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# Cutting down externalities of renewable energies: the matrix of dominant logics

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## Abstract

**Objective:** This work analyses the structure of the photovoltaic market, and the way the different development models and actors contribute in diverse forms to the creation of social value.

**Methodology:** A theoretical review of the regulations applicable to the photovoltaic industry sector is conducted, encompassing an examination of externalities and the presentation of findings.

**Results:** The study presents an analysis organised into four quadrants of a matrix with two main axes: the reduction of the carbon footprint (X) and the varied interests of the actors involved, namely saving or investing (Y). These quadrants represent a visual tool that allows understanding the different combinations of approaches towards carbon footprint reduction and the economic motivations of key actors in the photovoltaic industry.

**Practical implications:** The insights into the roles of various actors in the photovoltaic industry have important practical implications, offering a broader view of models that address social and environmental concerns beyond carbon reduction. This can guide public administrations in shaping policies for sustainable development and help investors choose projects that deliver both financial returns and social value.

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**Limitations:** The research relies on a theoretical review of regulations and externalities in the photovoltaic industry. While this approach highlights various social and environmental objectives, the lack of empirical data limits the direct assessment of the actual impact of development models and stakeholders on the creation of social value.

**Keywords:** photovoltaic industry; development models; carbon footprint; matrix of dominant logics; sustainability

**JEL Codes:** G32; M11; Q51

## 1. Introduction

The climate crisis and resource scarcity are critical issues facing society today. The interconnectedness of these two problems has resulted in serious negative consequences for people's lives and for the future of our planet. Efforts to address these problems require appropriate natural resource conservation and management measures. On the other hand, the scarcity of natural resources such as water, fossil fuels and minerals is also a critical issue. In this regard, the scarcity of fossil fuels is not only an environmental problem but also an economic one. Dependence on fossil fuels as a source of energy has led to an increase in greenhouse gas emissions, which further aggravates the climate crisis. Moreover, the exploitation of fossil fuels can have serious environmental consequences, such as air, water and soil pollution (Bouckaert et al., 2021).

In addition, climate crises and resource scarcity can increase the levels of economic and social inequality. The poorest and most vulnerable are often the hardest hit by these crises, while the richest have more resources for coping with the consequences of such crises. Poverty, social exclusion and lack of access to basic resources, such as water and energy, can make people more vulnerable to the effects of climate change and resource scarcity (Masson-Delmotte et al., 2018).

In this context, a legal framework has been developed, at both international and national legislative levels, aimed at promoting renewable energies. In the face of this promotion, the literature that analyses the advantages of renewable energy is abundant, but there is no literature that examines the possible externalities of renewable energies.

This study delves into the exploration and analysis of externalities associated with photovoltaic energy, a prominent and extensively promoted renewable energy source in contemporary discourse. Following this, the study proceeds to discuss the principal photovoltaic development models, delineating the roles played by key actors in their installation and utilisation. This examination is crucial for understanding the dynamics underpinning the deployment of photovoltaic energy and its implications for sustainable development, a key concept nowadays linked to smart cities, metaverse or industry 4.0 (Ramírez-Herrero et al., 2023). The culmination of these endeavours is the presentation of results in the subsequent section. Here, a matrix is provided to elucidate the contribution of each development model, juxtaposing their investments and carbon footprints. This analytical framework offers valuable insights into the comparative efficacy of different photovoltaic development approaches, thereby addressing a significant research gap in the literature. Lastly, the conclusions drawn from the findings underscore the potential of this study to inform the formulation of photovoltaic development models. These models not only contribute to climate change mitigation efforts but also promise to enhance a very important value in society nowadays, the social one. By bridging this research gap and offering actionable insights, this study contributes to advancing the discourse on sustainable energy transition strategies (Sheikh et al., 2016).

## 2. Theoretical framework

### 2.1. Energy actions for reducing the climate crisis

Amidst this urgent need to change the energy model, the institutional framework legitimates and reinforces a necessary change (Schin et al., 2023). Then, a broad legal framework has been developed to promote and regulate the ecological transition (Zuazua Ruiz et al., 2023). At the European level, a wide Acquis Communautaire has been developed (Directive 2006/32, Directive 2009/28, Directive 2012/27, Directive 2018/2001 and Directive 2019/944).

