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Building Energy Commons: Three Mini-PV Installation Cases in Apartment Complexes in Seoul

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Abstract: Solar photovoltaics (PV) deployment is not easy in dense urban areas because there is little space for the installation. Furthermore, tenants have few incentives to install PV panels because they frequently relocate, and most PV facilities are nonremovable. To address these factors, this study reports on an innovative model that collectively installed 260 W of mini-PV on the balconies of almost all the households in two high-rise apartment complexes in Seoul, South Korea. This project was unique in that it established energy commons in a community using private space. This study found that economic and social factors significantly influenced community-internal or micro factors, which in turn affected the success of the community energy project. Economic factors such as the expected economic benefit and residents paying no direct installation costs shaped the initial conditions for the commencement of the project. Leadership played a key role by speeding up the process, relieving residents' concerns and distrust. This study introduced an innovative community energy model that can be referenced by megacities and communities. It provides opportunities for enhancing awareness of energy transition via on-site energy production using renewable energy and allows even communities that have insufficient common space to build energy commons.

Keywords: community energy; dense urban area; mini-PV; collective installation; energy commons; internal factor

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1. Introduction

Community energy is a niche that can contribute to energy transition [1,2]. As a result, community energy attracts a great deal of attention from researchers. However, community energy studies that have investigated cases in dense urban areas are rarely found. This may be attributed to the conditions in megacities, where community energy initiatives rarely develop spontaneously [3]. Literature on megacities has focused on the potential or feasibility of renewable energy deployment and has recommended enhanced measures for promoting renewable energy [4–8]. Only a handful of studies [3,9,10] have investigated collective approaches for renewable energy deployment in megacities.

PV (photovoltaics) is the most viable option in megacities because of the densely packed buildings. However, a large share of the population in dense urban areas lives in high-rise multifamily housing, where it is impossible for people to install a renewable energy unit on their own rooftops. Furthermore, a significant proportion of these people rent rather than own their housing, so it is difficult to install a unit without the landlord's agreement [11]. Community energy projects in megacities need to be different from previous community energy practices if they are to deal with these issues. Rather than placing a renewable energy unit on individuals' own property, off-site and centralized installation of renewable energy facilities can be promoted by aggregating community electricity demand and contracting it to developers [12]. This approach is meaningful; however, it does not result in the enhanced awareness that is obtained from direct experience with renewable energy units installed on-site [13].

A different approach is possible. In 2017 and 2018, two community energy projects that collectively installed mini-PV with a capacity of 260 W in about 370 apartments were successfully completed in Seoul. Scaling up this community energy project has been discussed. By analyzing these experiments in Seoul with a focus on internal community conditions, such as leadership and trust, this study aims to identify enabling conditions and factors, and also challenge practices of promoting community energy.

This approach could be utilized as a best practice in other megacities, where renewable energy could be installed in a distributed and community-based way. The findings of this study will also fill the knowledge gap in community energy literature by investigating community energy projects in megacities and by analyzing the governance of projects carried out in high-rise multifamily housing, a typical dwelling in dense urban areas, which has not been analyzed in prior studies [3,9].

To attain the research objective, this paper is organized as follows: in Section 2, the definitions of community energy and influencing factors on community energy are presented. Section 3 introduces definition, status of and financial supports for mini PV in Seoul, South Korea. Section 4 briefly explains how this study is conducted. Section 5 analyzes three cases; the results are further discussed in Section 6. In sum, Section 7 is concluded with findings, implications and limitations.

2. Literature Review

2.1. Community Energy

Community energy, also called energy community, is an emerging concept and strategy for sustainable-energy transition and climate-change combat. The term has diverse definitions and attracts abundant academic debate [9,14,15]. For this study, we adopted the definition used by Koirala et al. [16] and Isabel [17]: community energy is to develop distributed energy resources with local community engagement [16]. In other words, community energy emphasizes a collective bottom-up approach for dealing with energy, climate change and sustainability challenges [17].

In the academy, community-energy literature covers a wide range of topics, such as concept definition and interpretation, ownership, operation model, economic benefits and energy justice. Moroni et al. [15] discussed what energy communities really are and could be. They proposed a new energy-community taxonomy that has four main categories of energy-related community. The first distinction is drawn between "place-based" and "non-place-based". Further differences come from "single-purpose" or "multipurpose" communities. Single-purpose communities are shaped solely for energy, while multipurpose communities have a wider range of objectives (such as shared management) [15]. Seyfang et al. [1] noticed that sometimes energy-community research focuses more on "community" than on "energy", so community energy projects were used as examples to show the benefits of public engagement and reveal the power of grassroots-led innovation. The results of this type of research can also be applied to other community actions, such as environmental protection and climate-change mitigation.

