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Market-Specific Barriers and Enablers for Organizational Investments in Solar PV—Lessons from Flanders

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Abstract: Solar Photovoltaics (PV) is an important contributor to a sustainable energy transition and consists of an increasingly affordable and accessible technology. Although solar PV policies in industrialized countries have mainly benefited affluent households, non-homeowner market segments often remain underdeveloped. In this paper, we review barriers and enablers for solar PV investments in non-homeowner market segments and investigate sustainability aspects of its institutional environment. We use focus group data from Flanders (Belgium) to investigate non-homeowner residential markets (including social, rental, and collective housing), public sector markets (including schools, and health and social care facilities), and commercial markets. They have in common that they are mostly governed or mediated by organizations, and that very specific regulatory and institutional conditions apply. Our main finding is that, even in times of high energy prices, the energy savings potential of solar PV is often not a sufficient condition for organizations to engage in solar PV investments. Major barriers include diseconomies of scale, split incentive problems, internal organizational barriers, and legal uncertainty. Important enablers are energy sharing frameworks and framework contracts for group purchasing. We conclude with recommendations on institutional quality, organizational capacity building, market development, mechanism design, and social justice to ensure sustainability.

Keywords: renewable energy transition; solar PV; energy policy; social sustainability; circular business models

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Citation: Van Opstal, W.; Smeets, A. Market-Specific Barriers and Enablers for Organizational Investments in Solar PV—Lessons from Flanders. *Sustainability* **2022**, *14*, 13069. https://doi.org/10.3390/su142013069

Academic Editors: SeyedBijan Mahbaz, Maurice B. Dusseault and Alireza Dehghani-Sanij

Received: 31 August 2022
Accepted: 11 October 2022
Published: 12 October 2022

1. Introduction

Solar Photovoltaics (PV) plays an important role in the renewable energy transition and will continue to do so in an increasingly cost-efficient way [1]. At a global level, solar PV supports the achievement of the United Nation's Sustainable Development Goals (SDGs) [2]. At the European level, boosting the deployment of and investment in renewable energy is a key part of the European Green Deal on clean energy transition and the revised renewable energy directive. The aim is to reach 40% of renewables in the European energy mix by 2030, and even a share of 49% renewables for energy used in buildings [3]. More recently, the European Commission launched its "REPowerEU Plan" which aims to increase Europe's energy independence from unreliable suppliers and fossil fuels. This plan is mainly driven by the current geopolitical (i.e., the war in Ukraine) and energy market challenges [4]. Finally, the investment level in renewable energy interacts with prospects of a nuclear phase-out, and the resulting fear of power outages [5].

Yet, solar PV policies in industrialized countries have mainly benefited affluent households, creating regressive redistributive effects [6–8]. These regressive effects stem from economic measures (e.g., green current certificates), fiscal policy measures (e.g., tax incentives), and the fact that not all households have legal, financial, or technical access to solar PV [9–11]. The slower uptake of solar PV in non-residential market segments also has consequences from a sustainability perspective. As we will discuss, this encompasses unbalanced environmental, social, economic, and participatory aspects of sustainable development.

In this paper, we address barriers and enablers for solar PV investments in non-homeowner markets in Flanders (Belgium). These market segments have in common that they are relatively underdeveloped, that they are mostly governed or mediated by organizations, and that very specific regulatory and institutional conditions apply. We organized focus groups to address the following market segments:

- Non-owner residential markets: including social and private rental housing, and collective housing (where residents only partially own the building they live in). These market segments have in common that third parties, such as social housing associations, landlords, or associations of co-owners, are involved in the decision-making process.
- Public and social infrastructure: including municipalities, schools, and health and social care facilities. These market segments have the production of (quasi-) public goods, public procurement procedures, and not-for-profit objectives in common.
- Companies and commercial real estate. These market segments share the commercial function of the infrastructure they invest in.

For these market segments, we investigate incentives that regulations and market structures give to opt for sustainable solutions, both looking at environmental aspects (e.g., circularity solutions), social aspects (e.g., distributional aspects), and economic aspects (e.g., budgets and incentive compatibility to invest). When considering circularity solutions, we explore economic, social, and environmental aspects of solar Product-Service Systems (PSS), PV reuse, end-of-life strategies, and the potential role of data technologies. (PSS models can be defined as a Third Party Ownership (TPO) model, defined as "a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs" [12]. The most common solar PSS-models are rental models, where customers pay a fixed monthly fee to make use of solar PV panels, and Power Purchasing Agreements (PPA), where service providers sell the electricity generated by PV panels they install on the roofs of their clients.) Our findings address concerns of institutional quality, organizational capacity building, market development, mechanism design, and social justice to ensure sustainability.

The main aim of this research is to provide insights into market-specific barriers for solar PV investments that may apply in market segments that are governed or mediated by organizations. While it may seem that the business case for solar energy during the current energy crisis is a no-brainer, there are still many regulatory, legal, economic, and organizational barriers that have to be taken into account. A good understanding of these barriers is helpful to identify and assess enablers that may be insightful for other market segments, other geographical contexts, and other tangible assets that one would like to assess from a sustainability viewpoint.

The rest of this paper is structured as follows. Section 2 discusses the empirical methodology of this paper. In Section 3, we give a concise overview of the relevant institutional context and present results for each market segment. In Section 4 we discuss overall learnings and indicate limitations and avenues for further research. In Section 5 we conclude with insights that can be transferred to other regions.

2. Materials and Methods

To be able to review and reconstruct barriers and enablers for solar PV investments in differential organizational markets, a large amount of necessary data has been documented only very partially. Therefore, we needed to gather expert perspectives, experiences, and implicit domain-specific knowledge by organizing three focus groups representing the three selected market segments. These focus groups were prepared, and their analysis was complemented with policy document analysis, academic literature, and semi-structured interviews.

The background of this study is a larger European Union Horizon 2020 research and innovation project on circular business models and strategies for solar PV. Therefore, we also used results of these focus groups in another publication that focuses on the enabling factors of circular strategies to invest in solar PV. In this paper, however, we focus on the role of differing barriers and enablers in the organizational markets we address.

Focus group research within the domain of solar energy was applied by other researchers to grasp stakeholder's perspectives on design options for self-consumption schemes [13], to obtain perceptions of residents and experiences of firms and policy makers [14], and to provide feedback on product development [15]. Other motivations for focus groups in solar energy research include gaining in-depth understanding of the awareness, barriers, expectations, and reasoning behind solar PV adoption [16], to organize in-dept discussions with experts [17], or to perform policy evaluations [18].

Focus group participants were selected to represent the demand side of the market. We discuss the parameters of these markets while presenting the results in the next section. Supply side actors were deliberately not included in the focus groups, because commercial considerations, e.g., ongoing public procurement procedures, may have contaminated a free and open discussion among the participants. For an overview of anonymized focus group respondents, refer to Appendix B.

The identification process to select participants started in August 2021. After we ensured the participation of the relevant experts of all major relevant actors in the market segments we selected, we organized three focus groups in the period December 2021–February 2022. Due to COVID restrictions and in order to lower barriers for participation, they were organized via an MS Teams meeting and supported by Miro boards. All focus groups were led by the authors and observed by two PhD researchers. The sessions were recorded, under approval of all participants, who also approved an informed consent declaration before participating in the Miro boards. The duration of the focus groups was 120 to 150 min. After transcription of the recorded sessions, results were analyzed independently by the two researchers, after which a joint analysis was compiled and reported at a consortium meeting of the CIRCUSOL project in Berlin (April 2022).

To include the perspective of the supply side of the market, we prepared these focus groups with semi-structured interviews. During these interviews, we invited respondents to identify relevant stakeholders to be included in the focus groups, to identify relevant barriers and enablers for different market segments, and to propose relevant questions to include in our focus groups. Afterwards, preliminary focus groups results were communicated again to the same set of interviewees for feedback, after which focus group participants were invited to comment on our final analysis. Including these feedback loops limited the number of factual errors and ensured that no critical issues were overlooked. For an overview of anonymized interview respondents, refer to Appendix A. We summarize our approach in Figure 1.