The so-called citizen energy communities have been conceived specifically as a response to the situation described above, enabling a form of citizen participation through which participants can have all their rights and freedoms as active consumers of electricity satisfied, their access to the network under conditions of non-discrimination ensured, and the participation in the electricity markets guaranteed by managing the generation assets they may have associated. Therefore, both at the European level and solely in Spain, various measures have been implemented to promote the use of photovoltaic energy and other renewable energy sources. These measures have been established in laws and directives that seek to reduce the dependence on fossil fuels and lower greenhouse gas emissions to address the challenges of climate change.

### 2.2. Externalities of photovoltaic energy

Although the implementation of these renewable energy technologies is key to reducing our carbon footprint, the possible externalities derived from their development must also be considered, since adverse impacts can diminish the expected benefits or even threaten the viability of a promising technology (Sheikh et al., 2016).

A study carried out by Yavari et al. (2022) found that solar farms, which often occupy hundreds of hectares of either natural environments or former agricultural areas, can have negative effects on natural hydrological processes, including the generation of runoff and the erosion of the local environment. Other authors, such as Maddison et al. (2022), have warned of the impact of the development of photovoltaic solar parks on the market prices of homes in their areas. Their results indicated that properties located less than 750 m away from a solar farm of more than 5 MW suffered a devaluation of 5.4 percent compared to the average relative prices. Furthermore, Roddis et al. (2018) analysed the degree of rejection of large photovoltaic projects by local communities due to the aesthetic deterioration of the local landscape, the deprivation of former public spaces and the non-sharing of the monetary and energy gains of the project. Aman et al. (2015) analysed the various benefits and risks, including health risks, derived from the use of toxic components in photovoltaic panels, such as ammonia and cadmium, and their danger of leaking into the immediate substrate through rain.

Another problem stemming from the purely capitalist approach comes from the potential exclusion of the poorest populations. In the capitalist system, there is a risk that populations with fewer economic resources may become marginalised by these advances due to the high initial costs required for the adoption of such technologies, including the cost of solar panels (Bartiaux et al., 2019; Bouzarovski & Tirado Herrero, 2017; O'Shaughnessy et al., 2021). As a result, existing inequalities are perpetuated, which further hinders access to a clean and affordable energy source.

Another issue related to economic exclusion arises from disparities in housing types between individuals with the lowest and highest incomes, and unequal access to rooftops for installing solar panels.

In conclusion, although the implementation of renewable energy technologies is necessary to reduce the carbon footprint, it is important to take into account the negative impacts that such technologies can have on the environment, human health, local communities and economic inequalities. Given the externalities presented by the implementation of photovoltaic energy, it is necessary to analyse the different models of photovoltaic development with special emphasis placed on the model offered by the social economy, i.e. energy communities.

Therefore, this study analyses the separate contribution of the photovoltaic development models and how each of them can help, or not, in the reduction of externalities. Based on the main groups involved in the installation of photovoltaic panels or stakeholders, this paper analyses the development models that are specified in the following section.

## 3. Photovoltaic development models

Over time, as the photovoltaic industry has matured as a market, differentiated business models have emerged based on installed kilowatts of power, varying size, installation location, technical and administrative complexity, involved agents and required monetary investment. In practice, these photovoltaic development models have traditionally been grouped into three categories: EPCs, rooftops and residential

(International Energy Agency, 2020). Additionally, in recent times, a new differentiated category has emerged through energy communities (Walker & Devine-Wright, 2008).

### 3.1. EPCs

Solar parks are developed in the photovoltaic (PV) sector through engineering, procurement and construction (EPC) contracts. In the PV field, such contracts are comprehensive agreements that appeal to a wide variety of players and clients, given their turnkey nature and the efficiencies they provide. The main executors of EPC contracts in the PV field are generally specialised engineering and construction companies with experience in the development of power projects. Often, these companies have extensive engineering and technical expertise, as well as experience in project management and equipment procurement. In addition, they often have established relationships with equipment and service suppliers, which can help ensure the quality and timely delivery of required components (Mittal & Gorowara, 2020).

PV EPC contracts can attract a wide range of direct customers, although most of these customers are not end-consumers, but rather institutional customers, such as investment funds or public administrations, which can, in turn, act either alone or in collaboration with each other (Kumar, 2022).

