SOLAR HEATING & COOLING PROGRAMME
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Solar Neighborhood Financing Mechanisms and Business Models

Economic incentives and business models that promote the diffusion of solar neighborhoods

IEA SHC TASK 63 | SOLAR NEIGHBORHOOD PLANNING

Technology Collaboration Programme
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SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Solar Neighborhood Financing Mechanisms and Business Models

This is a report from SHC Task 63: Solar Neighborhood Planning and work performed in Subtask B: Economic Strategies and Stakeholder Engagement

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1 Executive Summary

Solar neighborhood developments offer unique economic benefits versus typical solar developments. Since solar neighborhoods often span multiple land use spaces, local community members are key stakeholders in these developments. As such, involving the community can help promote and accelerate the investment and dissemination of these developments. In doing so, certain solar neighborhood business models can include individuals who otherwise cannot gain direct benefits from solar projects due to not having the ability to purchase their own solar equipment.

The market potential for neighborhood solar is promising due to the different forms these projects can take, including the different technologies that can be utilized and flexible size/capacity options. However, several risks exist for these developments, ranging from changes in policies that offer tax incentives for renewable energy projects or the consequences from an economic downturn that reduces the level of investment and available capital.

Solar neighborhood developments can utilize traditional financing mechanisms, such as equity-based financing, debt-based financing, and grants, or innovative financing mechanisms such as power purchase agreements (PPAs) and feed-in tariffs. In addition, crowdfunding mechanisms, such as solar leasing and subscription-based models, increase community involvement in these projects.

The project timeline of a solar development includes the development, construction, and operation phases. Based on this timeline, financing approaches can be categorized into project financing mechanisms that provide the capital expenditure (capex) needs of a development versus financing support mechanisms that support operational expenditure (opex) once the project is operating. Additionally, the distinction between when the public sector typically supports project capital demands versus the private sector offers a further categorization of financing mechanisms. Task 63 experts were engaged in discussions on the categorization of business model frameworks during project meetings, and the feedback was incorporated into the decision-making process for defining the design of relevant business models.

Three business models that promote solar neighborhood development were developed:

- Develop-to-Own model: The project sponsor retains ownership.
- Develop-to-Release model: The project sponsor forfeits ownership/partial ownership of the development.
- Develop-to-Host model: The sponsor offers the output of the project to individual customers.

The business models were developed to be flexible in terms of who sponsors the project versus who ultimately owns/hosts the completed development. This allows for models where community members can be involved in some way—either as sponsors of the project or as part of a customer base leasing or subscribing to the project's output.

2 Background

2.1 Introduction

2.1.1 Definition of solar neighborhoods

Based on the definition used in the IEA SHC Task 63, solar neighborhoods can be defined as a solar development that services a group of buildings or a city district or precinct. A neighborhood is a spatially defined, specific geographic area, often including different types of buildings and functions, open space, and infrastructure. A neighborhood can be part of a larger city or a smaller village, and can be part of an urban area, a rural development, or represent an isolated community. Furthermore, it can be connected to a district heating/cooling network.

Solar neighborhoods aim to maximize solar access and utilization. These neighborhoods implement passive strategies including equatorial orientation, high performance windows, and adequate solar control, as well as active solar strategies such as solar collectors for electrical and heat generation. Both buildings and neighborhood outdoor areas should be designed to maximize the use of solar energy.

In terms of economics, solar neighborhoods offer developers an alternative to typical solar developments and fill numerous market gaps by allowing previously excluded consumers to participate in the development of solar energy. In addition to extending many of the same benefits of traditional solar developments to other consumers, solar neighborhoods provide additional areas of value to individual consumers, communities, and developers.

2.1.2 Report objective and structure

The main purpose of this report is to describe the economic incentives and business models, including added values, that might potentially promote the diffusion of solar neighborhoods. To accomplish this, the report first introduces the high-level economic benefits of solar neighborhoods to establish the incentives, market potential, investment risks, and stakeholders that exist for investing in solar neighborhoods.

The report then provides a brief overview of the project development timeline and describes the ways solar neighborhoods can be financed. Typical and innovative financial mechanisms are categorized based on their relevance to the project timeline.

Solar neighborhoods can take many different forms and, as such, there are several potential business models that can be utilized. The final section of the report offers a set of business models tailored to solar neighborhood development that adequately captures the unique ownership structures that might exist in these developments. The design of these business models are intended to promote solar neighborhood dissemination.

2.2 Economics of solar neighborhood development

2.2.1 Economic incentives

Solar neighborhoods offer an array of benefits across levels: consumer-level, local-level, and for developers. While solar developments in general offer many benefits, this section discusses the added value for solar neighborhoods, specifically building upon the benefits of typical solar developments.