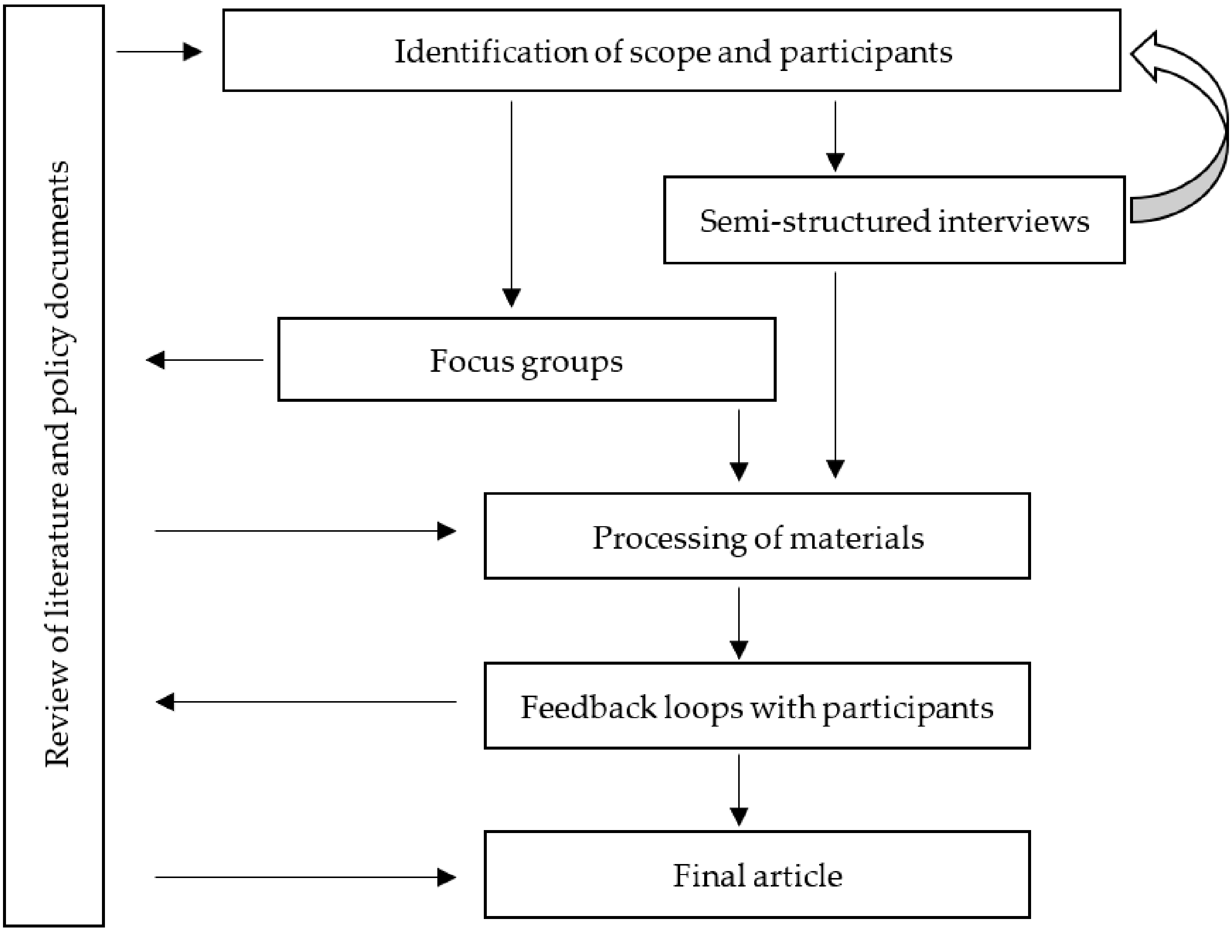

Figure 1. Research design.

3. Results

In this section, we start with a short overview of the most relevant evolutions in PV policy in Flanders. Next, we consecutively report findings on the three market segments under study, presenting results from a concise literature review, a brief market-specific reconstruction of the institutional context in Flanders, and a presentation of the most important focus group results.

3.1. PV Policy in Flanders

Solar PV has a high market penetration in Flanders. With an installed capacity of 608 Watt (W) per capita at the end of 2020, only Germany (646 W per capita) and The Netherlands (629 W per capita) show higher adoption rates [19]. Yet, according to figures of the Flemish Agency on Climate and Energy, only 6.81% of the available roof space has been utilized. With only 8.9% of the energy mix coming from renewable energy sources, Flanders performs significantly below the European average of 22.1% [20]. This shows both opportunities and a further need to speed up investments in solar PV.

As shown in Figure 2, the uptake of medium and large PV installations (>10 kW) in Flanders is slower than the uptake of (residential) small-scale installations. To understand the general evolution of these numbers, we give a brief overview of the most important evolutions on solar PV policy in Flanders.

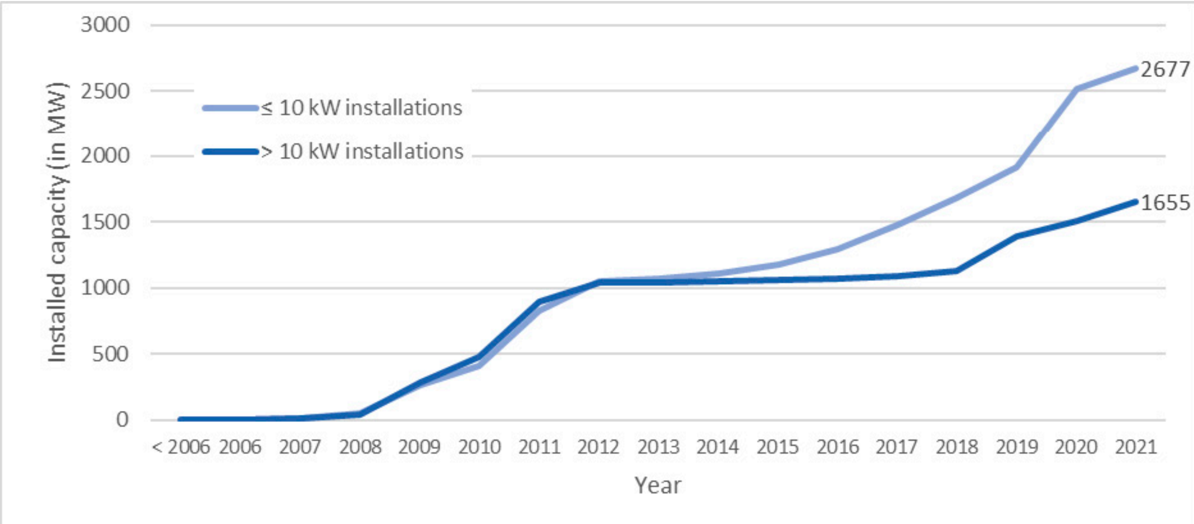

Figure 2. Cumulative evolution of installed capacity of solar photovoltaics in Flanders (in megawatt), by power class. Source: [19].

In Belgium, renewable energy is a competence of the regional governments. In 2002, the Flemish (regional) Government initiated a Tradeable Green Current (TGC) certificate scheme to support investments in renewable energy. Following a sharp price drop of solar panels in 2008, this system became overly generous, leading to a very fast growth of PV investments between 2009 and 2012 [11]. Because of budgetary reasons, regressive distributional effects, and market inefficiencies, the Flemish Government reformed this system. Until 2011, there was also a tax deduction system for residential PV investments. These elements combined, resulting in a much smaller growth path after 2012. After 13 June 2015, PV installations smaller than 10 kW no longer received green current certificates. For bigger installations, this system was only disbanded in 2021 and replaced by a subsidy scheme.

During recent years, the growth of PV installations increased again because of decreasing costs of PV installations and increasing electricity prices. Net metering provided at that time the major value proposition, being offset, however, by a prosumer tariff for residential scale installations and several attempts to introduce a general surcharge on the electricity bill for all electricity users. The political commotion with respect to PV policy resulted in diminished popular trust in solar PV [6,21].

In 2020, the Flemish Government launched a new initiative to promote residential PV installations with the promise that net metering would be ensured for the next 15 years. This was followed by a significant uptake of residential PV investments. In January 2021, however, the Belgian Constitutional Court canceled this 15-year grace period. With injection fees that are significantly lower than grid prices, the abolishment of net metering would drastically reduce financial returns of PV panels. The Flemish Government responded with (limited) compensation measures and a new subsidy scheme for PV systems and batteries. The court ruling, however, caused major public distrust in solar PV policies. As legal uncertainty and a lack of institutional quality deteriorates the investment climate for any asset, this resulted in a drop of new installed solar capacity of 59% between 2020 and 2021 (and even of 74% when considering residential-scale installations (≤10 kW)) [19]. Trust in this regulating institutional environment was even aggravated when the Flemish Government announced, in 2022, that it would partially revert its historical payment obligations of Tradeable Green Current certificates. (Flanders had a green certificate system that started 1 January 2002. This system, however, had several shortfalls. Verbruggen and Laes (2021) summarize them as (1) excess profits related to unfair cash transfers, (2) target fetishism, and (3) crowding out of disruptive technologies by easy money on mature systems. Therefore, but mainly for budgetary reasons, this system has been reformed several times and has gradually faded out [11,22].) While many of these measures only affected residential markets, legal uncertainty and a lack of institutional quality also affect investments by other economic actors.