Regarding ownership, Goedkoop and Devine-Wright [18] indicated that community energy projects could be collectively owned by community actors or shared between communities and developers. However, by conducting semistructured interviews with 19 shared ownership stakeholders, they found that shared ownership was difficult in practice in the United Kingdom despite high levels of support in principle, due to lack of trust and expectation gaps. Eitan et al. [19] viewed community–private-sector partnerships (CPP) as key drivers of renewable energy transition. They identified six CPP archetypes: knowledge sharing, private finance, local consumption, land seeking, community employment and lease.

Community energy is also viewed as a tool for enhancing economic benefits for participants. For example, Chaichana et al. [20] analyzed 26 community renewable energy

(CRE) projects in Thailand and concluded that CRE projects can bring economic benefits to people in rural areas of Thailand. With 1638 households involved in the CRE projects, total economic benefits worth approximately 173,000 USD per year were realized through either generated income or reduced expenses.

Regarding justice, Mundaca et al. [21] examined the perceived procedural and distributive energy (in) justice that can affect outcomes in two successful cases in Samsø (Denmark) and Feldheim (Germany). They highlighted the contribution of procedural justice for the success of both of these projects and identified the influence of distributive justice through interviews.

2.2. Success Factors for Community Energy

Factors affecting the success of community energy projects can be internal as well as external. Internal factors are those within a community; external factors are based in the wider socioeconomic and political contexts [3]. A similar categorization was adopted by Goedkoop and Devine-Wright (2016) in their discussion of shared-ownership renewable-energy projects. They used "micro" level to refer to factors residing within a project, such as trust, project expectations, coordinated negotiations, sufficient time and stakeholder engagement. These micro factors were both influenced by and an influence upon the "macro" context of national policies, institutions and norms [22]. While studying individual energy community cases, some researchers have further analyzed internal factors based on three dimensions: economic (e.g., financial benefits), normative (e.g., environmental protection) and social (e.g., uncertainty and trust) [23,24].

Figure 1 lists influencing factors identified in the literature, based on this external–internal structure and the economic–normative–social dimensions for the internal factors. External resources and supports are critical for community energy project development. These include governmental financial support; market incentives; suitable policies and regulations; technology availability; and good networks with local agencies, businesses, and intermediary organizations [25–29]. Internal economic factors, such as material resources and the profitability of the community energy projects, also play a significant role [30]. Normative considerations were also discussed in some literature [26,30]. The internal social factor is widely identified as the initiator and accelerator of the success of community energy projects. Crucial elements include pre-existing community cohesion and identity; community organization and community spirit; special skills, knowledge and experience among community members; community support and participation; core group and leadership; and transparency and trust between the community members [18,31,32].

Literature on factors influencing community energy covers both internal (micro) and external (macro) factors. Some studies have investigated one specific internal factor, such as community leadership [33], trust between communities and other stakeholders [18,34], or motivations of citizens to join and participate in community energy initiatives [31]. Some research has focused on one particular dimension. For example, Haggett et al. [32] reviewed 360 community energy projects in Scotland and concluded that internal social factors significantly influenced the success of projects across different stages of development (i.e., at the conception, feasibility, planning and operation stages).

Most literature about influencing factors has empirically reviewed energy community projects in a single area (e.g., a specific country or city), explored internal as well as external factors and provided an overview guideline. For example, the DOE [35] noted essential characteristics of a successful community energy plan: (1) being comprehensive, (2) integrating significant and ongoing community efforts, and (3) being proactive and ambitious but achievable. Hermawati and Rosaira [36] found seven key success factors of renewable-energy projects implemented in rural areas of Indonesia: (1) project planning and development; (2) community participation; (3) active communication and beneficiaries; (4) availability of technology maintenance schemes, workshops and technicians; (5) project management and institutionalization; (6) local government and other stakeholder support; and (7) network development.