2.2.1.1 Incentives for individual consumers

To the individual consumer, solar developments offer an avenue for reducing their energy bill and climate footprint while also decreasing dependence on the electric grid. However, typical private consumers of solar developments include individuals who own buildings capable of supporting rooftop solar or land that can accommodate a solar array. Through solar neighborhoods, these benefits are expanded to a previously omitted consumer class. Individuals who rent or live in an apartment or multi-family home who typically would not be able to install rooftop solar can be given the opportunity to invest in solar and receive the many benefits it provides. In addition, people who live in dwellings with unfavorable solar access or insufficient space for solar can also participate. Finally, low- and moderate-income consumers who may not have the sufficient budget or financing opportunities to deploy solar independently can participate in solar neighborhoods. This also includes more risk-averse consumers, who may not want or be able to cover the upfront costs of a solar development.

2.2.1.2 Incentives for the community

In addition to the benefits to the individual consumer, solar neighborhoods bring several benefits to the local community. Many of these benefits directly support the local community where the project is developed. First, the local labor market benefits from renewable energy developments as there is direct demand for project developers and workers in construction and maintenance, and indirect demand for services to support these industries. Thus, increased solar developments would lead to an increase in job creation to fill this labor demand.

The public sector can benefit as well. The increased tax revenue from the project itself and any further development resulting from the project can be re-invested in the community, benefitting those even not directly involved in the project.

The benefits of solar neighborhood developments go beyond economic benefits. A community can also provide purpose to unproductive land. Land that was otherwise serving no local benefits can be reappropriated to provide a tangible service to the local community. Removing derelict land can reduce the presence of pests and illegal activity, as well as remove visually undesirable space. These factors can, in turn, raise local property values. In addition, communities increasing their energy independence can improve the reliability of the electric grid, thus reducing stress on the grid infrastructure.

Reducing the need for fossil fuels can decrease the emission of pollutants that might negatively affect air and water quality, local ecosystems, and overall public health. As a result, investment in renewable energy sources would improve the overall sustainability of the local community.

Figure 1: Picture of a 5MW solar development that was built on a 15-acre closed landfill in Beverly, Massachusetts, demonstrating how solar developments can breathe new life to unproductive land. Credit: BlueWave Solar.

2.2.1.3 Incentives for project developers

The economic benefits of solar neighborhoods extend to project developers as well. Due to the shared ownership structure of these projects, developers can spread the risk of operating and maintaining these developments across members of a community. For example, a subscription-based business model would allow developers to lower their operating costs by offering ownership in the project to members who pay a subscription fee. These business models and their benefits will be further discussed later in the report.

Table 1: Summary of economic benefits of solar neighborhoods.

Consumers (individual)	Neighborhood/society	Developers
• No need for property ownership (renters can participate) • No rooftop space necessary • Lower risk • Opportunities for lower income consumers • No upfront costs • Save on bill costs	• Land use reappropriation • Increased energy independence • Increase property values • Landowner benefits • Job creation	• Lower operating costs • Additional technology options • Land use/solar incentives

2.2.2 Market potential for solar neighborhoods

While understanding the incentives is important to recognize the main economic drivers of solar neighborhood developments, the actual market potential of these types of projects should also be identified. The economic viability of a project relies on whether there is demand for such projects and whether the business proposition of these projects adds value to society.

Renewable energy investments are appealing due to falling prices for renewable technologies such as solar photovoltaics or solar thermal systems, increased energy demand for buildings and transportation, and renewable energy portfolio standards that exist in some shape or form in many countries (IRENA, 2016). Solar demand specifically is expected to increase as well, with global capacity being forecasted to surpass 370 GW by 2027 (IEA, 2022).

Solar neighborhoods, specifically, have a unique position in the solar energy market since they do not adhere to a single archetype, and any two solar neighborhoods can look drastically different in terms of capacity, technology, land use, and building types (Singh, 2023). A distinction of solar neighborhoods versus other solar energy developments is that a single solar neighborhood can employ the use of multiple technologies and cover a mixture land types (e.g. combination of residential, schools, commercial areas, etc.).

This flexibility could lead to further opportunities for solar neighborhood developments versus traditional development types. In addition, these developments are less sensitive to the costs of a single technology versus, for example, rooftop solar systems which usually utilize photovoltaics or solar thermal systems. Solar energy is extremely cost-effective and is even the cheapest form of energy with the lowest levelized cost of electricity (LCOE) in many countries (IEA, 2023). As new, innovative solar technologies are developed and become more cost-effective, the strategy options for solar neighborhoods increases, and potentially boost demand for new and existing neighborhoods.

The investment climate for solar neighborhoods is largely contingent on the policies and incentives designed to drive growth for renewable energy. Renewable portfolio standards (or similar policies) are a major driver for renewable energy investment as they increase the presence of renewable energy in the energy mix (Barbose, 2023). National and regional tax incentives and rebates are also key drivers as they reduce the overhead costs of renewable energy projects. Policies such as net metering (and, relevant for certain business models, virtual net metering) make these developments more favorable as they provide a clear stream of operational revenue from the project. Finally, at the local level, the ease to obtain the necessary permits and approvals for a project would dictate the ability for a project to be successfully implemented.

Another key driver of solar neighborhood development is public approval and/or interest in participating in a solar development (Qazi, et al., 2019). Community investment can create additional growth and the sentiments of locals (i.e. acceptance or rejection of a potential development) can promote or hinder a project. Educating local communities of the social, economic, and environmental benefits of these developments could potentially drive demand. Initiatives that partner communities with developers can also further boost market potential.