3.2. Non-Homeowner Residential Markets

Many studies on decisions to invest in solar PV focus on residential markets for homeowners. They stress the importance of economic factors, peer effects, environmental norms, trust in service providers and government policies, and the perception of benefits solar PV can bring [8,23–30]. Research on solar PSS models in residential market segments validates its value proposition to unburden up-front adoption costs, maintenance concerns, and technology risks [7,31–34].

While most studies on solar PV adoption focus on individual houses of homeowners, we looked into residential market segments where households do not (fully) own the houses they live in: social rental housing, private rental housing, and collective housing. An important shared feature of non-homeowner residential markets is the "split incentive problem". The split incentive problem is a principal agent problem, resulting from the fact that the flow of investments in and benefits from solar PV are not properly distributed among landlords and tenants. This split incentive problem arises both in models of PV ownership and in solar PSS contracts. Bird and Hernández (2012) describe two types of split incentive problems that arise in solar PV investments [9]:

- Landlords buy and supply potentially energy efficient homes, but their incentive is to supply these at the lowest possible cost, because they do not pay the energy or utility bills. Tenants pay the energy bills, and have high incentives to increase efficiency, but no control over the means to do so.
- Except for fixed-term rental contracts, landlords have no idea about how long tenants will reside in their houses. Due to the probability of a tenant moving soon, an investment in efficiency having a high upfront capital cost is risky. This is called the temporal split incentive.

We provide a schematic overview of these split incentive problems in Appendix C. Note that a third example of a split incentive may also occur between public authorities, demanding that renewable energy systems are implemented, and social housing associations, who are burdened with additional organizational roles [35].

According to the most recent figures (2018), the housing market in Flanders is divided into homeowners (72%), private renting (19%), and social renting (7%) [36]. Given the low market share of social rental housing, and the fact that waiting lists for social housing account for almost 170,000 individuals, the private rental housing market segment contains a large group of low-income and vulnerable households who are actually eligible for social housing [37]. The private rental housing stock is on average older than the social housing rental stock: 69% of private rental dwellings were built after 1960, compared to 84% of social dwellings [36]. Focus group participants point out that solar PV investments alone will not solve energy poverty nor housing quality problems for vulnerable households, but may provide a feasible stepping-stone.

3.2.1. Social Rental Housing

A growing body of literature on solar PV in social housing highlights the importance of combining renewable energy investments with access to affordable energy for vulnerable households. Success factors include resident awareness, financing options, trust, communication, and economies of scale. Barriers include a lack of behavioral change, financial risks, organizational and regulatory barriers, and technological complexities [38,39]. In social housing, economic motivations are also recognized as the main driver for solar PV investments [14,40]. A specific challenge is the role of solar PV in retrofitting projects [41–43], where social housing associations have clear benefits of economies of scale to boost the uptake of renewable energy in a cost-effective way, but remain challenged with budgetary limitations and a limited ability to influence occupant's behavior [44–47]. Third-party financing and PSS models can mitigate these budgetary restrictions in the short term, but profit motives of PSS firms are reported to generate mistrust among non-profit housing associations [39].

In Belgium, social housing is a regional competence. The Flemish Government organizes social housing through Social Housing Associations, who build and buy houses, and Social Rental Agencies, who rent houses on the private market. Both types of organizations have a similar goal: to provide affordable and good quality housing to households in need [37]. In 2018, changes to the Flemish Housing Decree allowed Social Housing Associations to partially pass on investments in renewable energy to social tenants. This incentivizes Social Housing Associations to invest in renewable energy for their tenants. As a result, Social Housing Associations in Flanders bundled forces in 2020 to establish Aster cv, a member-based energy co-operative (Aster is the abbreviation of Access to Sustainability for Tenants through Energy Effective Retrofit). For the next few years, their ambition is to install 650,000 PV panels on the roofs of 58,000 (i.e., one-third of all) social rental houses, resulting in a solar power capacity of 260 MWp, producing 234 GWh of solar energy per year.

Given the organizational capacity of Social Housing Associations and the economies of scale of this operation, PV ownership by Aster easily outperforms third-party PSS models in financial terms. These economies of scale occur when procuring the installation and its insurance, but also when negotiating the feed-in tariffs with a service provider. It is estimated that Aster will inject more than 100 GWh per year, which is a volume that generates bargaining power (participant 2.2). As self-consumption remains more interesting than selling power to the grid, Aster is also looking into opportunities to install neighborhood batteries and provide Electric Vehicle (EV) and Light-EV charging capacity.

Solar PV investments of this type provide an opportunity to decrease energy costs for a vulnerable group of residents. In the Aster model, social tenants will not face an increase in their monthly rent but pay a fee for the solar energy they consume. This fee is capped at the social tariff, as guaranteed by a Flemish decree. Moreover, Aster has an incentive to remain true to its social mission, as it faces a legal cap on the distribution of its profits (Aster is a co-operative that combines an official accreditation of the National Council for Co-operatives and federal recognition as a social enterprise, which generates a legal cap on the distribution of its profits to its members and ensures that profits are sufficiently reinvested in the social objective of the co-operative [48,49]). Focus group participants, however, point out that not every social dwelling has its own roof. Giving equal access to the benefits of solar PV requires a solidarization of solar returns to all users, but also a sound legal framework that allows Social Housing Associations to redistribute accordingly.

An important regulatory step has been the introduction, in December 2021, of a new manual that defines the information exchange between the distribution system operator (DSO) and other market parties. This new manual, referred to as MIG 6 (Market Implementation Guide), enables splitting solar energy production at one address between two users. This allows Aster to separate the use of produced power that has been self-consumed by the tenant, and to sell the rest itself to the market.

Since 2021, a new grid tariff methodology has incentivized maximal self-consumption of solar energy and stimulated an optimal dimensioning of the PV installation. This reform stimulates both lower energy bills for poor households, investments in solar PV, and a more effective use of raw materials following from a reduced need for extra grid investments due to peak-shaving mechanisms. However, as focus group participants point out, resident behavior will remain a source of uncertainty in terms of energy performance. Here, data technologies that provide thorough energy monitoring, keeping residents permanently informed about their behavior, combined with well-designed nudging strategies or links to other technologies, may provide opportunities. Focus group participants are positive about data technologies that would improve these insights, as long as this information is easy to interpret.

Data technologies may also provide opportunities for Social Housing Associations to learn from user and load profiles of their inhabitants. Whereas (supply-side) interview respondents are enthusiastic about the possibilities this creates to spur nudging and social learning among tenants, (demand-side) focus group participants are rather reluctant to apply these possibilities. Although they see opportunities to train residents to interpret and understand their own data, they clearly state that these data should only be used for correct billing. Opportunities such as using these data for educating vulnerable tenants on efficient energy consumption, or even to detect domicile fraud, are dismissed as normative "meddling", big brother practices, and privacy breaches. On the other hand, Social Housing Associations and Social Rental Agencies provide budget counseling for their clients, including advice on rational energy use. In that process, tenants share this kind of information as well, but at their own choice, albeit with much less detail and information compared to innovative data technology solutions.

Other innovations, such as making use of shared services and batteries, could improve both social, environmental, and economic outcomes. These include providing EV and Light-EV charging capacities, accompanied by services for car sharing, e-bikes, cargo-bikes, and electrical steps. Initiatives such as these may alleviate mobility poverty and enhance access to labor markets, goods, and services of their residents. Combined with docking station applications to load these Light-EVs, housing associations can also contribute to a cleaned-up open space (respondent 7).

3.2.2. Private Rental Housing

Literature on solar PV investments in private rental housing markets studies its impact on the value of rental properties [50], its impact on rental prices, and ways to change tenancy laws, tax regimes, and financing alternatives to stimulate landlords to invest in renewable energy [50–53]. Other research focuses on negative equity and justice aspects of solar PV adoption, since tenants do not have the same financial, legal, and regulatory access to solar PV as homeowners [54,55]. Proposed policy measures to improve social inclusion in this regard include energy counseling for tenants, models of innovative shared ownership, and co-operatives.

Although the advantages of solar PV are similar for private and social rental housing, the split incentive problem is larger for private rental housing than for social housing. While social housing is often built in blocks, in Flanders, private rental housing is mainly provided by private landlords owning, on average, one or two dwellings [37]. Social Housing Associations and their co-operative, Aster, have more organizational and economic leverage to solve this problem compared to individual landlords. Focus group participants, however, indicate that energetic (insulation) investments are far more rewarding and important to vulnerable households than having a PV installation. Note that investments in solar PV cannot be legally translated directly into higher rental prices, which even aggravates the split incentive problem of private rental markets compared to the social rental market. Only for new contracts with new tenants, rental prices (in real terms) can go up.

