts interviewed, brown spaces and rooftops may not be enough to achieve current energy targets, hence the need to move "on the ground" [ID 5, ID 10]. APV therefore appears as a "third way" for achieving both land preservation and land exploitation:

> "What are the right territories? So, the first idea is to say [...] contaminated sites [...]. The second area of interest could be the industrial areas, [...] which means photovoltaic sheds. The third, which is very available, is agricultural land [...]. However, if it is covered and therefore not used, we are essentially removing agricultural land. And therein lies the problem. Instead, agricultural land could be useful if we combine […] the energy project with the agricultural project". [ID 6]

The media portrayal of APV installations, on the other hand, emphasizes their perceived unsuitability due to their potential to alter or damage land, landscape and territories.[1] The press mostly represents APV as impacting the landscape. This can be seen in statements such as "Clean energy yes, but consideration must be given to local landscape treasures" [Art.17], underscoring concerns regarding aesthetic impacts. The press reports local activists' movements opposing APV for the same reasons: "We will have to give up a territory of cultivated fields, a view that with its wonderful colours is (or used to be) relaxing." [Art.31]

The importance of landscape is also remarked by farmers associations, cited by the press when claiming that this technology comes "with the risk of finding immense stretches of constructions that detract from the entire landscape, an element on which the tourist development of vast areas is also based" [Art.5]. Hence, aesthetical considerations are linked to economic impacts from which territories (and the social actors governing them) derive benefits; addressing these concerns, one article quotes a local politician stating that "a large-scale agrovoltaic plant at the entrance of a town that from tourism and the products of the 'truffle capital' derives part of its wealth is madness" [Art.36]. And so on: "Millions of euros are being invested to redevelop the internal areas, and agrivoltaics would nullify every effort made up to now" [Art.38]. We can see, then, how the perceived uniqueness of the landscape is explained in terms of ownership of the land and profitability of territories.

[1] "Land" can be viewed geographically or economically as a finite resource of soil, rocks, water, and vegetation, subject to private ownership [42]. This leads to competition among social actors for its acquisition, use, and trade. "Landscape" includes not only the physical features of land but also human perception and interaction with them through daily practices. It reflects cultural values, shaping community identity and views of the environment. Lastly, "territory" has a political aspect, signifying land claimed and governed by social actors. Together, land, landscape, and territory hold social importance due to their spatial and cultural meanings.

These dimensions appear to be more separated in experts' interviews. Indeed, on one hand, protests are explained as unfamiliarity with APV, thus providing an interpretation of this technology as an object not immediately fitting within the perceived landscape. Yet with habitual exposure installations should fade into the background, becoming normalised (culturally accepted) and less obtrusive: "Many times it's a matter of habit. If they are built in places where regulations allow it and therefore, so to speak, not in 'sensitive areas' from a landscape point of view - and appropriately mitigated - they will become normal." [ID 4]. Energy projects can then become part of a new landscape, despite initial protests:

> "Five years ago, a power line was built between a certain location in Friuli, where I live, and Udine. A long power line, I believe about [...] 55 and 65 metres high. The bell tower of my village is 65 metres high, and I said: 'Well, darn, it's a nice bell tower that can be seen from all over Friuli! So, the power line will be very noticeable.' [...]. I frankly tell you that now no one pays attention to that power line. [...]. It was built, we got used to it, we turned the page, we moved on."
>
> [ID 3]

On the other hand, the potential economic interactions cascading from APV diffusion are represented by experts as a win-win solution to land ownership conflicts, benefitting the territories who decide to adopt this technology. For instance, concerning tourism, one expert suggests that APV could foster it:

> "I can have a lemon grove, and therefore I can even take a walk in the lemon grove in the shade of the photovoltaic field, okay? So, it's evident that people start, indeed, to appreciate this thing because it almost drives a desire to take a stroll in a [agro-energetic] company, because I want to see how that works."
>
> [ID 9]

Another interviewee recalls how one of his clients, an Italian-American pasta producer, decided to invest in APV for two reasons: to gain an additional income from his land, and "to convey a message of integration between Italian quality and innovation, energy production, and the sale of food products overseas" [ID 2].