2.2.3 Investment risks

Investment risks arise from several conditions. The main areas of potential investment risk are detailed below.

Political risk involves issues tied to the stability of the political climate in a country or region. If the political climate in a country or region is too unstable, then investment in a renewable energy project may be hindered. For example, an unstable government facing political distress may be less likely to earmark funds for renewable energy incentives. Alternatively, political unrest from one country may impact the investment risk of another; geopolitical tensions can result in cross-border investment risks or impact the manufacture of, for example, solar panels from one country which would impact the price of equipment to an importing country. In addition, the manufacturing or supply chain of solar panels may be affected if the political unrest occurs in a country that provides raw materials for the manufacture of solar panels.

Economic risks include changes in inflation, interest rate hikes, and/or currency devaluation. Economic downturn can negatively impact the investment climate for renewable energy developments and cause investors to pull funding. Demand decreases, supply shocks, and other market-related risks can all negatively impact a renewable energy development. The acceptance of a solar energy project from the local community is especially important for solar neighborhoods. Additionally, removal or reduction in renewable portfolio standards could lead to a de-prioritization of solar in the energy mix. If the demand for solar energy is low or tied to “not in my backyard” (NIMBY) sentiment, there could be fewer financing options for the project.

Supply shocks also pose a potential risk to the success of a renewable energy development. Energy projects must account for risk in the supply of whatever resource is utilized for the energy generation. Since solar production is dependent on sunlight, changes in weather patterns or obstructions from new construction can impact solar production. Permanent or extended changes in weather patterns due to, for example, climate change could negatively affect the long-term production and viability of a solar project. Finally, changes in energy prices can affect the profitability of a solar project. Similarly, the oversupply of solar power (i.e. due to too many other solar projects providing solar power to the market) can reduce project revenue.

Regulatory risks arise when governmental policies change the financial viability of a renewable energy project. For example, a change in policy can remove or reduce the level of subsidies for renewable energy projects, thus making these projects harder to fund. This also can occur due to changes in tax incentives, feed-in tariffs, or renewable energy portfolio standards which were crucial to finance a project.

Finally, **environmental risks**, such as an extreme weather event (e.g. earthquake or flood) can impair a development, leading to delays in construction or cause damage that impacts operation.

2.2.4 Stakeholders

Understanding the project stakeholders helps to identify potential partners in a project. The typical stakeholders in a solar energy project are as follows:

- **Project sponsor**: The organization that is initiating the development of the project. This could be a utility, a group of investors, a development company, or an organization looking to improve their community.
- **Project developer**: The organization that carries out the primary development of the project.
- **Project host**: The organization that owns and maintains the solar project once it is operational. This could be the same organization as the project developer or sponsor, or, for example, an organization that purchases the project after completion.
- **Project investors**: Any organization or individuals that provide capital to the project.
- **Local/regional/national governments**: Permitting, regulation, and policy support measures for solar projects are all vital for the success of the project.

- **Utility**: The utility is a crucial stakeholder if the project intends to connect the solar system to the grid and sell energy produced by the project to the utility (e.g. via net metering).
- **Local residents**: The local community will be concerned about the environmental and economic implications of the project.
- **Customer**: Depending on the business model, the project might have a single or potentially hundreds of individuals who have ownership in the development itself or the energy produced by the project.

Solar neighborhood developments can consider additional stakeholders as well. Since solar neighborhoods often include a collection of buildings—and the extent of the development affects the design and construction of the building itself—a key additional stakeholder for solar neighborhoods would be the **building/facility occupants**.

3 Financing solar neighborhoods

3.1 Project timeline

To understand the different financing options available for any renewable energy project, it is important to have an idea of the project timeline. The figure below shows a simplified view of this timeline. The three key phases include the development phase (split into early- and late-stage), the construction phase, and the operation phase of the project (U.S. Department of Energy, 2013).

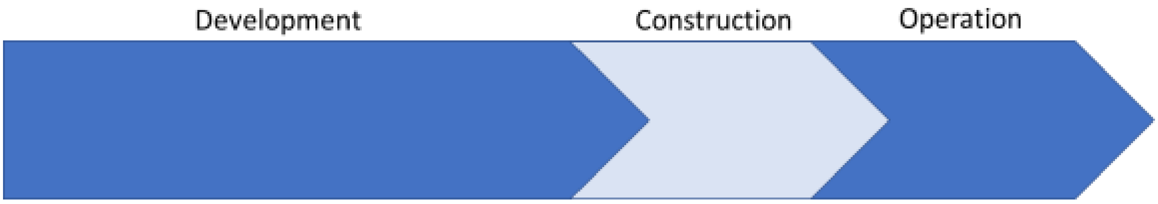

Figure 2: Simplified view of the project timeline.

The initial segment, the **development phase**, is arguably the most important phase of the project. Identifying and securing financing options occurs during this phase, which is also when the design, siting (including the purchase or lease of land), permitting, and contracts management takes place.