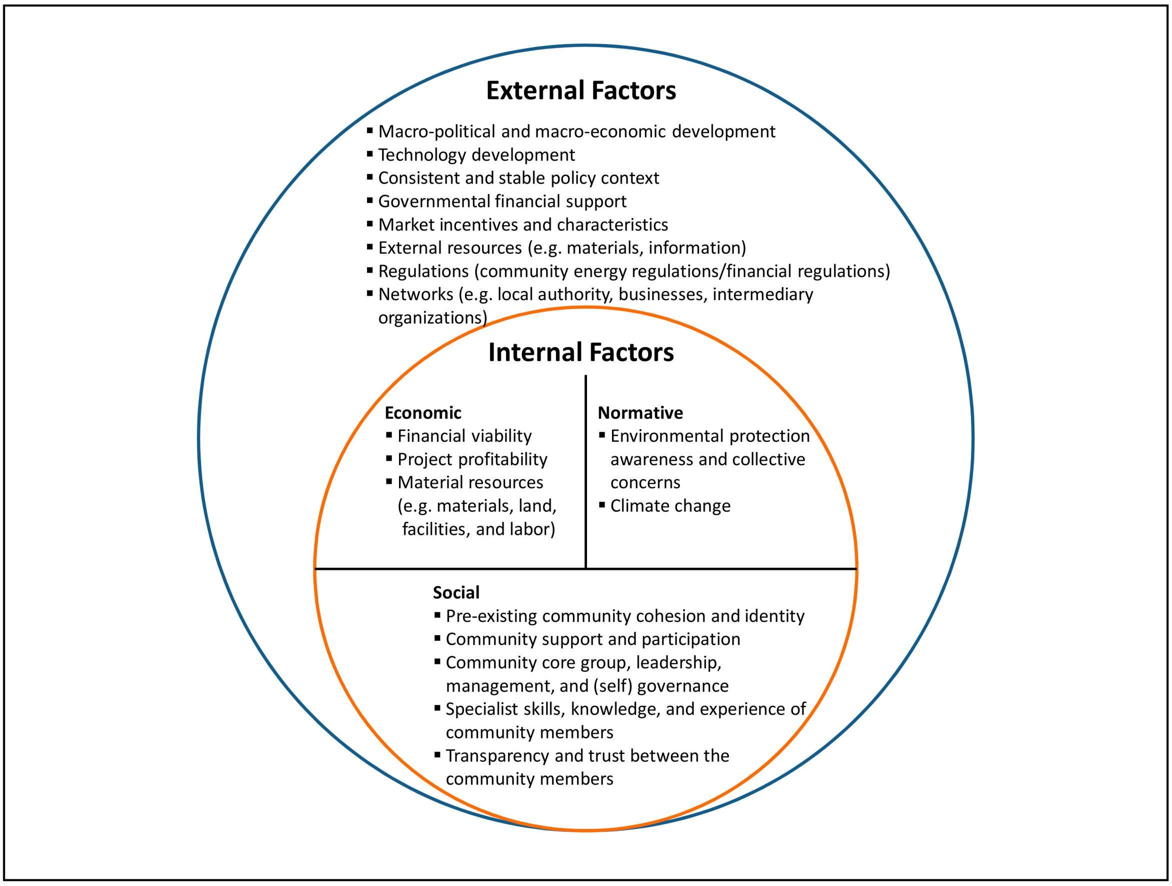

Figure 1. Success factors for community energy.

Because most research has been conducted in European countries, the United States or rural areas in developing countries, community energy deployment in Asian urban areas is missing from the literature. This study aims to analyze how communities processed the collective installation of small-scale PV in every unit of their apartment complexes, with a focus on how community internal factors apply within a dense urban context.

3. The Promotion of Mini-PV in Seoul

In the past, PV with a 3 kW capacity has generally been installed in residential buildings, but this needs a space larger than 25 m^2 [37] and is hard to displace once installed. It was impossible for residents of apartments or tenants who move relatively frequently to participate in energy production using renewable energy. As of 2017, detached homes accounted only for 11.6% of housing in Seoul, while multiunit housing comprised 87.4% and apartment buildings with more than five floors accounted for 58.1% [38].

Under the One Less Nuclear Power Plant (OLNPP) policy implemented in 2014, mini-PV has been promoted aggressively. In November 2017, the Seoul municipal government announced an ambitious goal as a means to implement OLNPP: "The City of Sun, Seoul" would deploy 1 GW of PV and PV panels on some 1 million homes by 2022. To achieve this target, the installation of mini-PV is prioritized due to the unique characteristics of Seoul's built environment. To attain the goal, this municipality promotes mini-PV with a capacity of about 260 W to be installed on balcony bars, a solution for 63% of the target households [39] (See Table 1).

Table 1. The Plans for 1 million PV homes by 2022 [39].