Although solidarity mechanisms and energy sharing systems can be developed in social housing, private rental dwellings with no suitable roof are also excluded from access to solar energy. The legal framework for energy sharing and local energy communities, however, is still under development, leading to legal uncertainty and suboptimal investment rates. Next to that, focus group participants indicate that the private rental market has no political priority to solve these issues. Note that only 5% of all housing subsidies are directed to the private rental market [36]. While it is possible to increase obligations of landlords to invest in energy efficiency and performance, these measures may spur landowners to sell their dwellings in the short term (as their return decreases) and crowd out vulnerable households in the long term (as rental prices increase).

For private rental markets also, focus group participants recognize that solar PSS models provide advantages of unburdening the upfront capital expenditure and service aspects. However, to what extent can solar PSS models solve the split incentive problem? Suppose landlords sign a solar PSS contract: in that case, PV panels are placed on their property and its benefits can be split between the landlord and the tenant. The regulatory reforms mentioned earlier allow for a split of solar energy production between two users in private rental markets, but since this is new, several legal and contractual uncertainties apply. Moreover, landlords only have a limited incentive to make such an investment, since feed-in tariffs are low. Therefore, the split incentive problem remains. Alternatively, if tenants sign a PSS contract, they would need the agreement of their landlord to have PV panels installed. The tenant and the service provider will need guarantees that this installation will not be considered as real estate by destination, but as moveable property. The most important question, however, remains: what happens if the tenant moves, and are service providers willing to take this risk?

In any case, there is a need for a clear legal framework that solves the split incentive problem for private rental markets. Both for ownership and PSS models, it has to be clear who will benefit from produced and consumed energy. This framework should incentivize tenants to maximize self-consumption while making a clear and incentive-compatible division of solar profits over tenants, landlords, and service providers. To make this transition work, it also has to be clear how this can be implemented in ongoing rental contracts (respondent 4). A sound legal framework to mitigate this split incentive problem would also enable the protection of tenants against inappropriate practices, as illustrated by a participant: "In some cases, landlords combined generous cash flows from green current certificates with a monthly fee of 50 to 60 euro tenants had to pay to have access to the solar energy production" (participant 2.5).

Another issue to tackle is the position of households who have a budget meter. Budget meters guarantee access to energy for customers who have difficulties paying their energy bills. It is a pre-paid system at social tariff rates for households who are entitled to them, or at average market fees for other households. At the end of 2020, there were 35,635 active budget meters for electricity in Flanders [56]. Focus group participants point out that households with budget meters cannot sell solar energy to the grid. In social housing, the Aster model can pool multiple households, but in private rental markets, this gives a clear disincentive to invest in solar PV.

With respect to data technologies, focus group participants also mention the advantages of improved insights in own consumption. Like in social rental housing, however, they point out an important privacy challenge and are reluctant about the idea that landlords can gain access to consumption data of their tenants.

3.2.3. Collective Housing

In collective housing and apartment dwellings, solar PV investments are even more complex because of existing ways of using space and ownership. Important barriers are legal regulations, which are often designed for single-family housing, and more complex decision-making processes in multi-family properties [57,58].

In recent years, booming housing prices and social and environmental concerns caused an increased popular interest in collective housing [59,60]. While the number of households in Flanders that live in collective housing settings is still very low, collective housing, also referred to as cohousing or (peer-) shared housing, has also received increasing policy attention. In 2018, the Flemish Government selected 28 projects to participate in a regulatory sandbox environment for experimental housing for a period of six years.

In collective housing projects, individual households do not fully own the houses or surrounding facilities they live in. With respect to investments in solar PV, similar challenges arise as in the case of apartment dwellings. Both housing formulas also share a partial split incentive problem and internal free-riding problems (including overconsumption of energy in common rooms). In 2020, about 27% of all dwellings in Flanders were apartment dwellings, compared to 23% in 2011 [61]. An important defining feature of cohousing, compared to apartment dwellings, is defined by the Flemish Government as follows:

in collective housing, residents voluntarily share at least one living space and have at minimum one private living space [62].

Both collective housing and apartment dwellings need an organizational governance structure to take care of common investment decisions: the association of co-owners, which delegates a syndic for operational activities. The decision to invest in solar PV (either through ownership or PSS models) has to be taken by a majority vote (or a higher percentage if stated otherwise in the statutes) in the general assembly of the association of co-owners. It is important to point out that decisions taken by this general assembly are enforceable against all co-owners, but also against its potential tenants. In case of a PSS-contract, the association of co-owners can decide upon a monthly fee that can be passed on to tenants, which would partially solve the split incentive problem for private apartment rental markets, but could put its affordability under pressure. Focus group participants estimate this additional cost to be EUR 70–80 a month.

Residents of collective housing and apartments buildings are not always aware of their rights with respect to investing in solar PV. One focus group participant illustrates this as follows: *"quite some residents living at the top floor think they own the roof of the building and start to install PV installations on it, without asking permission to the association of co-owners"* (participant 2.4). Major barriers for solar PV investments in collective housing and apartment dwellings therefore mainly consist of legal uncertainties, including aspects of one-meter billing, energy sharing possibilities, local energy communities, a proper division of costs and subsidies, and contractual uncertainties such as the right of superficies on commonly owned roofs. Since rental terms are becoming shorter and shorter, landlords are not eager to invest time and money to sort out these issues. Here, syndics that operate at a sufficiently large scale can play an important role. Economies of scale are key to making it worthwhile for them to invest time and money in training and proper contract formulations. Therefore, focus group participants consider the size of collective housing (and apartment) projects as a key determinant to make solar PSS models interesting. Once these projects are sufficiently large, even second-life panels can be taken into consideration.

With respect to data technologies, a major concern pointed out by focus group participants is that co-owners should not be able to have access to data of other residents. For associations of co-owners and syndics, however, it is not straight-forward to manage resident data. Within the CIRCUSOL project, a demonstrator was set up at a Belgian cohousing facility. In the light of this demonstrator, the energy consumption behavior of four out of 22 households was monitored over a longer period of time. In this specific case, the disclosure of the monitoring results towards the project partners was not considered an issue by the residents, but this may be (partly) due to the collaborative spirit of the cohousing community [63].

3.3. Public, Educational, and Social Infrastructure

Public, educational, and social profit markets share business-to-government characteristics, including public procurement procedures, a political and bureaucratic decision-making process, and non-commercial considerations. In many industrialized countries, more than 50% of funding of schools and the majority of residential health and social care facilities is provided from public funds, obliging them to adopt public procurement procedures. Mostly, they also prioritize non-commercial considerations in their real estate planning [64].

In 2012, the Flemish Government established the Flemish Energy Services Company (Vlaams Energiebedrijf) as an independent government agency to reduce the energy costs of the Flemish Government administration. Since 2015, this agency has organized all energy purchases of the Flemish Government administration and provided framework agreements and energy group purchases for other public authorities, schools, and non-profit organizations in Flanders. By the end of 2021 this resulted in 319 PV installations that account for electricity production of 14 MWh per year [65]. Supply-side respondents point out that these framework agreements are crucial for local authorities to be able to describe their needs and demands in a sufficiently correct way. Otherwise, they often consider private market segments as more profitable since the decision-making process in public sector markets is much slower and more time-consuming. Focus group participants confirmed this consideration.

3.3.1. Public Authorities

Studies on solar PV investments in public infrastructure deal with evaluation methods to evaluate their costs versus payback time, the gained access to affordable energy (often in remote areas), application possibilities (e.g., for public lightning and municipal pumping), and the reduction in greenhouse gas emissions [66–68]. Public authorities are also considered to have an important responsibility to showcase solar PV investments in public buildings.

Public authorities in Flanders include the Flemish Government administration, five provinces, 300 municipalities, and a wide variety of associations of municipalities and other public and semi-public legal entities. The Terra Platform, a patrimony and energy database, inventories and monitors over 2800 buildings and their energy data of the Flemish Government administration [69]. In 2018, joint electricity consumption of this patrimony accounted for over 2000 GWh, while in 2021 joint solar energy production accounted for 428 MWh, accounting for almost 10% of solar energy production in Flanders [19,70]. At the municipal level, the EU Covenant of Mayors for Climate & Energy is an important guideline for local authorities to invest in sustainable energy.