Once project planning has been completed during the development phase, the **construction phase** will begin. Financing will have needed to be secured by the beginning of this phase to cover the core overhead costs, or capital expenditure (CAPEX). These costs might include the purchase of construction material and payments to a construction company carrying out the construction.

Finally, once the development is constructed and operational, the **operation phase** begins. Further operating expenditure (or OPEX) will demand the need for further financing to be available during this phase. There are several financing options available during this phase to help the project reach a revenue-generating state.

3.2 Categorization of mechanisms

The next section offers a categorization of financing mechanisms to facilitate an improved method of matching potential measures given the demands of a solar neighborhood development. The key to these categorizations is understanding where they fall in the project timeline and the exposure to risk that the sources of these mechanisms might be comfortable with.

Financing renewable energy projects is not typically accomplished through a single source but using a mix of options. This mix of financing options is called the capital stack. Building the capital stack for a development requires careful consideration of the development timeline and the different risks that exist at varying points in the timeline. As such, financing is not usually procured all at once, but in different stages of the project via different measures.

3.2.1 Financing mechanism categorization

The first categorization of financing mechanisms breaks these measures into two categories: project financing mechanisms and financing support mechanisms. **Project financing mechanisms** are the primary sources of funding for a renewable energy project. While these mechanisms are usually identified and secured during the development phase of the project, these mechanisms are intended to provide capital for all stages of the project.

Alternatively, **financing support mechanisms** are supplementary mechanisms that provide means of reducing a project's operating costs (UN ESCWA, 2017). These mechanisms are identified during the development phase, though usually come into effect during the operational phase of the project. The main purpose of these mechanisms is to make project proposals more attractive to low-risk investors. Figure 3 is an adaptation of Figure 2 to include where these financing mechanisms are likely to appear during the project timeline.

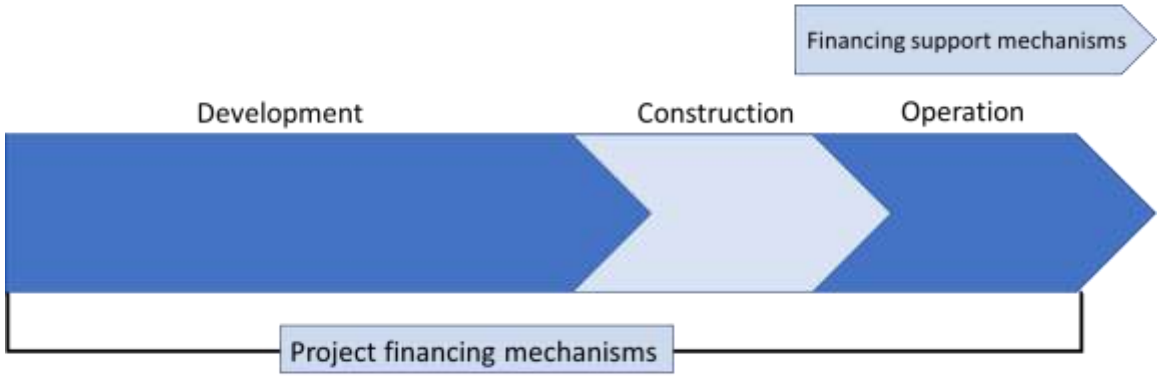

Figure 3: Project timeline including financing mechanism categorization.

3.2.2 Public/private categorization

The second categorization is also directly tied to the project timeline and the extent and nature of associated risks at each point on the timeline. The two overarching sources of financing are either from public or private sources.

The primary sources for public financing are local, regional, and national governments that are seeking to catalyze positive developments that might realize long-term economic and social benefits to society. In the case of solar neighborhoods project developments, the public sector would be attracted to the project's potential for supplementing clean energy efforts, providing high-skilled jobs, and galvanizing community efforts to improve their neighborhoods. As such, the public sector will provide financial incentives, such as tax rebates, while offering promising financing options such as grants and low-interest loans. The public sector is more willing to take risks to finance a solar project early in its insemination to reach a demonstration phase to help the project reach a state where it can attract further financing.

Private sector financiers usually prioritize mitigating their risk exposure given the level of potential return from the investment. Usually, these returns should come in the form of a short- to mid-term profit outlook. This means that the development is unlikely to be at its inception, but rather in a later phase in the project timeline and has successfully procured prior financing (for example, via public offerings). In addition, the social benefits of a solar project, such as clean emissions and job growth, are less valuable to the private sector. As such, earlier and/or high-risk investments from the private sector must be adequately rewarded with higher equity or debt offered with higher interest rates. Table 2 summarizes the different priorities between public and private sources of financing.

Table 2: Public versus private financing priorities and timeline.

	Public financing	Private financing
Priorities	• Promising proposals that increase use of clean energy • Projects that support local economic development • Long-term impacts of project	• Level of prior financing for development • Short- to mid-term profit outlook • Mitigated investment risks
Timeline	Early-stage development	Late-stage development, construction, operation

Due to the differences in risk that exist during the development phase, financing mechanisms can be further broken down by early-stage and late-stage development. The goal of early-stage development is to demonstrate the potential of the project. Since the viability of the project has not been proven, investors during this stage are exposed to much higher risk. As such, developers are less likely to attract meaningful funds from private investment firms during this stage.