Due to the high capital requirements, large investment funds and banks provide the necessary financing for EPC contracts in the PV sector. These projects often require significant upfront investment to cover the costs of design, equipment procurement and construction. Investors and banks provide this financing in exchange for a stake in the project or for interest payments over time (Wüstenhagen & Menichetti, 2012).

Solar farm development often includes provisions that transfer a significant portion of the project risk (such as the risk of delays or cost overruns) to the EPC contractor. This can make such EPC contracts attractive to investors and banks, as it reduces their exposure to risk. However, it also means that they must perform rigorous due diligence to ensure that the EPC contractor is capable and reliable (Mittal & Gorowara, 2020).

EPC projects for large photovoltaic plants are usually located in regions with high solar radiation and better land availability. These projects can vary significantly in terms of size and power output. Large-scale PV plants are often located in rural or semirural areas, where land is cheaper and more available. This can include deserts, semidesert regions or agricultural areas. Ideally, these locations have access to electricity transmission lines to facilitate power delivery to the grid (Kumar, 2022). These projects can vary greatly in size, power and required investment.

The impact on local ecosystems and biodiversity must also be considered. Large solar parks, which are mostly promoted through investment funds, require large areas of land, which can alter ecosystems and affect local flora and fauna. Implementing mitigation measures to minimise these impacts and ensure a harmonious coexistence between solar energy generation and environmental conservation is therefore essential (Vrînceanu et al., 2019; Yavari et al., 2022).

The participation of the community in the development of large-scale solar projects is also relevant. Lack of participation and consultation with local communities can generate conflicts and resistance to these types of projects. Therefore, one way to facilitate the acceptance of these projects is to involve communities from the initial planning stages and provide them with the opportunity to participate in decision-making and benefit-sharing (Roddis et al., 2018).

All these drawbacks have led to growing unease, especially among local communities in proximity to such projects and in the productive rural sector. In 2022, the relevant administrative procedures were granted for the development of 182 solar parks in Spain, which is equivalent to a total area of 53,000 hectares, most of them located in rural environments that have been affected by depopulation (Euronews, 2023).

### 3.2. Roofs

The rooftop solar panel installation model enables the efficient use of existing physical space that would otherwise be wasted. In urban or industrial areas where space is limited, this advantage becomes even more relevant.

Photovoltaic installations on the roofs of industrial buildings and the roofs of community buildings and shared structures, such as sports centres, swimming pools, schools, hospitals and other public or private buildings with large roof areas, represent a valuable contribution to distributed renewable energy generation. Transforming these areas into energy producers can help mitigate the pressure on rural areas and protect natural spaces (Wiginton et al., 2010).

Although these projects can vary in size and capacity, some generalities can be found. These facilities are typically located in densely populated urban or suburban areas, where land is more expensive and limited. Buildings with large flat roof areas or moderate slopes, such as school buildings, hospitals and commercial and residential buildings, are particularly suitable for this type of installation.

Proximity to the power grid and the orientation and angulation of the roof towards the sun are also key factors. Additionally, the size of these installations can vary considerably, but they tend to be smaller than large-scale solar plants. The size of the installation is limited by the available roof area as well as by aesthetic, structural and regulatory considerations. Depending on the roof area and the efficiency of the solar modules used, a typical installation could occupy anywhere from a few tens to several thousand square meters. This, in turn, leads to the power output of these installations varying significantly. Such output is usually measured in kilowatts (kW) rather than megawatts (MW). For example, an installation in a commercial building can have a capacity of 10 kW to 100 kW, although larger installations are also available. The final output depends on factors such as the roof area, the efficiency of the solar modules, the amount of sunlight available and the losses in the system. In addition, consideration needs to be given to the correct orientation and tilt of the panels for maximising sunlight collection, avoiding shading that reduces the efficiency of the panels, and ensuring that the building structure can support the additional weight of the panels (Mansouri Kouhestani et al., 2019).

The main promoters of photovoltaic installations on roofs vary according to the context, but in general they are institutional agents such as small and medium-sized enterprises (SME), social economy entities and public administrations that invest in photovoltaic solar energy systems as a way of reducing their energy costs and carbon footprint by taking advantage of the free spaces on roofs and rooftops where they are located (Burger & Luke, 2017).