Overall, when experts and media questions APV's interactions with the land, the landscape and the territory, it appears that both those in favour and those opposed to this technology refers to the economic impacts which may derive from these alterations.

7. Discussion

This study explores APV's representations and acceptance in Italy. As Agir et al. [10] noted, most studies on APV's social acceptance focus on stakeholder perceptions in countries with established systems and legislation. Our study diverges by examining Italy, where APV is emerging and regulations are still forming. This allowed us to capture meaning-making processes in a context marked by evolving laws and competing narratives influencing social acceptance. We discussed these themes by organising them in dyadic opposition to show how both the press and experts rely on the same argumentative poles to discuss APV [Table 3]. Our results highlight that, coherently with Jovchelovitch [37], no evident juxtaposition separates experts and non-experts' SRs. Indeed, whether APV knowledge is acquired through specific roles in society, as for experts, or through journalistic interviews, as for news articles reporting protesters' concerns, still this knowledge must face unfamiliar territories, leading to the generation of the same SRs. Let us now turn to the exploration of each dimension and its associated representational processes. We define the emerged acceptance themes (ambiguity, justice, agronomic risk, and exploitation) as mediated by representational processes (anchoring, objectification, and cognitive polyphasia).

The discourse surrounding APV is rife with ambiguity, both in terms of regulation and definition, a problem also observed by Carrause [22] in France. One fundamental question arises: is APV *truly* innovative, or is it merely a repackaging of existing photovoltaics technology? Indeed, especially in the press, APV is often described as an extension of conventional solar energy systems. This perception is reinforced by the interchangeable use of the terms "agrivoltaics" and "photovoltaics". While this could be the consequence of a low degree of awareness between the public -forcing media to choose more recognizable, understandable words for their target audience- this process is not unidirectional; the interchangeability found within media discourse may account for local communities framing APV through the lens of past, negative, experiences with PV projects. Indeed, press representations anchor APV as a continuation of past land-use conflicts. A similar phenomenon was in the debate on Advanced Thermal Treatment in the UK, where the technology was criticised as "incineration in disguise" ([28], p. 215). In the case of APV, the dichotomy between 'true' and 'false' reflects a clash between national and regional necessities and concerns, such as fulfilling national energy goals while respecting regional concerns and duties about land preservation.

Inconsistencies between national and regional authorities, alongside conflicting priorities between energy and agriculture, produce uncertainty on all acceptance levels. This mirrors findings from social acceptance research on APV in the USA, where Moore et al. [3] identified contrasting epistemic paradigms influencing stakeholder conflicts. In Italy, the lack of clear definitions hinders APV's diffusion, making firms and small enterprises reluctant to navigate the agronomic risks inherent in its deployment. Conflicts between state-regional authorities and energy-agriculture stakes are seen as conflictual both by the media and emerging experts, and the flexibility of Ministerial guidelines, while seemingly adaptive, becomes a barrier leaving stakeholders without the confidence needed to proceed. Therefore, our findings support Wolsink's [17] argument that resistance to innovation, often framed as community or public opposition, frequently stems from entrenched institutional lock-ins. Strong institutional capacity is instead essential for resolving these ambiguities and fostering socio-political acceptance [16]. As the definition of suitable areas is both a statal and regional competence, the uncertainty surrounding APV is likely to persist, deterring both political and market acceptance.

Justice concerns further complicate APV's acceptability, as both experts and media frame the technology through the inclusion- exclusion dimension. Many experts view APV as an opportunity to regenerate "wounded territories", aligning with the need for equitable transitions. Yet in the press APV is seen as a burden imposed on already over-exploited areas, potentially exacerbating historical grievances related to RETs conflicts. This reveals how justice narratives are redefined in Italy, where local histories and present tensions surrounding existing RETs projects play a significant role in shaping community acceptance. Overall, results underscore the importance of participatory planning processes that address distributive and procedural justice, ensuring that local voices are valued.