The purpose of late-stage development is to bring the project to the construction and operation phase and bring the project to a revenue generating stage. At this point, the concept has been proven and, as a result, there is reduced risk for investors.

Figure 4 further adapts the modified project timeline shown in Figure 3 by including delineations for where public and private investment will typically come into play during the project timeline. In addition, the development phase is broken out into early-stage and late-stage to demonstrate an expected split in available financing resources during the development phase.

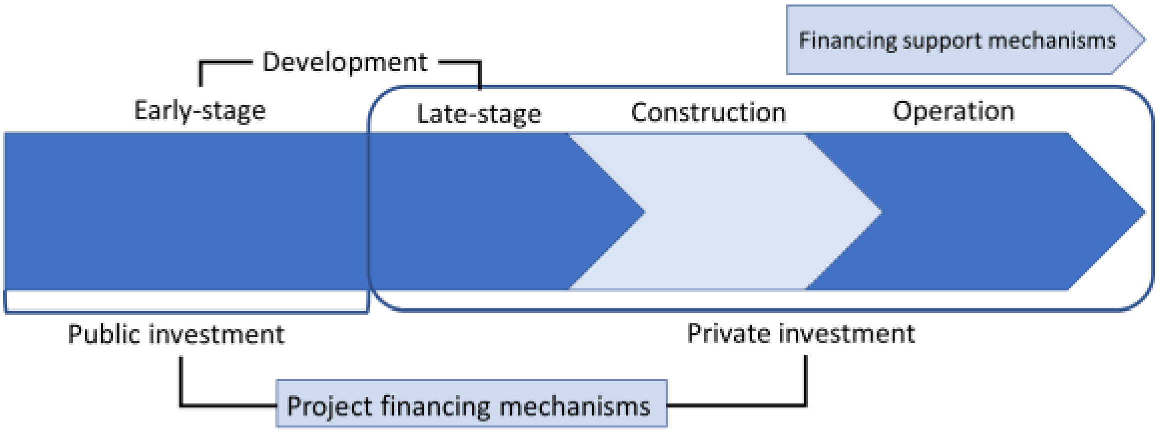

Figure 4: Project timeline including financing mechanism and public/private categorizations.

3.3 Financing mechanisms

Financing mechanisms can be broken out by traditional and innovative measures. Traditional financing mechanisms represent the most common ways financing can be procured for solar neighborhood developments, which are typically equity-based financing, debt-based financing, and grants (UN ESCWA, 2017). Innovative financing mechanisms make up novel and/or non-typical measures that generate value and revenue through alternative means.

3.3.1 Traditional financing mechanisms

3.3.1.1 Equity-based financing

Equity financing involves the sale of an ownership stake in a renewable energy project. Investors who offer capital for equity stand to benefit as shareholders in the project, with the right to the development's profits in addition to revenue earmarked for equity payments. Due to the high upfront costs of solar development projects, equity financing is a promising option for developers to attain a large influx of capital.

This type of financing is attractive to various types of investors, including:

- Private equity firms: Private equity firms, including venture capital firms, seek out early investment opportunities for high equity returns.
- Private individuals: Individuals can invest in solar via crowdfunding, microfinance, or community investment schemes.
- Investment institutions: Institutions such as banks, pension funds, and insurance companies might invest in a solar development as part of a larger clean energy investment portfolio.

3.3.1.2 Debt-based financing

Debt-based financing is a common source of early-stage financing for any development. Capital is borrowed from a debt-lending source, usually in the form of a loan or bonds. The principal amount along with any interest that is accrued are expected to be repaid to the lenders. It should be noted that due to the interest-bearing consequences of this form of capital, revenue is usually prioritized for the repayment of debt-based financing before equity payments.

Sources of debt-based financing include banks (both traditional, private banks and developmental, or "green", banks). Public institutions such as green banks offer more favorable loan conditions, including lower interest rates. The government of a country or region may also offer loan programs directly to qualifying projects.

Loans can take the form of a standard term loan with a fixed payback period and fixed interest rate. Alternatively, project financing allows developers to acquire loans by using the project assets as collateral. Finally, developers of especially large projects may be able to issue bonds that can be purchased by investors with the expectation that the developer will repay the bond's principal and accrued interest.

It should be noted that equity-based financing and debt-based financing are two of the most typical schemes for financing renewable energy projects. Comparing the risk of debt versus equity depends on whether a developer is adequately appeasing lenders or investors, respectively. Of course, debt finance is more sensitive to interest rates, but investors often have a more demanding profit return, which can be difficult, especially early on for operational projects.

3.3.1.3 Grants

Grants for renewable energy developments largely exist to galvanize local developments and climate change mitigation efforts. These grants are often crucial sources of financing for a solar development and, if secured, offer valuable capital that does not need to be paid back or result in the sale of project equity. However, grants typically have specific eligibility requirements. Most often, grants are offered by a federal or regional government who are seeking to incentivize clean energy developments and spark investment in this sector. Utility companies, non-profit organizations, and local community organizations can all be potential sources of grant-based financing.