When asked about the advantages of solar energy for public authorities, focus group participants refer to the responsibility of public authorities to act as a role model regarding renewable energy. The framework agreements provided by the Flemish Energy Services Company (VEB) are considered as an important enabler, creating economies of scale and lowering search costs. Moreover, tools such as GRO, an instrument to measure and increase the sustainability of construction projects, could inspire public authorities to include solar PV solutions into their projects. Participants also mention opportunities such as conversion to thermal storage, EV charging, energy sharing, and optimization and aggregation (grid) service management, which could further enable the uptake of solar PV. These opportunities could optimize self-consumption rates because public infrastructure is often not used during weekends and holidays. A specific challenge here is to combine and align human and financial resources from multiple organizational divisions and funding mechanisms; the benefits of integrated energy projects concern a multitude of domains and require a coordinated and transversal approach.

A major advantage of solar PSS models is, according to focus group participants, the possibility to let citizens participate in PSS group purchases. This way, municipalities can showcase solar PV investments and allow citizens to share in the profits. Therefore, the Flemish Energy Services Company offered a framework agreement for solar PSS, in close collaboration with citizen energy co-operatives. Another advantage is the service aspect of a PSS contract, unburdening local administrations in monitoring and repair. Note, however, that the Flemish Energy Services Company also has a Monitoring-as-a-Service (MaaS) offer. Because of public accounting rules, PSS models, however, are not deemed as necessary to avoid capital expenditures (CAPEX) for public authorities, rendering them a less interesting alternative in financial terms.

With respect to second-life panels, no framework contracts are available yet. Given the search costs and legal uncertainties in this developing market, framework agreements would be a crucial enabler to generate a substantial market pull for second-life PV. Public procurement procedures also have an important impact on optimizing product lifetimes of solar PV installations. One focus group participant illustrates this with an example of energy savings contracts with Energy Service Companies (ESCOs) with a contract duration of 15 years. This contract duration is mainly defined by financial criteria but gives an incentive to install hardware with suboptimal technical life expectancies.

Data technologies will improve monitoring and benchmarking possibilities. The Terra Platform provides a nice example of how automatization and smart metering can provide value for all participants. To make this happen, a close collaboration with Belgian grid operator Fluvius is crucial. In order to be able to develop future-proof solar solutions, combining new data technologies and evolving urban needs in the public domain, supply-side respondents remark that it is not always easy to identify and approach the right people within administrations to exchange ideas with. When innovations combine functionalities, representatives from multiple policy competences or even third parties, such as public transportation companies, are often involved. This may drastically slow the uptake or even off-grid demonstration of new innovations.

3.3.2. Schools

Schools are considered to have an important educational and promotional function with respect to solar PV investments [71]. In developing countries, solar PV give schools access to electricity, severely impacting student participation and performance [72,73]. In industrialized countries, many schools face the challenge to retrofit an old building stock, creating opportunities to lower energy costs and increase environmental outcomes by installing solar PV. This, however, comes with severe budgetary challenges [74,75] and increasing expectations on thermal comfort and health aspects [76,77].

In Flanders, schools belong to three different educational networks: public schools, run by an autonomous body on behalf of the Flemish Community; government-subsidized schools, managed by provincial, municipal or city authorities; or government-subsidized privately managed schools, mostly run by Catholic foundations. According to the Organization for Economic Cooperation and Development (OECD), Flanders has one of the most decentralized school systems in the world, with schools enjoying a high degree of autonomy to decide on a variety of topics, such as teacher recruitment, curriculum, assessment, and quality assurance [78]. With respect to school infrastructure, subsidies are organized by AGION, the Flemish Agency for School Infrastructure, while strategic investment choices and operational infrastructure management are decentralized [79].

Investments in solar PV are stimulated by free feasibility plans and zero-interest energy loans, organized by a collaboration between the Flemish Energy Services Company and AGION. By the end of 2021, this resulted in an installed solar capacity of 1.5 MWp [80]. Focus group participants indicate these energy loans as an important enabler for schools to invest in solar PV, as they claim the lack of financial resources to do so otherwise. They also point at the educational value of solar PV investments.

Yet, schools have a very specific challenge: in Flanders, they are closed for 14 weeks a year (including 8 weeks during the summer) and, on average, are only open on weekdays between 8:30 am and 4 pm. A direct consequence is that it is very hard to have sufficiently high self-consumption rates to make the business case for PV panels interesting in a post net-metering era. Note that most schools have limited electricity needs, compared to other (semi-)public infrastructure. Therefore, schools who invest in solar PV would benefit from energy sharing systems, battery systems, and EV charging facilities outside the school domains. Next, school infrastructure in Flanders sometimes consists of spatially scattered and old buildings, where retrofitting and insulation activities have to be performed first. A specific problem here is the fact that historically a lot of roofs still contain asbestos, which has to be removed first before installing PV.

The idea of solar PSS models for schools is praised for unburdening school boards and their transparency in terms of costs and risks. Focus group participants, however, mention limited subsidy possibilities for lease-based solutions, as the zero-interest energy loans can only be used for buying PV panels. Therefore, the central purchasing office of the Catholic schools started a collaboration with citizen energy co-operatives to enable solar PSS contracts in schools and allow citizens to participate in these projects.

With respect to the adaptation of data technologies, focus group participants mention the same issue as in other market segments: economies of scale are crucial to invest in dedicated and well-trained staff that can look into energy performance. Therefore, sector federations could be an interesting player to build insights and service their members. In order to do so, digital technologies, smart metering, and a close collaboration with Fluvius to gather data in an automated way are crucial. The Terra Platform is also mentioned here: focus group participants indicate it would be interesting for AGION to participate.

3.3.3. Health and Social Care

In health and social care, solar PV investments are also considered a key enabler to ensure the proper functioning of healthcare centers in developing countries [81], resulting in lower maternal and child mortality rates [82] and reducing within-country differences with respect to energy poverty in healthcare facilities [83]. Solar PV is also considered as a sustainable asset to increase the resilience of microgrids feeding critical healthcare facilities, mitigating the risks of power outages [84,85]. In this market segment, renewable technologies are also studied to cover all energy needs under critical conditions in order to reduce CO_2 emissions [86].

As is the case with schools, the organization of health and social care in Flanders is decentralized. From an organizational perspective, activities in health and social care are managed and organized by public authorities (18%), not-for-profit organizations (48%), and for-profit companies (35%) [87]. The market shares between brackets only show averages, as there are significant differences depending on the type of services we take into consideration. Infrastructure investments in health and social care are co-funded by the Flemish Government via the Flemish Infrastructure Fund for Person-related Matters (VIPA). To stimulate investments in renewable energy, the Flemish Energy Services Company performs energy scans and collaborates with VIPA to grant climate subsidies.

Compared to schools, most residential care facilities have very good user profiles for solar energy: hospitals, long-term care facilities, and most day care facilities are open 365 days a year. Note that schools and care facilities sometimes operate at the same site, so energy-sharing possibilities would significantly help the business case for solar panels in schools. Moreover, care facilities have sufficient roof space available, which is an interesting demand-side feature for second-life PV panels. As maintenance and repair services are considered as key enablers for second-life PV, PSS contracts have to be sufficiently interesting first. One barrier, however, is that the VIPA climate subsidies do not cover PSS contracts. Another barrier is that, for new buildings to be in accordance with energy performance regulations, care facilities should own the PV installations if they want to include them in the energy performance score.

Another important barrier to PSS contracts in health and social care is skepticism about the unknown. Although solar PSS framework agreements and projects exist for public authorities and schools, no similar initiatives have yet been developed towards health and care facilities.

3.4. Companies and Commercial Real Estate

3.4.1. Companies

Research on solar PV investments by companies focuses on optimizing set-ups to maximize self-consumption, on economic aspects, financing options, organizational barriers, required workforce skills, information dissemination, government policy support, and technical aspects [88–91]. Other topics include challenges with respect to electricity storage, energy sharing, the need for flexible electricity supply contracts, and opportunities of PSS models in commercial settings [92]. Moreover, case study research compares the advantages and disadvantages of ownership models compared to PSS models to finance onsite solar PV installations [93]. Specifically for farms, a growing literature focuses on the merits and challenges of agrivoltaics, where solar PV panels do not only generate power, but also create shading for crops, increasing water saving [94–96], reducing the competition for land between energy and food production [97–99], and having a potentially positive effect on job creation, community income, and tax revenues [100].