### 3.3. Residential

Photovoltaic installations on single-family homes are a small-scale renewable energy generation modality that is gaining ground, both at the individual and community level, due to its multiple benefits. Photovoltaic installations on single-family homes are typically located on the roofs of houses. The design and orientation of the solar panels play a critical role in the efficiency of the installation. Ideally, solar panels should be installed on the part of the roof that receives the most solar radiation throughout the year. Often, this indicates a southern orientation in the northern hemisphere, although the specific geographic location and the presence of shadows should also be considered (Wiginton et al., 2010).

These types of residential PV installations are typically smaller in size than large-scale solar plants or rooftop installations on industrial or commercial buildings. Depending on the available roof space and the household's energy consumption, a typical installation can range from 3 to 10 kW. However, some homes can accommodate larger systems if they have large roofs and high energy demand (Mansouri Kouhestani et al., 2019).

The energy generated by residential solar installations can help reduce dependence on the grid and, therefore, lower electricity bills. In some jurisdictions, although not in Spain, owners of PV installations can even sell their surplus energy to the grid, earning an economic benefit. Over the long term, these savings and benefits can offset the initial investment needed to install the system (Martins, 2017).

By generating their own energy, single-family homeowners become active participants in the energy transition. This can generate a sense of autonomy and responsibility and can encourage other members of the community to follow suit. In addition, residential PV installations can help raise awareness of the importance of sustainability and environmental protection (Van Der Schoor & Scholtens, 2015).

In the residential model, the primary agent is the citizen who owns a single-family home. The decisions made by such agents can be influenced by a variety of factors, including reduced energy costs, a desire for energy independence and an interest in contributing to climate change mitigation (Bohnsack et al., 2016).

In most countries, electricity companies are obliged to buy the surplus energy produced by residential photovoltaic systems and send it to the grid, a practice known as 'net metering', to balance what is discharged to the grid minus what is produced and, based on this, generate a bill to the consumer that is reduced by the variable part (Comello & Reichelstein, 2017).

In some cases, the utilities themselves may also offer financing programmes or incentives for the installation of photovoltaic systems (Iberdrola, 2023). Similarly, banks and financial institutions can offer loans or specific financial products, such as renting or leasing, for the installation of photovoltaic systems, thus facilitating the financing of these projects for homeowners (BBVA, 2023).

In addition to technical/administrative regulations, the public administration plays a fundamental role in the promotion of solar energy via economic incentive policies (Schin et al., 2023). At the Valencian Regional Government level, for the 2022-2023 cycle, there were subsidies in force with the objective of financing investments under Incentive Programme 4. This programme specifically promotes the adoption of self-consumption systems using renewable energies in residential areas, public institutions and the third sector.

### 3.4. Energy communities

In this section, we review some examples of initiatives advanced by social economy entities in the photovoltaic sector. Energy communities are groups that can be formed by citizens, cooperatives, SMEs and public administrations that work together to develop energy projects. Energy communities are a photovoltaic development model characterised by public–private collaboration and the promotion of citizen participation (Vañó-Vañó, 2020). This model is focused on the generation and distribution of renewable energy at the local level, with the objective of reducing energy dependence on large companies and promoting community energy autonomy (González Pons, 2022, 2023; González Pons & Grau López, 2021).

In this model, citizens, cooperatives and SMEs can participate in the production and distribution of renewable energy and promote the integration of citizens in the energy transition process. In addition, energy management is conducted in a collaborative and democratic manner, allowing for greater efficiency and transparency in the management of resources (Menéndez Sánchez & Fernández Gómez, 2022).

A renewable energy community is a decentralised energy structure in which the interests of the group are prioritised over the particular interests of individuals, but which is generally united by a common geographic location and a shared collective interest. Uniting and coordinating this type of decentralised community requires active and extensive management by its members (Walker & Devine-Wright, 2008). Renewable energy sources, such as solar energy, are intermittent and their production can vary significantly from day to day or even from hour to hour. This means that energy production needs to be constantly monitored to ensure that a sufficient amount of energy is being generated to meet the needs of the community. It is also important to manage and maintain the energy production facilities to ensure their efficiency and longevity. On the other hand, the energy produced must be distributed efficiently among community members. This may involve managing a local microgrid to which the community is connected, balancing its load and demand, and overseeing its interactions with the broader electrical grid. Given the intermittent nature of renewable energy sources, it may be necessary to store excess energy produced during periods of high production for use during periods of low production. This involves the management of energy storage facilities, such as batteries. Additionally, active management involves managing the financial aspects of the renewable energy community. This may include managing maintenance costs, determining energy rates for community members and negotiating energy sales contracts with third-party suppliers. Likewise, it is necessary to ensure that the community is complying with all relevant local, state and national regulations, including those related to energy production and distribution, safety and the environment. Finally, active management also involves maintaining positive relationships with community members and other stakeholders, providing education and awareness in regard to renewable energy, and encouraging community participation and collaboration (Menéndez Sánchez & Fernández Gómez, 2022).