3.3.2 Innovative financing mechanisms

3.3.2.1 Power purchase agreements (PPAs)

A power purchasing agreement, or PPA, is a popular financing mechanism adopted by developers to finance new projects and offers renewable energy where a high energy consumer can contractually agree to purchase energy from an energy producer.

PPAs represent a risk-free/low risk mechanism to finance renewable energy projects since the developer is not exposed to volatile energy market prices and do not require a complex hedging strategy. In addition, the developer also retains ownership as the customer buys the output of the project (energy) rather than the actual project. Open-source tools are available to assist large energy users, energy consumers, buyers' groups and local government to contract with off-site renewables projects through a PPA and therefore meet their renewables and emissions goals, assist in PPA monitoring and ensure value for energy consumers (CEEM, 2019).

An innovative model focused on retailer value is recently being rolled out by an Australian startup where households are provided with solar and batteries at no cost to consumers (PV Magazine, 2023). Aggregated solar households for the retailer allows them to pass on discounted energy rates to the households, incentivizing installation. Retailers use these assets as a Virtual Power Plant (VPP) to balance their hedging position and achieve cheaper energy contracts by flatlining the load profile of their portfolio. The approach is applicable to landlord/tenant arrangements and each system carries a not insignificant 10-year maintenance contract to entice solar installers to participate.

Much of the VPP smarts come on the software side as demonstrated by companies such as PowerLedger and their blockchain peer-to-peer PV strata solution at White Gum Valley Perth Australia where generated and stored power is sold directly to neighbors rather than exporting excess PV power to a retailer at a low price and being charged back higher kWh energy utility prices (Powerledger, 2018). Blockchain technology (similar to barcodes and scanners used at supermarkets to manage secure, high-volume transactions) is growing as an important cornerstone for decentralizing the energy grid.

3.3.2.2 Feed-in tariffs (FiT) / Feed-in premiums (FiP)

Feed-in tariffs (FiT) are contractually guaranteed above-market price for electricity producers, where electricity generated is sold on the spot market at an agreed fixed rate or at the spot price with an added premium.

Alternatively, Feed-in Premiums (FiPs) provide electricity producers a premium on top of the market price for electricity. Instead of a fixed rate, producers are paid the difference between the market price and the agreed-upon premium.

3.3.2.3 Reverse auctions leveraging FiT

Reverse auctions are an innovative way to secure an equitable price for supplied renewable energy that protects and benefits consumers, but also provides certainty for suppliers. Typically, an entity such as a local government will call for bids from suppliers to provide their best fixed price offer, they can deliver at a specified capacity of solar energy over a defined contract period. Evaluation criteria are set by the local government and bids are assessed based on best value for money. This also allows for criteria that requires, for example, a share in local manufacturing, community engagement and local economic development benefits (C40 Cities, 2018).

The Australian Capital Territory (ACT) government in Canberra has legislated for 100% renewable energy supply by 2020 and zero net emissions by 2050 and applied a synthetic reverse auction process. The winning bid is awarded a FiT price on a monthly 'Contract for Difference' basis by the ACT's electricity distributor, ACTEWAGL, who are required to pay the renewable energy supplier the difference between the FiT price for each MWh of renewable electricity generated and the value of that MWh in the wholesale electricity market. If the market price is higher than the FiT price, the supplier will be paid the difference and the savings are passed on to ACT consumers. FiT prices are fixed for 20 years and not indexed to inflation, so that as wholesale price of electricity increases over time, FiT payments go down and savings go up. All the renewable energy certificates associated with the generation are transferred to the ACT government (ACT Government, 2020).

3.3.2.4 Crowdfunding/Subscription model

Crowdfunding allows a developer to partially finance a project through a decentralized funding platform. In essence, if a developer offers subscription opportunities to crowdfunded investors, they can build a subscriber group that helps fund the upfront costs and participates in a solar neighborhood community program to partially cover the operating costs.

A subscription model for a solar neighborhood project allows community members the ability to own the output of a solar project (and, as a result, access the benefits) in return for a subscription fee. Subscribers stand to benefit from the output of a solar development via a peer-to-peer network, where prosumers (European Environment Agency, 2022) sell energy to consumers, or by receiving credits for excess generation via virtual net metering.

An example of this is the Križevci Crowd investment initiative in Croatia (Energy cities, 2020). This is a citizen driven solar investment where the local municipality uses funds from individuals to install a PV system to cover public building electricity consumption and pays back the citizens through fixed interest micro loan agreements involving monthly savings and revenue from surplus exported energy. The success of this approach led to the establishment in March 2020 of a local energy cooperative called KLIK (Križevci Laboratory for Innovation in Climate) to deliver a pipeline of new public-private projects (Net Zero Cities, 2022).

Similarly, solar leasing grants individuals the ability to lease the solar assets themselves—not just the output—via fixed or regular payments to the development's host, who maintains the solar facility and ensures its smooth operation.