Target	Balcony Type	Residence and Building Type	Other	Total
Number of households (Thousand households)	633	366	5	1004
Capacity (MW)	180	366	5	551

Note: the capacity of PV that would be installed on balconies is 0.26 kW and the capacity of PV that would be installed on detached houses/private buildings is 1 kW.

As presented in Table 2, the upper limit of mini-PV is not prescribed, but it generally refers to PV with a small capacity used for household consumption. Mini-PV is categorized into three types based on capacity, installed structure and connectedness to the meter: balcony, residence and building. The "balcony-type" mini-PV is installed on the balconies of apartment buildings and can be easily detached and reinstalled in the case of movement, much like electric appliances. Generally, the capacity of one panel of balcony type mini-PV was 260 W. (According to the technological progress, the capacity is being increased. It is not connected to the electric meter but rather is connected to a power outlet like an electric appliance. Often, two panels of balcony-type mini-PV are installed in an apartment unit. Unlike balcony-type mini-PV, "residence-type" and "building-type" PV is connected to the electricity meter so people can directly see the amount of electricity generated from the installed PV. The electricity generated from residence- and building-type PV is subtracted from the electricity bill through a net-metering system.

Table 2. Classification of mini-PV and municipal installation subsidy [40,41].

	Balcony Type	Residence Type	Building Type
Capacity	250 W–1 kW	1–3 kW	3 kW+
Connectivity	Power outlet	Electric meter	Electric meter
Subsidy in 2018	1400 KRW/W (smaller than 500 W)	600,000 KRW/kW *	600,000 KRW/kW (general installation)
	600 KRW/W (from 500 W to 1 kW)		700,000 KRW/kW ** (installation along with MOU)

Note: * there are maximum subsidies for residence type that vary with capacity: up to 5200 thousand KRW and 6300 thousand of KRW of subsidy can be provided for residence-type mini-PV with capacity less than 2 kW and 3 kW, respectively. ** When building-type mini-PV is installed through signing a memorandum of understanding with the SMG or a religious organization.

The SMG provides financial support for deploying mini-PV, as presented in Table 2. In addition to the municipal government's support, district offices provide subsidies for mini-PV installation as well. As seen in Table 3, with these subsidies, the actual payments to people who install mini-PV ranges from 60 to 250 thousand KRW (50 to 210 USD) (The average exchange rate between KRW and USD for 2017 (1189.72 KRW/USD) has been applied in this paper) depending on the type of mini-PV [42]. The mini-PV generates 19–96 kWh of electricity, depending on capacity, and reduces bills by 4–17 thousand KRW per month (about 3–14 USD) [37]. Generally, the payback period for this payment is much less than two years.

Thanks to generous support from municipal and district governments, mini-PV has been deployed rapidly. At the end of 2018, the cumulative capacity of installed mini-PV reached 118,311 kW in 170,207 households (See Table 4).

Table 3. 2019 Mini PV installation subsidy [42,43].

Type	Capacity (W × Number)	Size (m)	Total Cost (Thousand KRW)	SMG Subsidy (Thousand KRW)	District Subsidy (Thousand KRW)	Actual Payment (Thousand KRW)
Stationary type	300 × 1 335 × 1	1.6 × 1.0 1.7 × 1.0	527 586	417 466	50 50	60 70
Console type	310 × 1 310 × 3	1.7 × 1.0 1.7 × 1.0	581 1593	431 1293	50 50	100 250

Table 4. Annual Installations of Mini-PV (Data obtained from Seoul Energy Corporation on 14 February 2019).

	Balcony Type		Residence and Building Type		Total	
	Households	Capacity (kW)	Households	Capacity (kW)	Households	Capacity (kW)
2002–2011	N.A.	N.A.	11,678	11,678	11,678	11,678
2012	N.A.	N.A.	2721	2721	2721	2721
2013	N.A.	N.A.	4368	4368	4368	4368
2014	1777	420	6444	6444	8221	6864
2015	3258	902	10,520	10,520	13,778	11,422
2016	8311	2187	16,761	16,761	25,072	18,948
2017	18,605	5121	17,327	17,327	35,932	22,448
2018	41,704	13,129	26,733	26,733	68,437	39,862
Total	73,655	21,759	96,552	96,552	170,207	118,311

4. Methodology

This study analyzes three cases of collective installation of balcony-type mini-PV in apartment complexes in Dongdaemun district, Seoul: (1) Hongreung Dongbu Apartments (Complex A), (2) Hwigyeong Best Vill Apartments (Complex B), and (3) Cheongsol Wooseong Apartments (Complex C). The first two cases successfully completed installation of mini-PV in nearly 100% of the apartment units in the complex. However, the last case was still being discussed and processed. One of the authors participated in all three cases as a member of Dongdaemun Maeul Net and a member of the Energy Community/Welfare Division of the Implementation Council for OLNPP from 2016 to 2018.

