HEINRICH BÖLL STIFTUNG

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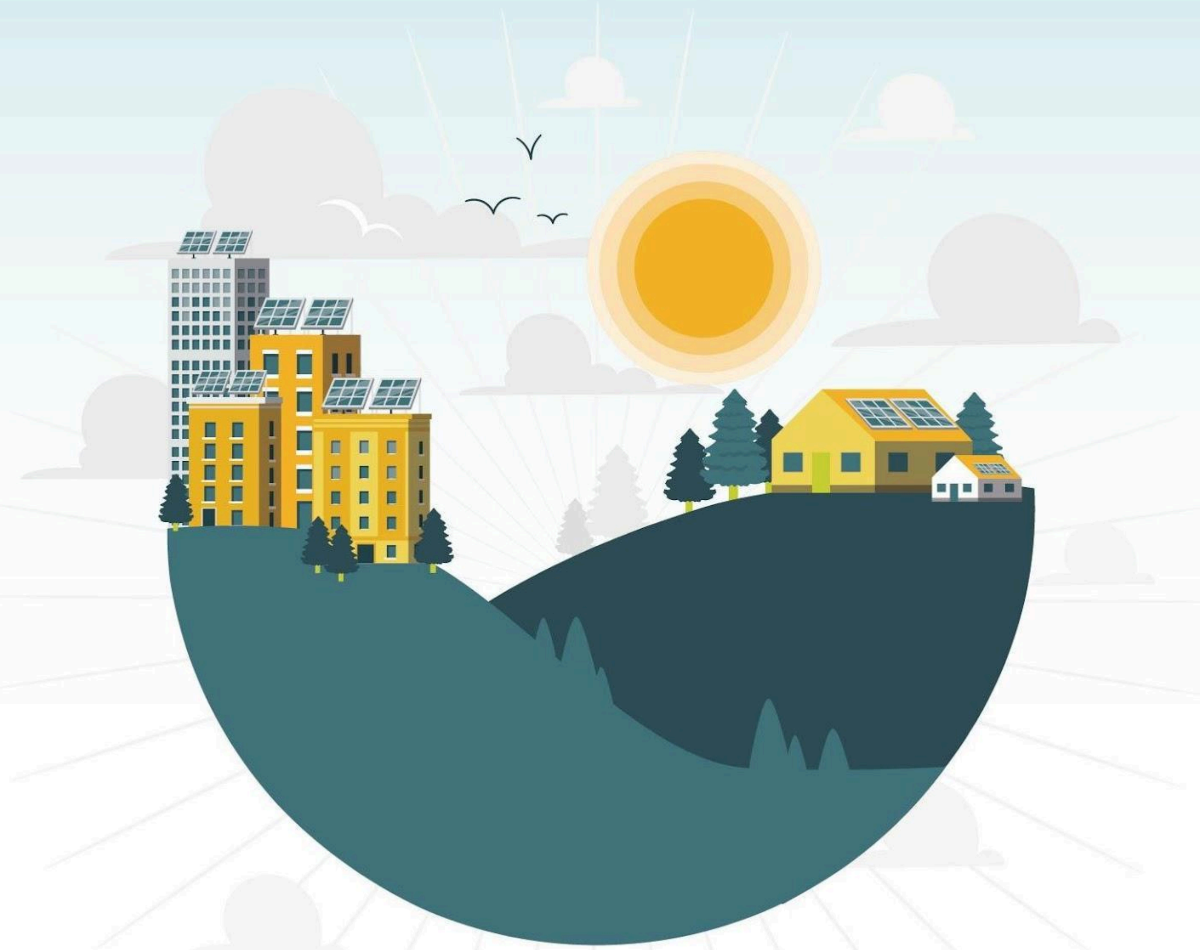
Heschel Sustainability Center

NZO

Renewable energy sharing among neighbors



PROJECT NZO
The Heschel Center for Sustainability
Heinrich BOELL STIFTUNG

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Preface

In the ever-evolving landscape of the energy sector, the necessary shift towards a decentralized grid stands as a significant catalyst for promoting a new era of sustainable energy. As the world struggles with the urgent need to transition to renewable energy sources, the restructuring of the electricity market becomes paramount. A decentralized grid plays a critical role in navigating the complexities of this transformative journey.

The decentralization of the electricity grid presents a unique opportunity to promote the generation of renewable energy in proximity to consumption sites. This strategic approach facilitates the integration of a greater share of renewable energy sources into the grid, bypassing the use of transmission lines, and thereby easing the grid congestion. The close proximity of energy production to consumption sites reduces the need for substantial investments in the development of transmission infrastructure, and minimizes electricity transmission losses. This holistic model marks a crucial advancement toward establishing a more resilient and sustainable energy landscape.