3.3.2.5 Solar green bonds

Solar bonds are typically low-interest bonds used as a debt instrument for renewable energy projects. Similar to regular bonds, solar bonds are issued by the project developer to investors looking to make a return by investing in clean energy / their local community. These types of bonds should be certified as part of due diligence to ensure the issuers claiming benefits from green aspects of the bond are legitimate and not in fact greenwashing. Green Bond Principles (ICMA, 2022) and Green Loan Principles (APLMA, 2021) are voluntary guidelines that provide a framework for issuing and granting green bonds and loans, based on four core components: use of proceeds, process for project evaluation and selection, management of proceeds, and reporting. Similarly, the Climate Bonds Initiative is an organization that promotes the development of a global green bond market, by providing certification, standards, and research.

3.3.2.6 Green revolving fund

A green revolving fund is a pool of capital specifically allocated for renewable energy projects that generate cost savings. When these savings are eventually realized, they are pooled back into the revolving fund to be reinvested in other renewable energy projects. Green revolving funds can be established by an organization looking to finance energy saving projects internally, or by external organizations looking to finance renewable energy projects, such as local governments or non-profit organizations.

3.3.2.7 Microfinancing

Microfinancing is an effective strategy for investors to provide loans to individuals with limited to no access to credit or other financing options. This mechanism is particularly useful for residents of low-income, developing countries who do not have access to the same financing resources as residents of more developed countries and reducing poverty rates (Miled & Rejeb, 2018).

3.3.2.8 Certification programs and Carbon Offset initiatives

Renewable Energy Certificates (RECs) or Energy Attribute Certificates (EACs) (Bischoff & Ditze Energy GmbH, 2022) are certification programs aimed at meeting greenhouse gas emission reductions and driving a transition from fossil fuel to renewable energy sources. For example, each REC represents a certified generation of one amount of renewable energy (typically 1 MWh). These certificates are then traded and provide an offset to upfront capital costs of a solar system. The number of RECs are normally allocated based on the estimated annual generation potential of a given location (APVI) and scaled to reduce over time in line with anticipated decreases in system purchase and install costs. Such finance mechanisms have, for example, helped deliver 3.60 million PV installations in Australia, with a combined capacity of over 32.9 gigawatts (APVI, 2023).

The UN Carbon Offset Platform, is an e-commerce platform supported by the United Nations Framework Convention on Climate Change (UNFCC) where a company, an organization or a regular citizen can purchase units (carbon credits) to compensate greenhouse gas emissions or simply support action on climate (United Nations Climate Change, 2023). It also provides a carbon footprint and green events calculator to support citizens in climate action awareness and understanding the impact of taking carbon appropriate action. The Carbon credits through the awarding of Certified Emission reductions (CERs) help support renewable energy projects around the world, especially for communities from developing countries.

3.3.2.9 Mortgage incentives and Net-Zero Energy Social Housing

Long-term zero or low interest loans for solar systems paid back from energy savings or associated local government rates/taxes and re-mortgage finance linked to the improved asset value of a property once a system is installed have helped accelerate investment in solar by local communities. Recently, the Dutch government announced changes in mortgage rules set for 2024 to incentivize buyers towards renewable energy and energy-efficient homes. Properties with higher energy ratings, will receive larger mortgage loans, boosting their value. Conversely, homes with lower ratings are predicted to depreciate (Hitijahubessy, 2023).

Similarly, the Dutch and other European countries have implemented high-performance renovations to reduce the burden of energy utility bills for low socio-economic inhabitants. This social hosing net-zero energy renovations work well if coupled with energy performance contracts that factor in the behavior of building occupants. Such renovations require local government and developer investments aimed at delivering healthier living spaces and in turn, help reduce dependence and cost pressures on health services. (Pellegrino, Wernert, & Charti, 2022).

3.3.3 Application of categorizations

By considering the project timeline and the categorizations discussed in this section (see Table 3 for a categorization of some of the discussed financial mechanisms), we can infer some of the available financing options for financing various phases of the project. In addition to any available tax incentives and utility rebates, the project developer can consider the correct mix of financing mechanisms when creating their capital stack for their project.

Table 3: Categorization of financing mechanisms.

Project financing mechanisms		Financing support mechanisms
Public	**Private**	
• Grants • Government loans	• Equity • Bank loans	• PPAs • FiTs/FiPs • Subscribers

4 Solar neighborhood business models

4.1 Overview

As mentioned previously, solar neighborhoods typically span various building and land use types. A single solar neighborhood can include both residential and commercial spaces, and multiple solar strategies. As such, there could be multiple owners of these spaces, meaning multiple stakeholders who might be involved as developers and/or hosts of the project.

Business models that aim to promote development of these projects given these conditions must be appropriately designed for mixed ownership spaces. With that in mind, the definition of the business models described in this section are based on the discrepancy among the project's sponsor, owner, and host. An approach utilized by the U.S. Department of Energy was used to describe the business model developed in this report (Jason Coughlin, 2010).

4.2 Business models

Three business models were conceptualized: the Develop-to-Own model, the Develop-to-Release model, and the Develop-to-Host model. While other, potentially more common business models for solar developments certainly exist, the business models detailed in this section are specifically designed to promote solar neighborhood development. It should be noted that these business models only consider new developments—not models based on owner transfer or purchase of an existing development. In addition, it should be noted that the term "develop" does not constitute only new developments, but also retrofits of existing buildings.