This study analyzes the process and governance in the three cases using data collected through participant observation. It focuses on the community internal context because the cases had a similar external context—the same informative, administrative and financial support from the district and Seoul. This study analyzes the context to find out how the collective installation of balcony-type mini-PV projects was initiated, how challenges were solved and how the process was governed. This study draws implications about the internal enabling conditions that enabled the attainment of nearly 100% mini-PV installations in the apartment complexes.

5. Three Collective Mini-PV Installation Cases in Apartment Complexes

5.1. The First Collective Mini-PV Installation in an Apartment Complex in Seoul

The Hongreung Dongbu Apartments (Complex A) consist of four buildings and 371 apartment units. In 2012, the lights in the common space of this complex were replaced with LED lights. Because of this energy-efficiency enhancement activity, an awareness of energy-related activities developed among residents. At the council of occupants' representatives in November 2016, the chairman, who had heard about the economic benefits of balcony-type mini-PV from one apartment resident, suggested collective installation of mini-PV in all units of the apartment complex using the "reserves for long-term repairs" collected from profit-seeking activities in the complex's common spaces, such as leasing parking lots, selling recyclables and presenting advertisements at common spaces. These reserves were also collected as part of residents' monthly utility bill payments. Under the Multi-Family Housing Management Act, the reserve is used to repair and manage the apartment facilities.

The apartment office manager examined the budget needed to carry out this project, taking into consideration the available subsidies from the SMG and district office. Initially, it was estimated that individual households would need to pay 95,000 KRW (about 80 USD); however, the actual cost to individual households was increased to 120,000 KRW (about 101 USD) when the plan changed to installing mini-PV on apartment rooftops rather than on lower-level apartment balconies. The amount of solar radiation at lower-level units was not enough due to shade from trees. The reserve would be used to cover the cost, so individual households did not need to pay anything from their own purses. At the council meeting in December 2016, this project was introduced as an official agenda item. The project was approved by unanimous agreement.

During January and February 2017, a solar-system installer was selected from among seven designated by the SMG. Then, placards were placed to promote the project to apartment residents. Initially, the installation of balcony-type mini-PV at every household was to be completed by April 2017. However, unexpected issues extended the installation process to the end of June 2017. Distrust between various actors impeded the implementation of the project: for example, some landlords were suspicious that tenants might ask for the installation cost when they move out, and some residents were suspicious that the management office might ask them to cover the cost later. In addition, the installation locations on the balconies of individual units were initially chosen to maximize the amount of radiation. Due to different preferences about the placements, such as coordination with the internal conditions of each apartment unit, the installation took more time than planned. Difficulties in communicating with residents who were staying long-term in other countries delayed the installation process as well.

To deal with various issues, residents' representatives and the office manager actively promoted the project and persuaded the residents to participate in it. In addition, they asked the opinions of leaders of the apartment complex, such as the chairman and members of the senior resident committee and the president of the neighborhood association. Consequently, mini-PV was installed in 360 of 371 households in this complex as of August 2018 (see Figure 2). Together with this collective installation of mini-PV, the community applied to the ESV (Energy Self-reliant Villages) program and the collective activities were extended to incorporate energy saving. The community was awarded the grand prize in Environment and Encouragement in the SMG's Apartment Energy Saving Competition in 2017, and the resident representatives and the manager won commendations from the head of the Dongdaemun district office in 2017.

Figure 2. Installed mini-PV in Hongreung Dongbu Apartment buildings.

5.2. The Second Collective Mini-PV Installation in an Apartment Complex in Seoul

The Hwigyeong Best Vill Apartments (Complex B) installed mini-PV in every unit of its complex, following the example of Complex A. This 18-year-old apartment complex consists of three buildings (22–26 floors) and has 372 units. It was expected that the environment of the complex would be harmed by the construction of the Jang-An logistics terminal next to it, which would likely lead apartment prices to decrease. Therefore, the community searched for measures that would enhance the community environment.

The case of Complex A was frequently mentioned in the media, and it was observed that the image of those apartments had been enhanced. In addition, Complex B had won the top prize at the 2015 Apartment Energy Saving Competition by replacing lights in the underground parking lots with LEDs, thanks to the proactive initiative of the office manager. Furthermore, after the private daycare center located on the second floor of the apartment management office was converted into a public daycare center in 2017, 60 million KRW (about 50,432 USD) was provided to Complex B by the district office to compensate for the rent no longer collected from the private daycare service. The additional fund inflow was included in the reserves for long-term repairs.