In its "Sun Plan 2025" (Zonneplan 2025), the Flemish Government aims to collaborate with sector federations and municipalities to stimulate companies to invest in solar PV. One of the policy instruments is a "sun coach", which supports companies with free and independent first-line information, pre-scans, and an evaluation of tenders. From a pilot project, the most frequent questions and barriers relate to roof quality, tender evaluation, inverter choice, and administrative procedures. Entrepreneurs also indicate they have neither the time nor knowledge to proceed in solar PV investments [101]. Another policy instrument is the Energy Efficiency Fund (EEF) of PMV, the investment company of the Flemish Government, to support Energy Service Companies (ESCO's). This resulted in a solar project portfolio of 16 MWp in Flanders. The Flemish Government also developed a brochure to inspire companies to let employees participate in solar PV projects, by means of a worker energy co-operative [102]. Other supporting mechanisms include a premium by Fluvius of a maximum of EUR 1500 for small installations ($\leq$10 kW), investment support for installations over 40 kW ("call green power"), and an increased fiscal investment deduction.

Apart from generic and earlier discussed advantages of solar PV, focus group participants stressed the importance of energy cost reductions and referred to an increasing interest of companies in energy self-sufficiency and in possibilities to operate off-grid. For many manufacturing and agricultural companies, energy reliability is even more important than energy prices. Given ongoing political discussions in Belgium on a nuclear phase-out, the fear of power outages during winters increases. Energy requirements vary by company size and activity; shopping malls are open when the sun is shining, but construction companies have only a limited need for energy at their company seat, as most energy consuming activities are performed on dispersed construction sites. In this case, energy sharing solutions and batteries will be key to making solar investments worthwhile. The possibilities of energy sharing could be very promising in business parks as well, but legal limitations are also still in place. In agriculture, large roofs may provide an interesting opportunity for solar electricity production, but the energy demand of most farms is rather limited and seasonal. Focus group participants also point out that many industrial companies mainly need heating or cooling—an energy demand solar PV does not directly resolve.

The major barrier for solar investments, as identified by both supply-side respondents and demand-side focus group participants, is the recurrent uncertainty of the regulatory framework, causing a deep mistrust in regulatory bodies and the Flemish Government. Other barriers include the roof quality and asbestos. For farms, the limited capacity of the distribution grid in rural areas is often a major barrier for solar PV investments as peak solar production during the summer may cause power outages. Identified enablers for solar adaptation include tax cuts, smart loans for energy investments, group purchases and energy sharing in business parks, possibilities for energy sharing, and co-operative models to let workers, citizens, or customers participate. The replacement of asbestos roofs also creates opportunities for solar investments. Multiple focus group participants even point out that subsidies may be abolished, as they consider the technology sufficiently efficient.

A particular driver for companies is the electrification of cars, as EV charging infrastructure may serve their clients and co-workers. This creates an incentive to invest in PV panels and contributes to a positive company image. In times of high energy prices, it also provides a new comparative advantage for shops in their struggle to compete with e-commerce. One respondent illustrates this with a demonstrator project at a gas station: "Tesla drivers are the most profitable customers, not because of the charging, but because of the purchases they make while charging" (respondent 3). Employer's federations, however, point out that many entrepreneurs are still waiting to install quick-charging capacity until prices drop. These quick-charging installations are most interesting for smaller and medium-sized shops, where customers tend to stay for relatively short periods. Other companies are thinking the other way around and look how EV charging business models can improve self-consumption.

With respect to solar PSS models, focus group participants point out that the upfront investment is not a big burden anymore for most companies, as prices drop, loan conditions are accessible, and fiscal policy supports ownership. From a financial perspective, PSS models are therefore considered as disadvantageous compared to other ways to finance solar investments. Within companies, professionals who decide about investments are often used to calculate the total cost of ownership of alternative investment options. Moreover, from an accounting perspective, PSS models without a leasing firm are very disadvantageous. One particular advantage of solar PSS, however, is that it may not be considered as an investment—requiring management buy-in at the strategic level—but as an operational decision that can be made by the technical manager of the company. According to one focus group participant, this could speed up solar PV investments in national branches of multinational firms (participant 1.6).

A particular enabler for solar PSS could be the increasing legal requirements on energy performance, where PSS models could be an interesting alternative to speed up investments if funding is a problem in the short term. Focus group participants consider flexible versions of PSS models as a key enabler. Especially for start-ups, PSS models could provide access to solar energy in the short term, but flexible contracts with a call option to buy the installation after, e.g., 5 years would be considered as much more interesting than the current 20-year contract durations. Another flexible alternative would be a rent–buy system where users gradually increase their ownership share in the PV installation. An important remark, however, is that most start-ups do not own, but rent the infrastructure they use. Moreover, for mature companies, flexibility may enable the take up of PSS contracts, e.g., providing flexibility in contracts when a building is sold to another companies.

According to focus group participants, the use of second-life assets is not that uncommon in many industries. Examples include second-life kitchens and facilities in the catering industry and the use of refurbished office materials. The application of second-life PV panels, however, is considered by most participants as unfeasible, unless for a highly motivated and ideologically driven market segment. An important exception here is farms; the combination of sufficient roof space and low energy needs means that installing panels with a lower efficiency is no big issue. Furthermore, aesthetic aspects of using different types of PV panels are less relevant and PV panels entail another interesting functionality: they provide shelter and shading for crops. Second-life panels could also be used for off-grid applications to charge Light-EVs, and help to organize and reduce visual pollution of scattered Light-EVs, while attracting potential customers to companies. Identified enablers include awareness building and group purchases to lower average search costs for second-life panels.

Data technologies may provide functionalities that make solar PV investments attractive. Improved insights into their own data enable companies to simulate the impact of new investments on energy needs. Data technologies also invite companies to gain insights into energy consumption and look beyond finding yet another new supplier when energy expenditures are increasing. Data technologies may also be supportive to attract and organize sharing devices, such as e-steps, e-bikes, or cargo e-bikes. According to all focus group participants, this is an area with a large number of unexplored and unexploited opportunities. Rising energy prices raise the awareness of companies to improve their energy performance, but habit formation and strong beliefs about customer preferences are also barriers to changing energy consumption patterns. This is illustrated by one focus group participant as follows: “In fashion retail, some members still believe no customers will enter their shop if the door is not permanently open” (participant 3.1). Focus group participants also complain about a lack of collaboration with grid operator Fluvius and energy providers to gather aggregated data.

3.4.2. Commercial Real Estate

With respect to commercial real estate, the literature focuses on the impact of solar PV investments on real estate value and rental prices, and its interaction with methods to evaluate the commercial and environmental outcomes of retrofitting projects [103]. Solar PV is considered significantly less expensive than Heating, Ventilation, and Air Conditioning

(HVAC) solutions and investments in insulation [104,105]. Some authors once considered commercial building rooftops without solar PV as "waste real estate" [106], while also more recently, commercial rooftop solar energy markets have been considered as an under-developed sector, facing significant barriers to deployment [107].

Companies often do not own the buildings they occupy. Offices, shopping malls, and retail stores are often owned by commercial real estate agencies. As Environmental, Social, and Governance (ESG) criteria become increasingly compelling, and obligatory energy performance standards rise, investing in solar PV is a relatively easy and cheap way to enhance the future-proof value of commercial real estate. Moreover, in deep retrofitting projects (where extensive energy upgrades are carried out to improve a building's overall energy performance), solar PV investments are considered as a must-have.

Accessibility for professional and residential tenants and their clients and co-workers is also increasingly imperative, boosting the demand for EV charging infrastructure, which is in turn an enabler for PV investments. Another important development, triggered by the COVID-19 crisis, is the increased demand for flexibility in the market for office buildings and a surge of hybrid construction projects combining residential functions, shops, and offices. This development requires flexible contracts for energy and HVAC solutions.

In commercial real estate, tenants have limited leverage to invest in solar PV themselves. Here, similar barriers apply as in the case of apartment buildings and collective housing. Energy sharing at a building level would increase self-consumption, making solar energy more profitable, but faces other problems such as legal uncertainties and split incentive problems.

In Flanders, the market for solar PSS models on commercial real estate has begun to develop, with a variety of contract types, including the standard 20-year contract and 27-year contracts, which are both terminable after 9 years (in line with classical commercial rental contracts). Contractual innovations include splitting up contractual obligations of owners and tenants, where the latter party has more flexibility to terminate the contract. A major challenge of these contracts is that each of the three parties (owner, tenant, service provider) should be able to benefit from it under varying market conditions. With respect to monitoring and data technologies, owners could increase the value of their property by investing in new technologies and sell-up by providing services to their tenants.

4. Discussion

4.1. Barriers and Enablers

Based on our empirical results, we summarize an overview of the main barriers and enablers that were identified by focus group participants and interview respondents in Table 1. Note that many of these barriers and enablers may apply to all market segments. Moreover, we should be aware of significant within-group differences in each market segment. This table, however, gives an indication of the barriers and enablers that appeared to be the most salient in the market segments under discussion. It shows that, in different market segments, differing barriers may be important to address, and differing enablers may drive market players to solar PV investment.