Agronomic risk adds another layer of complexity to APV acceptance, particularly concerning the potential impact of this technology on certified crops like DOP and IGP. Farmers express apprehension about losing productivity and cultural integrity, as these crops are deeply tied to regional identities. Experts highlight the need for additional research to address these concerns and refine APV systems to better align with established agricultural practices. These barriers are shaped by fragmented regulations and a lack of coordination between agricultural and energy authorities, a problem not faced in the literature on APV acceptance. The definition of APV as a strategic solution for integrating solar projects with local interests, as proposed by experts interviewed in the U.S. [7], concerns a minority in Italy. Instead, the cognitive polyphasia surrounding the representation of APV as an agronomic risk, one that "enlightened" farmers [ID3] should run sooner than later, highlights that APV is seen by experts and media more as a "compromise"

between energy and agriculture than a win-win for both sectors. This may anchor market actors' expectations in terms of its complexity and uncertainty, leading to hesitation or a wait-and-see approach. As APV continues to be discussed and tested in the market, these initial representations will likely shape how future stakeholders perceive the technology's financial feasibility and risks.

The theme of exploitation highlights the existing tensions as it frames APV through the lens of land use. In this sense, media narratives depict APV as a commodification of land and landscapes, undermining its potential for sustainable development. In contrast, proponents of APV views it as a techno-fix that can increase land value by doubling or tripling it, thanks to the integration of energy production with agriculture and tourism. These SRs align as both media and experts represent APV through the land's economic value, effectively commodifying it. However, alternative representations of the land or landscape as a common good -held by concerned locals whose voice is sometimes reported in the press- are silenced. Indeed, regional stakeholders and agricultural companies discuss the land-use issue emphasizing its suitability for certain practices over others; while at the national level, APV guidelines treat land as a neutral space, even though the power to designate suitable areas for its diffusion is strongly contested between statal and regional authorities. Therefore, the potential for surpassing the issue of land scarcity (a critical factor in acceptance research) is reframed in terms of potential economic gains and losses derived from incompatible uses, while local communities discuss the landscape as a common good overall incompatible with any commodification. This highlights a disconnect between local, regional, and national interests, fostering locals' mistrust toward broader transition policies. To address this issue, governance structures that enable cooperation across scales, including mechanisms that empower local and regional stakeholders while aligning with national objectives for sustainable energy development, are needed.

Across these lines of disconnection (national-regional, energy-agriculture, and common-commodity) emerges a pressing need for a new type of "middle actor" capable of bridging these divides. Such a role demands both deep integration in the everyday life of local communities and the specialized expertise honed through years of study and practice. Local agronomists are well-positioned to fulfil this role. By engaging in dialogue with project designers, they can effectively translate national policy objectives into tangible, locally resonant solutions. Their expertise should enable them to interpret how APV systems can (or cannot) harmonize with existing agricultural practices, addressing agronomic risks such as the potential impact on regionally significant certified crops. This is significant as these crops are more than economic commodities: they are cultural symbols deeply embedded in regional identities. Acting as mediators between abstract policy frameworks and the lived realities of local stakeholders, agronomists can play a critical role in reducing resistance, fostering trust, and promoting the equitable implementation of APV. Furthermore, their involvement could foster local ownership and a greater sense of shared purpose in the transition to renewable energy.

"Sustainability" also emerges as a missing link across the four identified dimensions. Indeed, while the State focuses on promoting "advanced" and "innovative" APV systems (fitting criteria A, B, C, D, E from Table 2), some experts suggest that these criteria should also apply to "standard" APV to promote a sustainable deployment of this technology, as in the guidelines promoted by the Campania region. However, they fear that aiming for lower environmental impact may prolong project completion times. While this concern is valid, active stakeholder engagement and consideration of their perspectives during project development can lead to commendation for APV projects, as seen with the "Terra del Sole" project. In this context, the significance of expertise lies in defining how to achieve a more sustainable proliferation of APV. Therefore, the legislative framework must clarify what makes APV a more sustainable option than traditional PV. We propose that APV deployment could benefit from integrating justice standards within its guidelines. Promoting these standards may also help create a shared understanding of what APV entails, thereby reducing ambiguity.