Thanks to the existence of a model to follow, the inflow of additional funds to use and the proactive apartment office manager, mini-PV installation and participation in ESV were brought up as an agenda item at the council of occupants' representatives in December 2017. The manager surveyed the installer options and analyzed the actual payment from residents in the first two months of 2018, which was 70,000 KRW (about 59 USD). It was found that 26 million KRW (about 21,854 USD) of the total cost that the apartment residents would pay could be covered with the reserve. This project was presented and explained to the residents after the selection of the installer in February 2018. Then the manager visited individual units to obtain the residents' agreement prior to the initiation of the project. Thanks to the beliefs formed from winning the prize in 2015, it took only a week to get agreement.

Mini-PV with a capacity of 270 W was installed in 362 of the 372 households within three months, from April to June 2018. The installed mini-PV is owned by the apartment complex because the installation cost was paid using the collective fund. Residents who wanted to own and retain mini-PV and when they moved out needed to separately pay the 70,000 KRW individual cost.

Although the awareness of the office manager was high because he had a career as an energy manager (the SMG trains some people (as of 2018, 20 people) and has them visit apartments and conduct energy consultations for households in Seoul) and there was a model to follow, some challenges occurred as well. Some residents opposed the installation due to the low economic benefit, less than 10,000 KRW per month (about 8 USD). In addition, the orientation of the mini-PV was initially chosen taking into consideration the conditions of individual buildings; however, some residents wanted to install it in a different orientation. About 20 households that had installed mini-PV before this project complained, so 70,000 KRW (about 59 USD) was provided to these households to recoup their previous payment and then the unit was converted into the complex's asset.

5.3. The Suspended Trial Scale-Up

The third case was still in the preparation stage. At a similar time as Complex B, the Cheongsol Wooseong Apartments (Complex C) started a collective mini-PV installation project. This apartment complex is much larger (1110 households) than the two cases discussed earlier. At the regular meeting of Dongdaemun Maeul Net in December 2017, the promotion of mini-PV installation in the Dongdaemun district was discussed, including the idea that the organization's activities could be expanded through the deployment of mini-PV at apartment complexes where members lived. The chairman of the council of occupants' representatives in Complex C, who was also a member of Dongdaemun Maeul Net, took the initiative to install mini-PV in Complex C. This organization planned to participate in the project as an intermediary support organization. In addition to the collective installation of mini-PV, an application to the ESV was discussed at subsequent meetings of Maeul Net in January and February 2018.

The collective mini-PV installation and application to the ESV program were discussed at the regular council of occupants' representatives in February 2018. However, participation of Maeul Net was canceled because the organization was already cooperating with the ESV activities of Complex A. Therefore, the apartment women's association, which was newly elected, was chosen to carry out the ESV activities.

The complex was selected for ESV, and the collective installation of mini-PV in Complex C initially seemed that it would be carried out swiftly. However, the project was not implemented as expected because of internal organizational issues, temporal sensitivity and internal conflicts. Consequently, it lost momentum to collectively install the PV, and the project was suspended.

Information regarding ESV activities and cases of collective mini-PV installation were shared with residents' representatives and women's association members at the regular council of occupants' representatives in April 2018. In addition, four project presentations were scheduled during the daytime and evening on a Friday and Saturday in April, but the plans were canceled even though the program brochure was completed. Groundless rumors were heard by the residents, such as that the project was initiated in order to leave a legacy of achievement for the current mayor before the provincial election on 13 June 2018. As the provincial election approached, collective activities were suspended to avoid misconstruing the intent of the activity.

Furthermore, because of the replacement of the office manager and the opposition of a representative, the initiative lost momentum. Consensus among the residents' representatives was not attained because one representative strongly argued for other priorities, such as the replacement of elevators. Although the collective installation of mini-PV could have been implemented based on a vote, the decision was suspended to avoid conflict within the council. Meanwhile, the office manager was replaced and the new manager viewed the project as a burden added to existing tasks. In addition, because the chairman of the council and the members of women's association were new to those positions, they were not able to concentrate on the implementation of the project because communication with residents was not easy and they were preoccupied with taking over their tasks.