The most important enabler in this era is the mere fact that, in times of high energy prices, solar PV investments have a significant energy savings potential. While some market players do not have sufficient access to their own roof, or a rather limited potential for self-consumption, energy-sharing frameworks are indicated as an important enabler for all market segments we studied. Not all market players are equally able to carry the upfront investment, and some market segments suffer from significant diseconomies of scale. Therefore, group-purchasing initiatives, framework contracts, or cooperative solutions may resolve this burden, as well as green energy loans for parties that face a lack of liquidity.

Yet, our work shows that technical solutions on energy sharing and financial solutions to lower prices or provide access to investment capital are sometimes not sufficient to spur organizations into solar PV investments. The split incentive problem remains a major barrier in rental markets and markets where co-owners have to align investment decisions. Moreover, internal organizational barriers may slow down investment decisions, and internal split incentives within organizations may cause suboptimal investment rates. Finally, legal uncertainty remains a major barrier in many market segments.

Table 1. Overview of major barriers and enablers for solar PV investments in non-homeowner markets in Flanders.

	Non-Homeowner Housing			**Public and Social Infrastructure**			**Commercial Infrastructure**	
	Social Rental	**Private Rental**	**Collective Housing**	**Public Infrastructure**	**Schools**	**Health and Social Care**	**Companies**	**Commercial Real Estate**
Barriers								
Upfront investment (CAPEX)		x			x	x		
Split incentive problems	x	x	x					x
Limited self-consumption				x	x			
Diseconomies of scale		x	x		x	x		
Internal organizational barriers			x	x	x		x	
Roof quality	x			x	x		x	
Legal uncertainty		x	x				x	x
No own roof	x	x						
Enablers								
Energy savings	x	x	x	x	x	x	x	x
Energy sharing frameworks	x	x	x	x	x	x	x	x
Group purchasing/framework contracts	x			x	x	x		
Electrification of cars							x	x
Self-sufficiency						x	x	
Green energy loans					x		x	

4.2. Limitations and Avenues for Further Research

When interpreting the results of this paper, it is important to be aware of its limitations. Limitations involved include its geographical focus, the focus group methodology, and the focus on solar PV panels. While Flanders (Belgium) is a relevant context to study sustainability disparities in densely populated industrialized regions or highly regulated and multilayered policy settings, it is a less relevant context to draw conclusions for isolated communities or developing countries. While replication of this study in similar contexts would be beneficial to deepen our understanding and validate our findings, an even more promising avenue for further research would be to apply a similar research approach to developing countries that are confronted with highly increasing regulatory innovations.

The limitations of focus group research are well documented and include challenges at the crossroads of social psychology, behavioral psychology, and ethics, including issues such as dominant voices, group-think, consent, confidentiality, and risk of harm [108–111]. Therefore, it would be valuable if further research replicates this approach over time. Another avenue is to complement this research with survey data, addressing multiple stakeholders for each market segment under study. Such an approach, however, is beyond the scope and feasibility to report in one article.

A third limitation we would like to address is the fact that we mainly focus on solar PV as a renewable energy source. While solar PV has some defining technological and economic characteristics, our findings cannot be transferred automatically to other renewable energy sources or storage solutions, including solar thermal applications, wind energy, heath pumps, or energy storage configurations. Yet, the application of these technologies in varying contexts has a large number of sustainability challenges, leaving them a promising field for further research.

5. Conclusions and Recommendations

In this paper, we depict the merits and challenges for organizational market segments to invest in solar PV, investigating its barriers and enablers in a multilayered and dynamic institutional environment. These market segments have in common that they are relatively underdeveloped while having significant potential to enhance sustainability by embracing solar PV. In our overview, we investigated environmental aspects (e.g., circular options), social aspects (e.g., distributional aspects), and economic aspects of sustainable development. We addressed aspects of sufficiency (e.g., energy savings) and efficiency, and encountered elements of participative, redistributive, and procedural equity.

Following our review of different organizational market segments for solar PV, we identify five fields of concern for organizations, regulatory authorities, and service providers to take into account: institutional quality, organizational capacity building, market development, mechanism design, and social justice to ensure sustainability.

Regulatory uncertainty and distrust have been identified as a key barrier among all market segments under study. A substantiated long-term vision on energy policy is a critical starting point to foster investments in renewable energy by all economic actors, especially in a context where earlier financial and regulatory promises have been reverted. Moreover, organizational market segments, such as schools, housing associations, and healthcare facilities, already operate in a highly controlled regulatory environment, and therefore need a sufficient degree of legal complementarity with energy policy in general. This should ensure that policy measures are aligned over multiple policy levels and domains, and do not obstruct each other at the expense of organizations willing to invest in solar PV. Therefore, it is important for government agencies and regulatory bodies to learn from other policy domains and other regions, and to invest in policy evaluations and real-life demonstrators. Future research on legal complementarity in the field of energy policy would be beneficial to enable policy makers to identify, measure, and evaluate whenever policy levels and domains are not sufficiently aligned.

To grasp the potential of solar PV in full, organizations also need to invest in organizational capacity building. Economies of scale are key; during the procurement phase, but also while governing operations, larger organizations, well-structured initiatives of group purchasing and member-based co-operatives have the potential to negotiate better conditions, implement superior follow-up management methods, and embrace the possibilities of data technologies. While small organizations hardly have trained staff to monitor installations and interpret data, large organizations have a bigger potential to designate and train staff that is able to perform these tasks. Service providers need a knowledgeable and responsible person within the organization to deal with. Regardless of the size of an organization, this "no empty chair condition" must always be fulfilled in order to capture (future) organizational energy needs, and understand consumption profiles and the relevance of ancillary services, in order to prevent being exploited by hit-and-run sales or depressing lock-in contracts. Organizational and governance design, however, should enable these dedicated staff to translate the needs they detect towards effective decision-making processes, by aligning interests within organizations to act accordingly. Therefore, a first and important step for organizations is to start from a wider and strategic vision on sustainable and future-proof infrastructure, including an appropriate organizational and governance design.

A third field of concern is market development for new technologies and circular solutions. Reuse markets for PV or markets for new solar PV (data) technologies are often incomplete; demand is lacking because supply is uncertain, and supply is lacking because demand is insufficient. This way, many innovations remain trapped in a small scale or in path-dependent lock-in situations with suboptimal standards and regulations. Governments, big corporations, sector federations, and member-based co-operatives, however, have enhanced capabilities to co-develop framework contracts (e.g., for second-life solar PSS) and organize purchasing power to trigger market-pull dynamics beyond minimal scale levels that are necessary for new markets to develop. Since skepticism towards the unknown is a major barrier for solar PV uptake in new applications, organizational market segments have the mobilizing ability to create dynamic economies of scale, invest in demonstrators, and showcase their feasibility with validated business models, attracting new suppliers and further developing markets. Governments can support this development with regulatory sandboxes and the co-development of standards, warranties, and test protocols. Comparative evaluation research of innovative case studies could spur the diffusion of lessons learned across technologies, markets, and regions.

In organizational market segments, roles of those who decide, use, and pay are often scattered across divisions or between contractual parties, creating principal agent problems such as the split incentive problem. Therefore, data technologies should be embraced to limit informational asymmetries and free-riding problems, and contractual innovations should provide clear guidelines on distributing costs and benefits between users, owners, and service providers. Applying insights from behavioral economics and psychology, including nudging, habit formation, and cognitive biases to this challenge provides a promising field for further research. With the rise in energy sharing solutions, the need for deeper and actionable insights in this field will only increase. Here too, framework contracts should be developed to lower barriers for solar PV investment in multi-ownership and shared-user settings. Further research in applied law and economics on the design of these advanced framework contracts could enable decision-making processes for both practitioners and policy makers.

Finally, in order to translate the benefits of solar PV into a sustained contribution towards a sustainable development, we conclude with aspects of social justice that should be taken into account. Solar PV has been proven to enable access to schooling, healthcare, clean water, and affordable energy for low-income households in the most vulnerable regions of our planet. Yet, solar PV policies in industrialized countries have mainly benefited affluent households, creating regressive redistributive effects. Energy sharing has been identified as a key solution to align disparities between parties who have available roof space but less suitable consumption profiles, and those who do not have legal, financial, or technical access to solar PV. As in household market segments, member-based co-operatives could be established in organizational market segments, and to mutualize the benefits of solar PV (and new ancillary services), safeguarding internal solidarity mechanisms in its governance while creating sufficient economies of scale for procurement and enhanced operational governance.