Table 2
Summary of contextual background of APV in Italy.

Dimension	Criteria	APV in Italy
Sociopolitical	Strong institutional capacity	Heterogenous competence
	Political Commitment	National plan promoting APV
	Favourable laws and regulations	National and regional guidelines
Market	Competitive costs	Highly variable
	Informations and feedback	AIAS organizes outreach events
	Access to financing	Available, but slow bureaucracy
Community	Local ownership and use	Anecdotal observation of media and dissemination events
	Participatory project siting	
	Recognition of externalities or positive public image	

Note: dimensions derived from Wüstenhagen et al. [16], criteria derived from Sovacool & Ratan [17].

In conclusion, this study illustrates how representational processes shape the reception of emerging technologies like APV, particularly in contexts marked by ambiguity and socio-political tension. By integrating SRT with existing acceptance frameworks, it provides a nuanced understanding of the socio-cultural dynamics underpinning APV diffusion. Future research should build on these findings to explore how shifting representations influence acceptance over time and across diverse contexts, contributing to more inclusive and sustainable energy transitions.

8. Conclusions

Renewable energy transitions represent a social change process as much as a technological one. In this scenario, the coexistence of conflicting representations plays a crucial role in shaping public acceptance of RETs [26]. In this paper, we explored how different communication and knowledge arenas, one more reified (experts) and one more consensual (the press), interact through blurred boundaries in the representation of an emergent technology shaped by regulatory ambiguity.

Our exploratory focus on local media covering APV protests and expert interviews has revealed how APV's acceptance is influenced by representational processes. Interestingly, these representations stand on the same ground whether one support or oppose the RET under study. However, SRs are naturally dynamic. We can expect the identified meaning-making processes to be transformed as the regulatory surrounding APV landscape becomes clearer.

Indeed, comparing the current situation in Italy to our findings reveals a significant escalation in the intensity of the debate surrounding APV. In May 2024, a political conflict emerged at the national level, involving the Minister of Agriculture and the Minister of Environment. The former, aligning with concerns raised by one of the largest farmers' association in Italy (Coldiretti), issued a prohibition on the installation of any photovoltaics project in agricultural areas. He justified this ban by claiming it would curb the "wild" proliferation of ground-mounted installations. However, this decision was met with strong opposition from energy associations, who argued that photovoltaics installations currently occupy only about 0.1 % of agricultural land. Following mediation with the Minister of Environment, it was later clarified that the installation of APV systems would be permitted, and specific operational guidelines for such projects were provided. We can take this conflict as an example of conflicting understanding of what APV is, illustrating different desired pathways for solar diffusion. Moreover, while APV guidelines have now been operationalized into law, tensions between regional and national authorities persist; for instance, the Sardinia region recently challenged a positive EIA for an APV project proposed near an archaeological site. Therefore, despite being exploratory in nature, this study may provide a benchmark for examining to which extent the same SRs will be shared across multiple levels and in situated contexts, with significant implications for the future

Table 3
Themes and illustrative examples found within media and experts' discourse on APV.