6. Discussion

Among the various renewable energy technologies, PV is the most feasible in an urban layout with densely placed buildings. Solar projects installed by or for communities are referred to as "community shared solar" or "shared solar" or "community solar initiatives" [44,45]. Similar to the diverse forms of community energy projects, shared solar projects have their own individual characteristics. This program often installs centralized solar projects with a relatively large capacity in off-site fields; communities collectively finance these projects via purchasing shares or subscriptions to electricity providers [46]. This type of project is a great option for urban utility consumers who are not likely to be eligible for individual installation of PV on their own rooftops [11]. Of course, there is another type of community solar—"collective" and on-site installation of PV with small-scale capacity on the rooftops of residential and public buildings, as found in "Centrales Villageoises" in France [46,47]. However, collective and on-site installations of PV are difficult to find in urban areas.

There were many examples that formed energy commons using common places such as the rooftops of high-rise multifamily buildings in South Korea, including Seoul [47]. This study introduced a new community energy model applicable to multiunit dwellings in dense urban areas, a model that collectively installed very small-scale PV on the balconies of individual units in an entire apartment complex, then designated the installed mini-PV as common resources for the complex.

This is an innovative model for deploying PV in megacities, one that effectively resolves the space issue and the initial installation cost. Initial installation cost is an important barrier for the deployment of domestic PV [4]. The additional and unexpected budget outlay and the reserve collected from profit-seeking activities in common areas of the apartment complexes enabled the collective installation of mini-PV. Rather than paying the cost directly out of pocket, using the reserve that had been collectively raised for long-term maintenance and repair of apartments helped residents not feel a direct economic burden from the project and facilitated their agreement to the projects. In addition, economic benefits that could be directly expected by individual households, such as reduced electricity bills, facilitated the agreement of residents to this project. Expectations of increased property values was another economic factor in the successful cases. Property values at one apartment complex that partially installed mini-PV through an ESV program increased more than similar apartment neighborhoods [48].

By comparing the successful cases and the suspended case as seen in Figure 3, this study noted the importance of leadership. Leadership, especially the leadership of the office manager, facilitated the process of collective installation based on the concrete trust built from past energy-related achievements in the successful cases (Complexes A and B). Because the office manager was a full-time employee of the complex, the manager's initiative and contribution played a key role. In addition, the leadership responded appropriately to unforeseen challenges, particularly concerns about the potential advantages and disadvantages of the project.

The influence of internal factors can be seen in the suspended case in complex C. Unfortunately, the scale-up case was carried forward during a politically sensitive period, as the provincial election approached. Because the incumbent administration promoted low-carbon and sustainable energy transition [49], support for renewable energy was often politically framed in South Korea. This dwarfed the newly elected leadership. The new leadership was instead occupied with taking over the original tasks that they needed to deal with. There was not much room for them to take on a new initiative and successfully promote it.

Community leaders for this project mostly consisted of the office manager and occupants' representative, who are employed or elected differently than "informal leaders", as Bénit-Gbaffou and Katsaura [50] described. They will serve out their term as community leaders unless they lose their reputation. In addition, the project leadership demonstrated voluntary action. Because the PV installation was not an original task for the community, leaders were not actively engaged in the suspended case. This called for incentives for leaders, especially for the office manager. In the absence of proper incentives, this new initiative was viewed as a new burden by the office manager.

Community as place is transitioning towards community with shared vision, as described by Kim [3] and Walker [51]. Because community leadership is less hierarchical [52] it depends on trust, which needs time to be formed. The confidence of being trusted by members enables leaders to actively engage in a project [33]. In other words, strong leadership armed with relevant energy can expedite the process, as seen in the second case. Unlike the successful cases, the community in the suspended case was much larger, which made effective responses by the newly elected leadership difficult.