Supported by the *Heinrich Boell Foundation*, this paper assesses regulatory frameworks in several countries that encourage and support renewable energy generation near consumption sites. Within this context, the paper places a particular emphasis on a novel European regulation known as "Collective Self-Consumption" (CSC), a model facilitating the sharing of renewable energy among neighbors, which has emerged in European countries in the last few years.

This paper further delves into regulations that support the transition to a decentralized electricity grid in the United States. With an approach different than the European, The U.S. primarily encourages and subsidizes the utilization of solar power and battery storage. The U.S further facilitates various microgrid initiatives, a strategy with significant potential to enhance the country's transition to renewable energy.

We urge Israeli decision-makers to explore diverse approaches to energy-sharing projects and, in particular, to conduct a comprehensive investigation into the collective self-consumption regulatory framework. This regulation holds tremendous potential to further promote the transition to renewable energy in Israel.

Europe: Collective Self-Consumption[1]

Collective self-consumption (CSC) is an innovative regulation that enables sharing of renewable energy between neighbors. Initially, this regulation was aimed at encouraging the installation and use of photovoltaic (PV) systems in multi-apartment buildings. The necessity for a clear regulatory framework enabling and supporting this idea pushed several European countries to legislate such a solution. Over time, the need to expand this regulatory framework for sharing solar power in proximal buildings, has caused the regulation to change in several European countries, introducing the neighborhood scale of CSC.

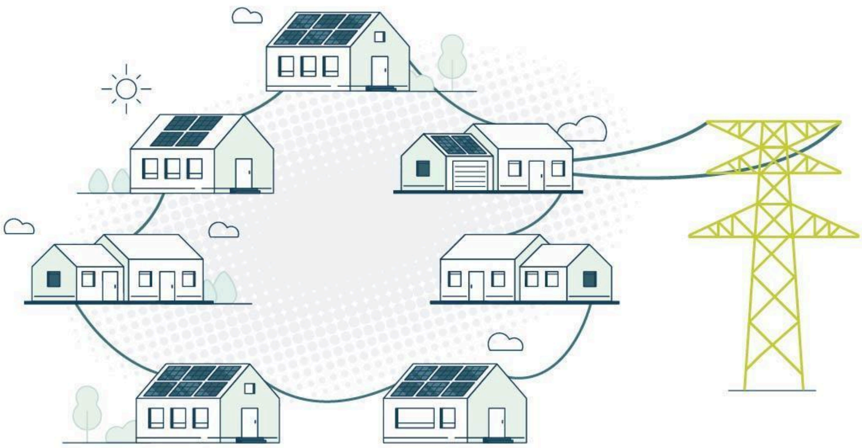
In 2018, The European Union's Renewable Energy directive (RED II) introduced the concept of *"collective self-consumption"*[2] for the first time. The RED II directive defines CSC as the collaboration of at least two renewable energy self-consumers within the same building or multi-apartment block, enabling them to share the renewable energy generated on their premises. It grants these collective self-consumers the right to generate, consume, store, and sell renewable energy. The directive exempts CSCs from network fees and other relevant charges, levies, and taxes applicable to each renewable self-consumer. Additionally, it provides CSCs with the flexibility to receive funding through various support schemes[3].

Aligned with the EU's framework, different European countries developed the regulation in accordance with their own guiding principles, resulting in significant variations. Nevertheless, certain fundamental principles remain consistent across most European countries.

[1] This chapter synthesizes information from the sources listed below.

[2] Jointly acting renewables self-consumers.

[3] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources ("RED II"), Official Journal of the European Union.



The "Basic" Model of CSC

Typically, CSC members are either prosumers (individuals who both consume and produce renewable energy) or consumers who share locally produced renewable energy. The CSC needs to get the Distribution System Operator's (DSO)[4] approval to operate, and sign a contract with the DSO for electricity supplied from the grid to its members. The energy produced by the CSC members can be sold to the grid at standard feed-in tariff.

CSCs may include one or more supplier(s), who would be in charge of renewable energy production, and an operator tasked with the project's management. The operator's role may include managing aspects such as billing, collecting data pertaining to energy consumption and production within CSC members, and interactions with the DSO. In some countries, the operator is responsible for ensuring energy supply to all CSC members, even when locally produced renewable energy is unavailable. CSC members sign contracts with the CSC operator that outline all relevant details, including electricity pricing for energy sharing.

The role of a CSC operator can be assumed by various actors, including the supplier(s), renewable energy communities (legally recognized entities), or a third party such as an electricity company. Notably, in certain countries, community representatives may assume the operator's role even without establishing a formal legal entity.

The CSC regulatory framework usually targets solar energy production on rooftops, wherein some countries do not limit the

[4] Distribution system operator (DSO) is the operator of the electric power distribution system which delivers electricity to most end users. In Israel, the sole DSO is the Israeli Electricity Company.

amount of solar power that can be produced within the CSC's premises. CSC can be formed in a multi-apartment building, a few nearby buildings, or in an entire neighborhood, depending on national regulations.