An example of an energy community is Som BiniSolar, which is a project of the cooperative Som Serveis Energetics S. Coop., which is itself a cooperative of consumers and users. The cooperative has 167 individual members/family units from the town of Binisalem (Mallorca), which has a population of 6,700 inhabitants. The corporate purpose of the cooperative is to actively provide its members with the marketing, distribution and production of electricity from renewable sources. To this end, the Som BiniSolar energy community project consists of the installation of 126 photovoltaic modules of 400 W on the roof of an industrial warehouse, providing an estimated power of 50 kW. This allows partners to pay for electricity at cost price, enables consumers to enjoy protection from market fluctuations and empowers citizens to make decisions about electricity production. There are three types of participation available: as a user member, one can guarantee renewable energy at cost price for 1 year in advance (from 86 euros); as a prosumer member, one can install a minimum of 1 panel (from 1,052.03 euros); and as a member, one can contribute to voluntary social capital (return 3 %) (Som Serveis Energètics S. Coop., 2023).

One of the most ambitious energy communities in Spain, for example, is COMPTEM (Comunitat per a la Transitió Energètica Municipal). This project is another case of close public-private collaboration in which a social economy entity leads the development. It is promoted by the Crevillent electric cooperative (Enercoop group), with the participation of the Crevillent City Council, the Generalitat Valenciana and the Institute for the Diversification and Saving of Energy (IDAE). This project also serves as an example to energy communities of how the photovoltaic development mix (residential, roofs and EPCs) can be combined for a single purpose. To achieve this, the objective is to reach an installed power of 5,000 kW through a mix of residential in private homes and roofs in municipal spaces (1,600 kW) and small solar parks in the surrounding areas (3,400 kW). In the urban environment, the city council provides the roof areas of 21 municipal public spaces (15,000 $m^2$ of surface) (Enercoop, 2023).

## 4. Results

Upon characterising the participating agents and development models, this study delves into the primary findings concerning the following inquiries. Firstly, it scrutinises the principal actors in the photovoltaic industry, with a particular emphasis on delineating their distinctive logics. This entails the identification and delineation of the diverse motivations, strategies and objectives pursued by these actors within the sector. Of particular interest in this examination is the role played by social economy entities. This segment of the market, which amalgamates economic and social objectives, assumes a unique position within the photovoltaic industry. The inquiry is aimed at situating these entities in the global context and comprehending their interactions with other market stakeholders.

Secondly, the study elaborates on the four primary photovoltaic development models, namely EPCs, industrial rooftop installations, residential installations and energy communities. These models are analysed in relation to the principles and objectives of the social economy, elucidating how they align with these principles and how various actors employ specific combinations of these models in their operations.

The third objective entails assessing the organisational, technical and commercial intricacies of each of these models. This examination focuses on factors such as the requisite organisational framework, technical prerequisites, business impediments, associated expenses and profitability of each model. Such an approach facilitates a comprehensive understanding of the merits and drawbacks of each model and also offers insights into the impediments and opportunities within the photovoltaic sector.

Finally, the study seeks to ascertain the social value associated with mitigating carbon emissions and the additional social value attributed to elements beyond carbon reduction for each of the development models.

### 4.1. Matrix of dominant logics

Once the agents participating in the solar industry have been reviewed, we examine how their behaviours are articulated and social benefits are derived in pursuit of the general interest. In a broad sense, a social impact can be understood as 'the consequences on human populations of any public or private action that alters the way people live, work, play, relate to each other, organise themselves to meet their own needs, and generally function as members of society. The term also includes the cultural impacts and transformations involving changes in the norms, values and beliefs that guide and rationalise their knowledge of themselves and their society (Burdge et al., 2003).