Theme	Examples within media	Examples within experts	Dyadic opposition	Detailed theme	Representational process
Ambiguity	"Whether it is the new APV or the old PV, it makes little difference." [Art.9]	"Through APV, one does not wonder whether it can or cannot be on a certain territory: one wonders how it can be on it." [ID 15]	True-False	APV is not universally perceived as a sustainable option due to regulatory conflicts (Statal-regional, energy-agriculture). Instead, it is viewed either as disguised PV or as a win-win solution.	Detractors of APV objectify it as ground-mounted PV, while supporters focus on its distinct technological features to highlight its innovative nature.
Justice	"A healthy and productive community cannot be trampled on by agencies responsible for issuing opinions and permits without involving citizens" [Art.36]	"They had contacts with companies that [...] would tell them 'We will put the panels at a certain height'. Then at the end […] they go and see, and they would put these panels on the ground. So, in that sense, […] you try to deceive the owner" [ID 13]	Inclusion-Exclusion	The press frames APV as a burden in regions that have faced controversial energy projects. However, within broader environmental concerns, APV is repositioned as a tool for stakeholder-driven justice.	Past wounds suffered by the territory serve as a cognitive anchor: detractors of APV frame it as another burden, while supporters view it as an opportunity for territorial regeneration.
(Agronomic) Risk	"A real assault that could lead to the loss of >9000 quintals of corn kernels and 5000 quintals of wheat and hay" [Art.20]	"Yet, many owners say they don't care, because the important thing is the passage of farm machinery on previous or new crops" [ID 13]	Repetition-Innovation	APV challenges the continuity of farmers' practices, with energy companies risking agriculture's symbolic value by prioritizing solar over agronomic production.	Supporters present APV as an objectification of modern, sustainable agriculture. However, they acknowledge the need for further research to preserve established farming practices, showing cognitive polyphasia.
Exploitation	"[APV] would disfigure our landscape and would inevitably have repercussions on tourism, thus on the economic fabric of the area" [Art.5]	"We need to go ahead with rooftop deployment. But to cover our renewable targets, we have to go into the territories as well." [ID 10]	Common - Commodity	APV diffusion raises concerns about land exploitation. Both supporters and opponents agree on the importance of land preservation, yet leisure, energy, and agronomic activities frame land as a commodified resource. Protesters, however, view land (scape) as a common good to protect from solar expansion.	APV is represented according to different representational projects who share a preference for land exploitation. This silence alternative representations based on the land as a common good.

development of APV. Future research should build on this approach to explore how shifting representations consequently impact the social acceptance of this technology.

Despite these insights, our study has limitations. The methodology may have overlooked positive reactions to APV, and the over-representation of entrepreneurs in our sample could skew perspectives. Future research should include a broader range of stakeholders to provide a more comprehensive view. Future studies should also replicate this analysis in other countries and across levels, to identify shared themes and specific understanding in different national, regional or even narrow contexts. Additionally, the prominence of justice themes, where detractors frame APV as an additional burden and supporters as a chance for regeneration, suggests a need for further research into how energy justice and APV interact. The proposed justice continuum (Inclusion-Exclusion), as well for the continuums characterising the other themes, can be explored building appropriate scales. According to our study, when presented with these scales, experts and non-experts alike will position themselves drawing on conflicting SRs of APV. For example, one can understand APV to be innovative and necessary, yet exclusionary in its diffusion. In essence, the concept of sustainability serves as a unifying framework that ties together these dimensions. Achieving sustainability in APV development requires clarity in defining the technology, promoting energy justice principles, mitigating agronomic risks, and balancing economic development with environmental conservation. By addressing these dimensions holistically, policymakers, industry stakeholders, and local communities can work toward a more just and equitable deployment of APV technology in Italy and beyond.

CRediT authorship contribution statement

Mirella de Falco: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mauro Sarrica:** Writing – original draft, Supervision. **Alessandra Scognamiglio:** Writing – original draft, Supervision. **Roberto Fasanelli:** Writing – original draft, Supervision.

Funding

De Falco, M., Joint International Doctorate in Social Representations, Culture and Communication. Research conducted under the European Union-funded project Next Generation EU, Mission 4 Component 1 CUP B53C23002530006.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors gratefully acknowledge the support and collaboration that facilitated the development of this article. This work has been re-adapted from ENEA Master's Thesis No. 3290, in partnership with the University of Naples Federico II. Special appreciation is extended to the Italian Association for Sustainable Agrivoltaics (AIAS), whose invaluable assistance enabled access to a network of experts, several of whom were engaged for interviews.

Data availability

The authors do not have permission to share data.

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