Furthermore, the geographical limit of CSC differs according to the countries' regulation: some countries set a limit of 2 km between production and consumption points[5], some only allow the establishment of CSCs if they have one single connection to the electricity grid, and others permit CSCs' consumers and prosumers to have a connection to the same transformer station. Sometimes the CSC is approved only if it uses a private or internal grid (such as an electric grid inside a building).

CSC has the potential to form the foundation for microgrids. Unlike microgrids, CSC does not mandate the integration of storage systems and management software, and remains consistently grid-connected.

As CSCs encourage local consumption of renewable energy, thereby lowering the congestion on the electricity grid, they are generally exempted from paying electric grid fees (or pay less). That is a key incentive, facilitating a more profitable selling price for producers and reducing the payback period for investors[6]. In addition, a CSC usually can set its own electricity price for the energy it produces. This joins an exemption of the CSC from other taxes and levies usually applied on renewable self-consumers.

In addition, CSCs can benefit disadvantageous populations in two ways: a third party can serve as an operator and supplier of CSC in low-income areas, charging low prices for the renewable energy it produces and sparing the initial investment in the PV systems. Second, disadvantages can become CSC members as consumers, even without a suitable roof for a PV system, enjoying lower prices for electricity[7.]

The next chapter will further discuss the CSC regulatory framework in 4 selected European countries, which were found to have particularly interesting and detailed regulations: Germany, Austria, Switzerland, and Portugal.

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[5] Such as Portugal, Spain and France.

[6] Anthony Roy, Jean-Christophe Olivier, François Auger, Bruno Auvity, Salvy Bourguet, Emmanuel Schaeffer, A comparison of energy allocation rules for a collective self-consumption operation in an industrial multi-energy microgrid, Journal of Cleaner Production, Volume 389, 2023, 136001, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2023.136001.

[7] See for example, a community CSC in Telheiras neighborhood in Lisbon, Portugal (PT); The "Buurzame Stroom" project in the city of Ghent, Belgium.

Germany[8]

Legislated in 2017[9], Germany's CSC legislation is known as the Mieterstrom (tenants' electricity), initially focusing on PV systems in multi-apartment residential buildings. The German Federal Ministry for Economic Affairs and Climate Action (BMWK) concludes that tenants' electricity has the potential to supply up to 3.8 million flats, about 18% of rented flats[10].

The German legislation enables a building's owner, landlord, a housing cooperative, an electricity service provider or other third party to supply solar energy directly to the building's tenants, thereby encouraging local consumption of renewable energy. The solar energy produced on the building's rooftop is consumed by the building's tenants, while the surplus electricity can be sold to the grid at regular solar feed-in tariff. When the PV installation does not generate sufficient electricity to meet the residents' demands, they will receive electricity from the public grid at the regular electricity pricing.

The regulation acknowledges 4 different active parties:

1. The end consumers - apartments renters in the building.
2. The supplier, who generates solar energy supplied to the end-consumers.
3. The operator[11], who is managing the project and in charge of the electricity reaching the end consumer.
4. The local DSO: which is responsible for electricity sold to or bought from the grid.

In Germany, the operator and supplier are usually the same person or entity. In practice, many landlords do not generate and supply the electricity themselves, but commission third parties and provide them with the required roof space. Many of these third parties are companies specializing in energy services[12].

In a Mieterstrom project, end consumers are required to enter into a single electricity supply contract with the operator[13]. This contract encompasses all their electricity requirements, including arrangements with the local DSO or other electricity suppliers for the

[8] This chapter synthesizes information from the sources listed below.
[9] Renewable Energy Sources Act (EEG 2017), The German Federal Ministry for Economic Affairs and Climate Action.
[10] Renewable energy sources in figures, National and International development, The German Federal Ministry for Economic Affairs and Climate Action, 2021, p. 41-42.
[11] In Germany, the Mieterstrom's operator must not be an end consumer of the solar electricity.
[12] Frequently asked questions about landlord-to-tenant electricity, The German Federal Ministry for Economic Affairs and Climate Action.
[13] Mieterstrom Q&A, The Federal Network Agency (GER).

energy consumed from the public grid. Mieterstrom projects does not mandate residents to participate, each renter in the building can decide annually whether they would like to join or remain in the project[14]. In Mieterstrom projects, the owner of the building is responsible for grid line maintenance[15]. Furthermore, there is no restriction on the amount of solar power generated in those projects[16].

Economic Incentives

The *Mieterstrom* offers several economic incentives for both the operator (which is typically also the supplier) and the end consumers:

End-Consumers Incentives

- Electricity price for the solar energy generated within the CSC is determined in the electricity contract. The agreed price must not exceed 90% of the local electricity tariff[17].
- Green electricity - generated from renewable sources.