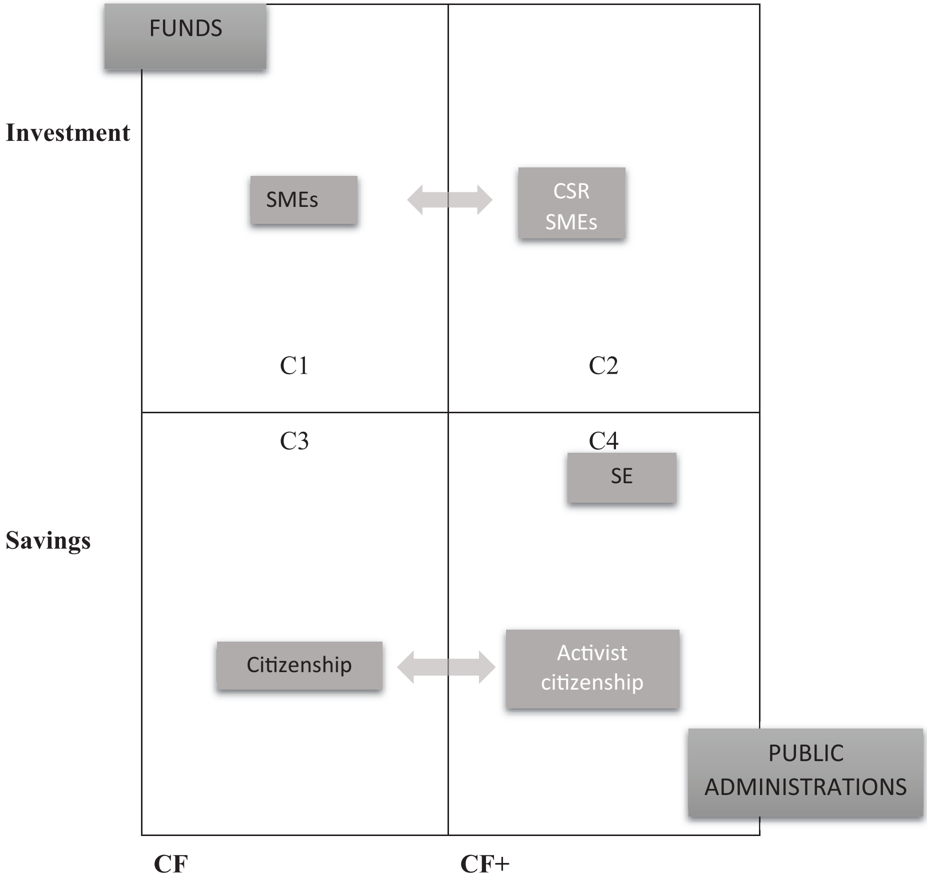
The reduction in the carbon footprint (CF) is an indicator used to measure the amount of greenhouse gases emitted during the production and consumption of goods and services. However, as has been seen, there are other aspects beyond CF that are also important for sustainable photovoltaic development (see Figure 1). The approach developed by the social economy (SE) and the public administrations is aimed at integrating these other elements (CF+): the protection and conservation of the physical, landscape and environmental surroundings, the fight against poverty and for energy autonomy, the dynamization of the industrial fabric and legal compliance and the level of consonance with the public agenda. The different agents can follow a CF or CF+ logic, which is reflected in the photovoltaic development models they implement. At the same time, we can differentiate between agents on the ordinate axis because, when developing the installation, the interest in electricity savings predominates or, on the contrary, it is conducted due to an investment interest in obtaining economic profits. On the x-axis, we can differentiate between the agents that only provide the social value of CF and those agents that additionally provide CF+, such as local development or community acceptance. Thus, the following matrix is used to characterise industry agents from those among the spectrum of the social economy that is focused on the general interest.

The regulatory framework does not allow small producers to obtain economic returns from the excess watts discharged into the electrical grid. Therefore, the underlying economic interest of citizens is only addressed by this agent in terms of electricity bill savings. On the other hand, there has been a greater environmental and social awareness that has motivated a significant part of society to assume an activist role and consider CF+ elements such as popular empowerment, environmental integration and local development. This serves to position citizens in the dominant logic matrix between quadrants C3 and C4.

Meanwhile, SMEs, like citizens, cannot obtain direct economic returns through the discharge of electricity back to the grid, but they do so by exercising an economic activity under the capitalist logic that seeks to reduce costs to maximise profits; this results in the investment additionally providing the social value of reducing the carbon footprint, placing these SMEs in quadrant C1. There is also a growing number of SMEs that, under the umbrella of corporate social responsibility (CSR) and the sustainable development objectives of the 2030 agenda (Zuazua Ruiz et al., 2023), are incorporating additional elements such as participation in local development projects and making efforts to minimise the environmental impact of their facilities. These SMEs are located in quadrant C2.