Author Contributions: Conceptualization, W.V.O.; methodology, W.V.O.; validation, A.S.; formal analysis, W.V.O. and A.S.; investigation, W.V.O. and A.S.; resources, W.V.O. and A.S.; data curation, W.V.O. and A.S.; writing—original draft preparation, W.V.O. and A.S.; writing—review and editing, W.V.O. and A.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research has received funding from the European Union's Horizon 2020 research and innovation program (call: H2020-EU.3.5.4) under grant agreement 776680 (CIRCUSOL).

Institutional Review Board Statement: Ethical review and approval were waived for this study for the following reasons: (1) The research does not target any vulnerable groups, such as under-aged persons, persons with disabilities, etc. Target groups are 18+ and participate from their professional capacity. (2) The research involves solely the use of professional opinions on market-specific barriers and enablers on solar business models. The research does not entail any activities that would result in any form of pain, anxiety, physical or psychological stress for the participants. Participants to the research are not at risk of any sort of harm, health impact, stigma or prosecution. (3) The aims of the research are clearly stated to the participants. (4) Participation to the focus groups is entirely voluntary and not linked to any reward or adverse consequence on those participants that refuse to contribute. (5) No sensitive or personal data are gathered or processed; all results will be reported anonymously.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors would like to thank Lize Borms, Ässia Boukhatmi, Roger Nyffenegger, Lars Strupeit, focus group participants, interviewees, and participants at the CIRCUSOL consortium meeting in Berlin (21–22 April 2022) for valuable feedback and discussions. All remaining errors are the sole responsibility of the authors.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Abbreviations

AGION	Flemish Agency for School Infrastructure
CAPEX	Capital Expenditures
DSO	Distribution System Operator
EEF	Energy Efficiency Fund
ESCO	Energy Service Company
ESG	Environmental, Social and Governance
EV	Electrical Vehicle
HVAC	Heating, Ventilation, and Air Conditioning
MaaS	Monitoring-as-a-Service
MIG	Market Implementation Guide
OECD	Organization for Economic Cooperation and Development
PPA	Power Purchasing Agreement
PSS	Product-Service-System
PV	Photovoltaic
SDG	Sustainable Development Goals
TGC	Tradeable Green Current
TPO	Third-Party Ownership
VEB	Flemish Energy Services Company
VIPA	Flemish Infrastructure Fund for Person-related Matters

Appendix A

Appendix A.1. Respondents

In Table A1, we provide an overview of interview respondents.

Table A1. Interview respondents.

ID	Date	Stakeholder Type
Respondent 1	19/11/2021	Service provider 1
Respondent 2	2/12/2021	Service provider 2
Respondent 3	2/12/2021	Researcher 1
Respondents 4 & 5	2/12/2021	Federation of service providers
Respondent 6	6/12/2021	Service provider 2
Respondent 7	7/12/2021	Service provider 3

Appendix A.2. Interview Structure

For each of the three focus groups we prepared (non-owner residential, public sector and commercial market segments), we asked the following questions in a semi-structured interview:

- Given the list of participants we identified already, which participants should we not forget to invite or include?
- What key questions would you like to ask to these focus group participants, if you had the chance to do so?
- Which relevant cases should we know to prepare this focus group?

Appendix B

Table A2. Focus group public and social infrastructure (7 December 2021).

ID	Professional Position	Stakeholder Type
Participant 1.1	Energy expert	Federation of municipalities
Participant 1.2	PV expert	Public procurement agency on renewable energy
Participant 1.3	Sustainable infrastructure expert	Supporting association for health & social care facilities and schools
Participant 1.4	Energy expert	Governmental agency for school infrastructure
Participant 1.5	Energy expert	Regional federation of schools
Participant 1.6	Investment manager	Governmental investment company
Participant 1.7	Public finance expert	Bank

Table A3. Focus group social & private rental housing, and collective housing (22 December 2021).

ID	Professional Position	Stakeholder Type
Participant 2.1	Policy expert	Association of social rental housing
Participant 2.2	Operational manager	Energy co-operative of social housing associations
Participant 2.3	CEO	Association of tenants
Participant 2.4	CEO	Association of landlords
Participant 2.5	Social Worker	Civil Society project organization
Participant 2.6	President of the Board of Directors	Association for housing for vulnerable households
Participant 2.7	Energy Expert	Environmental civil society organization

Table A4. Focus group companies and commercial real estate (18 February 2022).

ID	Professional Position	Stakeholder Type
Participant 3.1	Circular Economy expert	Employer federation
Participant 3.2	Circular Economy expert	Employer federation
Participant 3.3	Energy expert	Federation of farmers
Participant 3.4	Innovation expert	Construction federation
Participant 3.5	Innovation expert	Real estate study center

Appendix C

The diagrams in Figures A1 and A2 represent the split incentive problems we discussed in Section 3.

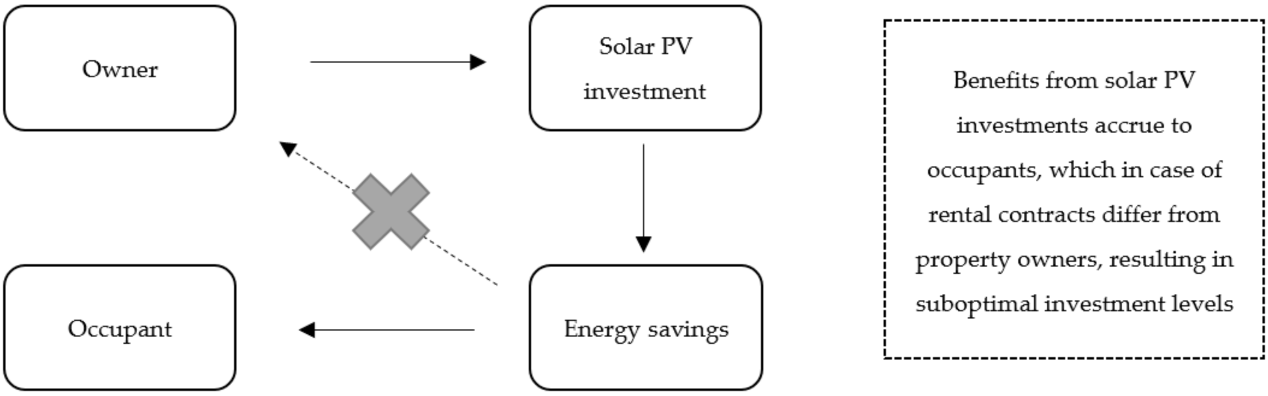

Figure A1. The split incentive problem.

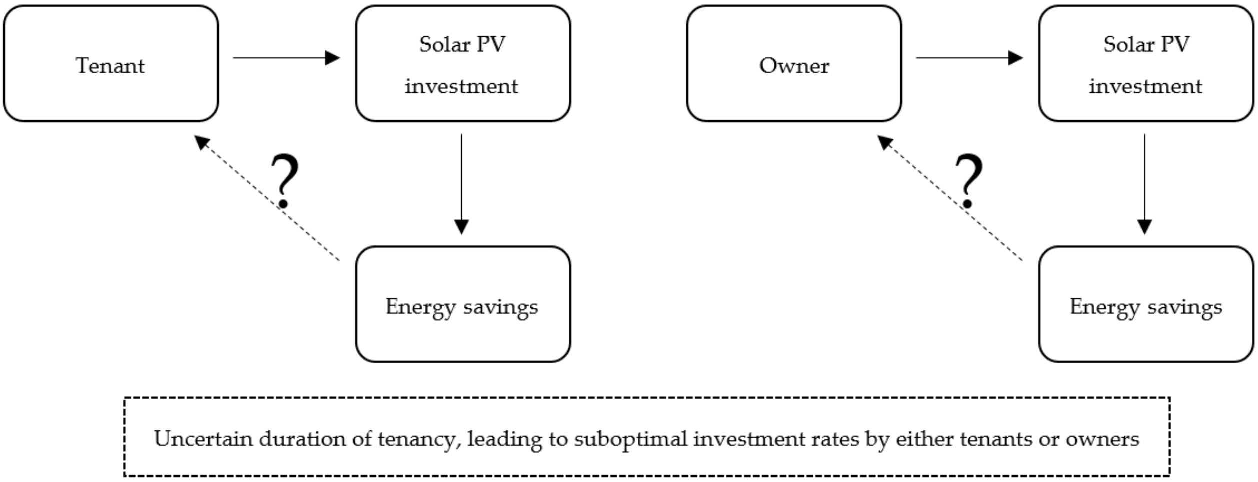

Figure A2. The temporal split incentive problem.

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