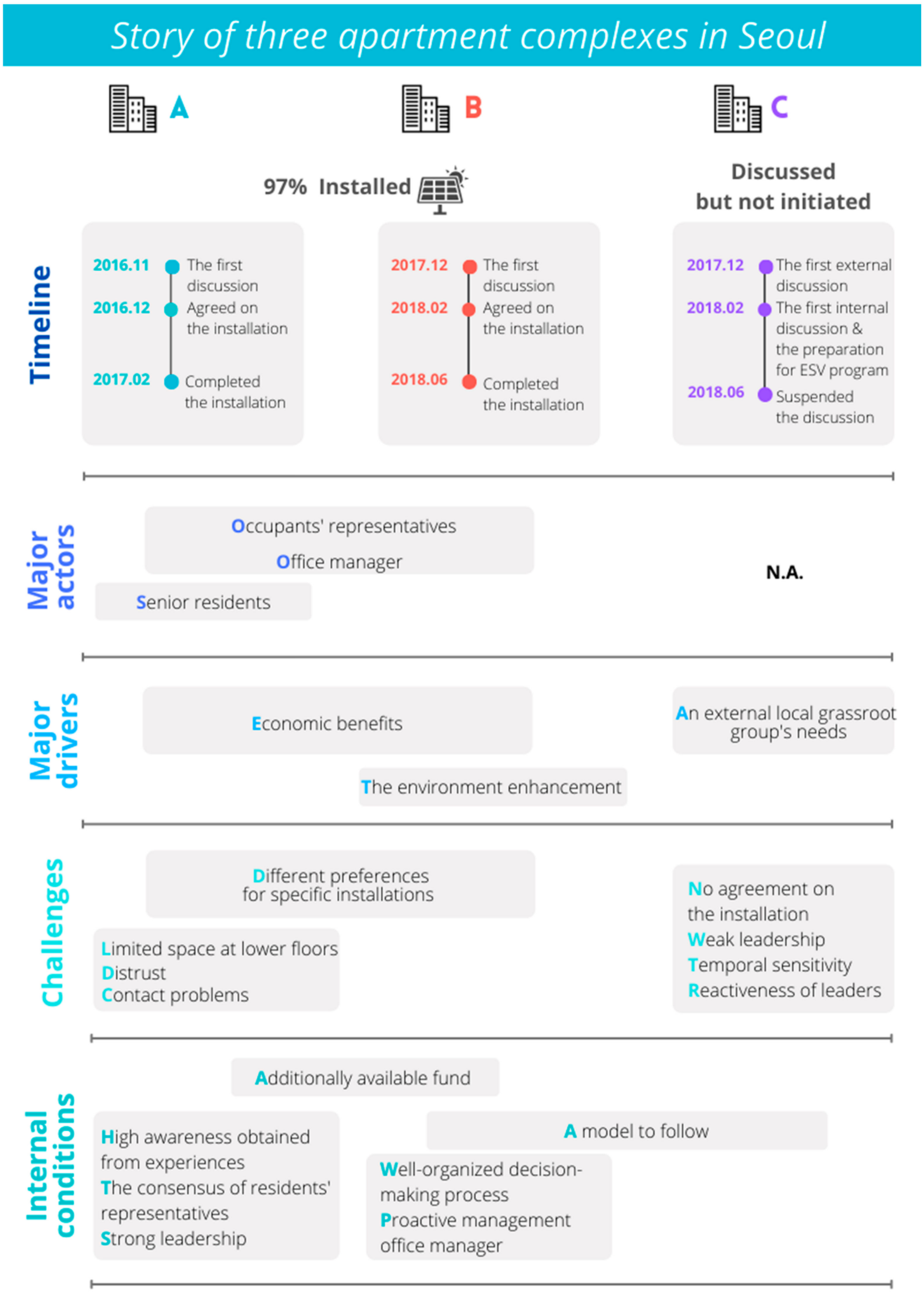

Figure 3. Snapshot of the collective mini-PV installation cases.

7. Conclusions and Policy Implications

This study analyzed community energy projects that collectively installed a very small-scale PV with a capacity of 260 W on the balconies of individual households in high-rise apartment complexes in Seoul, South Korea. This is unique in that the projects established energy commons by using private space, unlike other community energy projects. This study introduced an innovative community energy model that can be referenced by megacities and communities, which creates opportunities to enhance awareness of energy transition via on-site energy production using renewable energy and allows communities, even those with insufficient common space, to build energy commons.

The contextual analysis of two successful cases and one suspended case, with a focus on the community-internal (or micro) factors that affected the success of the community energy project, allows us to find significant influence from economic and social factors of internal factors on the project. Economic factors, such as the expected economic benefit and no installation cost being directly paid by residents, shaped the initial conditions for the commencement of the project. Leadership played a key role across the whole project by speeding up the process, relieving residents' concerns and distrust. The leader whose role was a practitioner, the office manager, was the most important. In contrast, weak leadership could not solve the unforeseen challenges that emerged in the suspended case.

Although this study focused more on community-internal factors, the scaling up or mainstreaming of this project needs external enabling conditions as well. Ruggiero et al. [2] emphasized the importance of intermediary organizations for scaling up or mainstreaming [1]. In addition, the existence of strong incentives or education and training could help community leaders more actively engage in or be more empowered in community energy initiatives.

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