Likewise, public administrations, in economic terms, are motivated by savings and management efficiency and not by the logic of profit due to their public nature. Furthermore, from the acquis of community directives, CF+ models are being

**Figure 1.** Dominant logic matrix




Source: Own elaboration.

promoted which, in addition to reducing the carbon footprint, aim to provide environmental, economic or social benefits to the local community. Therefore, taking these aspects into account, such public administrations are placed in quadrant C4.

For their part, social economy entities do not promote the development of photovoltaic energy as an investment strategy to obtain economic returns, but rather focus on monetary savings for members of consumer cooperatives and energy communities. Furthermore, like public administrations, they not only seek to reduce the carbon footprint but also account for elements such as a fair ecological transition that does not leave the poorest behind, the participation of the local community, the empowerment of the consumer, the promotion of a democratic culture and the ensuring of consistency with the public agenda. All this places the social economy entities in quadrant C4.

### 4.2. Mix of models

Next, we systematise the ways in which each agent uses a specific model mix.

The residential model where the photovoltaic installation is located on the roofs of single-family homes constitutes a modality of small-scale renewable energy generation (3 and 10 kW). The design and orientation of solar panels play a crucial role in the efficiency of such installations. Ideally, solar panels should be installed on a part of the roof that receives the most solar radiation throughout the year. This development model is especially oriented towards citizens with access to their own roofs and a sufficient level of income to carry out this type of project. In addition, energy communities and consumer cooperatives also make use of this model, often in combination with other development modalities such as roofs.

The model of installing solar panels on roofs allows companies to generate their own electricity, especially in industrial estate environments where industrial warehouses are available. The facilities have average capacities of 10 kW to 100 kW, although larger facilities are also available. Furthermore, the use of the roofs of industrial warehouses and companies for the installation of solar panels represents an efficient use of space that would otherwise be wasted. In urban or industrial areas where space is limited and where shared structures such as sports centres, swimming pools, schools, hospitals and other public buildings can be used, this advantage is even more relevant. Thus, the agents that use this model are SMEs, social economy entities and public administrations.

Regarding the EPC model for developing solar parks, these projects can vary greatly in terms of size, power and required investment (from 100 kW onwards). While it is typical for investment funds to take a more aggressive approach in promoting solar parks, their aim is to maximise size to leverage economies of scale and achieve greater financial performance. While administrations and especially social economy entities also make use of the EPC model, they promote more measured and coordinated projects with the local community as well, which gives rise to smaller solar parks.

The final model under consideration is that of energy communities, which can bring together a great diversity of agents such as citizens, cooperatives, companies and public institutions to develop energy projects (see Table 1). An energy community is a model of photovoltaic development characterised by public-private collaboration and the promotion of citizen participation. This model focuses on the generation and distribution of renewable energy at the local level and aims at reducing the energy dependence on large companies and promoting the energy autonomy of the community. In this model, citizens, cooperatives and SMEs can participate in the production and distribution of renewable energy, promoting the integration of citizens in the energy transition process. Furthermore, energy management is conducted in a collaborative and democratic manner, thus allowing for greater efficiency and transparency in resource management.

Thus, we have those traditional agents (citizen/residential, SMEs/covers and investment funds/EPCs) opt for a specific model of photovoltaic development, which is the

**Table 1.** Model mix according to agent

| | Money investment | Citizenship | SMEs | Social economy | Public administration |
|---|---|---|---|---|---|
| **EPCs** | V | X | X | V | V |
| **Industrial roofs** | X | X | V | V | V |
| **Residential** | X | V | X | V | V |
| **Energy communities** | X | X | X | V | V |
| V: complies; X: does not comply | | | | | |

Source: Own elaboration.

simplest and most direct solution. Public administrations, especially social economy entities, are sources of organisational innovation and promote the use of solutions that combine a mix of development models to satisfy the interests of the partners.

### 4.3. Social value

In the global energy landscape, the development of photovoltaic energy is emerging as a valuable strategy in the fight against climate change, as all the relevant development models are aimed at reducing the carbon footprint, a goal aligned with the interests of global society. Even so, this positive environmental impact, although a common factor, is not the only aspect that deserves attention. There are other tangible social benefits, referred to here as CF+, which vary depending on the photovoltaic development model in question.