4.2.1 Develop-to-Own model

An organization looking to develop and own/operate a solar neighborhood. This includes both an organization (e.g., group of building owners) looking to transition their existing land, building, or collection of buildings into a solar neighborhood or an organization looking to purchase/construct the space and buildings to develop a solar neighborhood. The developer owns the solar assets and its production and can also attempt to generate revenue from their facility occupants (in the case of a space with tenants).

4.2.1.1 Example

Jubilee Housing provides affordable housing in the Washington DC area, including the Maycroft Apartments complex (Mango, 2019), (New Partners Community Solar, 2022). To increase the energy resiliency of the complex, Jubilee Housing worked with developers to install a solar system with battery storage and a resiliency center that provides power critical services to its residents.

Figure 5: Solar arrays at the Maycroft Apartments complex. Credit: New Partners Community Solar, 2022.

4.2.2 Develop-to-Release model

An organization looking to construct a solar neighborhood and surrender full or part ownership once operational. This can be done by leasing out the solar assets to individuals and function similarly as a solar garden (in this case, the developer may elect to retain some level of involvement handling the solar neighborhood's operations as a service for lease owners). Alternatively, the developer might opt to forfeit full ownership of the entire development. For example, an investment group or development firm that wants to develop then sell a project for a profit, or a non-profit looking to develop a solar neighborhood then forfeit control to a community organization or firm better equipped to handle the operation of a solar neighborhood.

4.2.2.1 Example

The Harvard Community Solar Garden in Massachusetts, United States began as an initiative to connect local residents with solar developers (National Association of Home Builders, 2023). In this case study, community members organized to sponsor a solar garden that was developed by a third party and financed largely by solar leases purchased by individuals within the organization. Ownership of the project is spread among shareholders rather than being centrally owned.

4.2.3 Develop-to-Host model

An organization looking to construct a solar neighborhood and share the output of the project once operational. For example, the developer could utilize a subscription model in which they would still own the solar neighborhood assets, but the energy output and related benefits would be owned by individual subscribers.

4.2.3.1 Example

Som Energia is a Spanish renewable energy community with more than 77 000 members (European Environment Agency, 2022). Members pay membership fees, with benefits that include electricity supplied from 100% renewable sources. Part of this supply is directly from generating facilities that Som Energia has installed and owns themselves. Members can utilize the solar production for self-consumption, thus reducing their energy bill, while Som Energia can gain access to capital to make further installations and purchase solar panels in bulk.

4.3 Summary

The table below provides a summarized breakdown of the key differences between the models.

Table 4: Summary of business models for solar neighborhoods.

	Develop-to-own model	Develop-to-release model	Develop-to-host model
Sponsor	Consortium of building owners or community members or a single organization, such as a single building owner, a utility, or a private development firm	Consortium of building owners or community members or a single organization, such as a single building owner or a private development firm	Consortium of building owners or community members or a single organization, such as a single building owner or a private development firm
Developer	Project sponsor or third party developer	Project sponsor or third party developer	Project sponsor or third party developer
Owner	Project sponsor	Owners of individual leases (potentially with partial ownership of the project sponsor)	Project sponsor
Host	N/A	Third party host	Project sponsor or a third party host
Customer base	N/A	Community members, including residents of the neighborhood	Community members, including residents of the neighborhood
Potential financing mechanisms	Traditional financing mechanisms such as grants, equity-based financing, and debt-based financing. Innovative financing mechanisms such as PPAs and FiTs/FiPs.	Traditional financing mechanisms such as grants, equity-based financing, and debt-based financing. Innovative financing mechanisms such as PPAs and FiTs/FiPs. Crowdfunding may be employed via the sale of leases of the project to a customer base of individuals within the community.	Traditional financing mechanisms such as grants, equity-based financing, and debt-based financing. Innovative financing mechanisms such as PPAs and FiTs/FiPs. The subscription model may be employed where the host offers the output of energy produced be the development to a customer base of subscribers.

5 Conclusions

Solar neighborhoods are a promising way to capture all the economic benefits of typical solar energy projects and extend these benefits to the larger community. This is particularly relevant given the progressive transition of traditional centralized energy supply to increased levels of embedded and distributed renewable energy generation and storage in urban areas. Communities and individual building owners are gaining an intrinsic understanding of the value of becoming active prosumers of renewable energy—both as producers and consumers.

From an economic perspective, solar neighborhoods are exposed to the same risks as other solar projects but have the potential to exploit a larger range of technologies and possible investors than typical developments. It is important to understand the project timeline and the types and categories of financing mechanisms—both typical and innovative—to which solar neighborhood developments have access.

Due to the mixed land use and ownership of solar neighborhoods, business models should highlight the involvement of community members. This means allowing different ways for individuals to participate in a solar neighborhood, either as a sponsor, host, or owner. Therefore, to promote the dissemination of solar neighborhoods, business models should be designed to be flexible in terms of who develops and owns the project relative to who sponsors the project.

This report provides useful information to help raise awareness of the range of financing approaches and mechanisms that are directly applicable within the solar neighborhood context.

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