Large-scale solar parks, although effective instruments for reducing carbon emissions, may have fewer positive impacts when local ecosystems are considered. Large solar farms can cause significant environmental damage, especially if they are disproportionate to the local environment. Rural lands, which are often used for agriculture, can be severely affected, disrupting traditional livelihoods. In some cases, this can lead to a form of urban speculation, with the massive sale of agricultural land reserved for use in solar energy development.

On the other hand, photovoltaic development models, such as renewable energy communities and residential installations, generate significantly greater social value. These models promote energy sovereignty by reducing dependence on large electric companies, which in turn can lead to greater autonomy for both individuals and communities. Furthermore, by providing a more accessible and sustainable energy alternative, these models can be effective tools in the fight against energy poverty. Photovoltaic development models that focus on industrial facilities and large-scale solar parks typically prioritise cost reduction and profitability maximisation. Although this may result in less social participation, these models can provide significant economic and environmental benefits. However, they cannot exceed the benefits provided by models focused on citizen participation. In terms of local development, energy communities represent the most significant contribution in this area by promoting local employment and energising the industrial fabric at the local level. Photovoltaic development models in residences and industrial roofs can also provide benefits in this sense, since they can boost the local economy by creating jobs and stimulating economic activity.

Finally, it is essential that all photovoltaic development models operate within the legal framework and comply with the energy policies established by public authorities. The models that best align with these policies tend to receive the greatest incentives and support, which, in turn, promotes their development and expansion. Therefore, it is clear that the photovoltaic industry, in addition to its essential contribution to reducing the carbon footprint, can generate significant social value. The degree of CF+ thus generated depends on the photovoltaic development model used. In this respect, the social economy can play a vital role by providing the greatest amount of CF+, given that it can more efficiently integrate aspects such as direct environmental impact, popular sovereignty, local development and political coherence (see Table 2).

**Table 2.** Social value by development model

| | **CF** | **CF+** | | | |
|---|---|---|---|---|---|
| | **Carbon footprint** | **Environmental integration** | **Sovereignty popular** | **Development local** | **Political fit** |
| **EPCs** | V | X | D | D | D |
| **Industrial roofs** | V | V | D | D | D |
| **Residential** | V | V | V | D | D |
| **Energy communities** | V | V | V | V | V |
| V: complies; X: does not comply; D: can comply | | | | | |

Source: Own elaboration.

## 5. Conclusions

This study endeavours to elucidate the role of the social economy in the solar industry, addressing a significant research gap in the literature. Through a review of the main actors in the photovoltaic industry, the dominant logics among various stakeholders have been identified. These actors encompass citizens, small and medium-sized enterprises, social economy entities, public administrations and investment funds. An analysis of how these actors navigate investment incentives versus savings and carbon footprint reduction CF versus CF+ considerations has been conducted within the framework of the social economy.

The examination of these dynamics reveals the emergence of distinct models within the photovoltaic industry, including EPC projects, rooftop installations, residential installations and energy communities. These models vary not only in their business structures but also in the degree of social value they bring to the community. Furthermore, the evaluation of these logics and models unveils two contrasting visions within the photovoltaic industry. On the one hand, there is a predominantly capitalist approach, epitomised by the EPC model, which prioritises minimal social engagement and focuses primarily on meeting CF reduction targets. Conversely, the social economy approach, exemplified by the emphasis on energy communities and associated social organisational models, emphasises broader CF+ considerations. These include environmental integration, local development, popular sovereignty and political coherence, reflecting a more holistic approach to sustainable development. Additionally, hybrid models such as residential and rooftop installations, which draw from both social and capitalist economies, have been observed. While these models incorporate partial elements of CF+, they boast greater applicability due to fewer legal, capital and organisational requirements. This accessibility renders hybrid models potentially more prevalent in the sector.

In conclusion, this study underscores the multifaceted nature of the photovoltaic industry, illustrating how diverse actors and development models can yield varied impacts and benefits concerning carbon footprint reduction and social value creation. Crucially, it calls attention to the pivotal role of the social economy in fostering development models that generate value from both environmental and social perspectives, thereby contributing to the advancement of sustainable energy transitions.

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