Operator and Supplier Incentives

- Tenants' payment for the local renewable electricity consumed.
- A special subsidy, called "the tenant electricity surcharge", received from the local DSO[18]. Pricing is determined based on the installation capacity and the solar system's commissioning date. The surcharges generally range between 2-3 ct/kWh[19], and are financed through the federal budget[20] with guarantee for 20 years[21].
- Feed-in tariff for surplus electricity fed into the grid, also guaranteed for 20 years.
- Exemption from grid fees, as the electricity is directly supplied to end consumers without utilizing the public grid.
- Exemption from various taxes and levies, including electricity tax (see figure 1).
- The ability to set the electricity price (for the share of locally

[14] Frequently asked questions about landlord-to-tenant electricity, Federal Ministry for Economic Affairs and Climate Action.

[15] Source: An interview with Tobias Kelm, project manager and renewable energy policy expert, the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), October 10th 2023.

[16] In the 2023 amendment to the Act, the previous limitation of a 100 kWp installation per Mieterstrom project was lifted. Source: Solar systems on multi-unit buildings: tenant electricity surcharge and feed-in tariff: EEG 2023 Removal of the 100 kW limit, The German Federal Network Agency (GER).

[17] Energy Industry Act (EnWG) §42a Abs. 4, The Federal Office of Justice (GER).

[18] Frequently asked questions about landlord-to-tenant electricity, Federal Ministry for Economic Affairs and Climate Action.

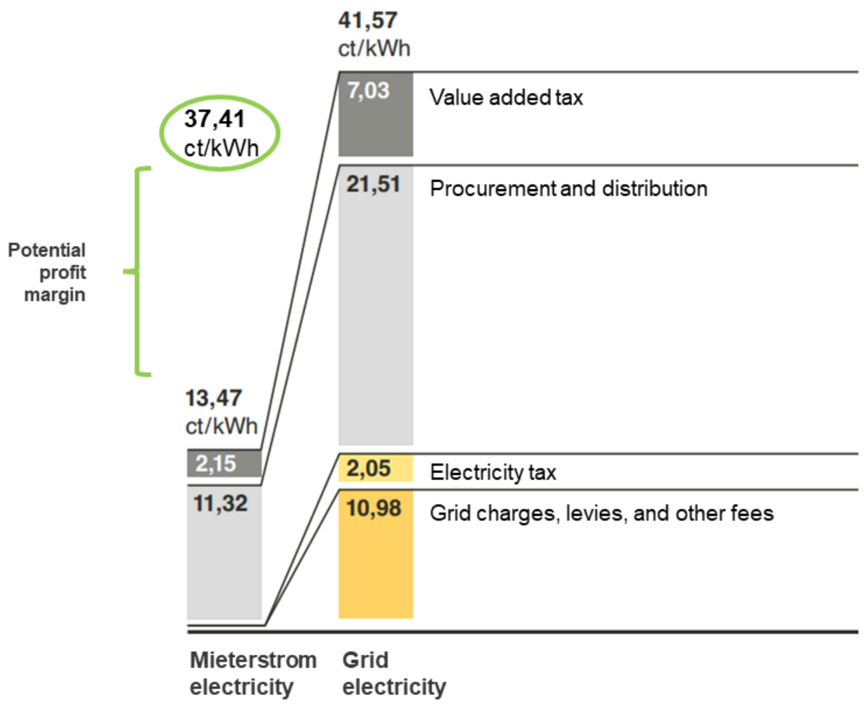
[19] In January 2021, the price range was between 3.79 ct/kWh (10 kWp) and 2.37 ct/kWh (100 kWp). Mieterstrom: Energy transition in your own home, Federal Ministry of Economic Affairs and Climate Action (GER).

[20] EEG-surcharge, The Federal Ministry of Finance (GER), confirms that from 2023 onward, all EEG related subsidies are financed via the federal budget.

[21] Mieterstrom: Energy transition in your own home, Federal Ministry of Economic Affairs and Climate Action (GER).

generated solar energy) at up to 90% of the basic local tariff. This is advantageous due to lower production costs, resulting in profits (see figure 1).

Figure 1: an example of electricity cost components for grid electricity (right) and tenants' electricity (left)[22]



Source: adapted from, Polarstern GmbH (GER) / reprinted with permission.

Billing System

Electricity billing in a *Mieterstrom* project relies on a combination of direct consumption from the PV system(s) and electricity sourced from the public grid. There are three common billing systems, with the summation meter model being the most widely employed (see figure 2)[23]:

According to the summation meter model, a PV system placed on the rooftop of a multi-apartment building is equipped with a generation meter (in orange) to measure the amount of solar energy generated; each apartment is equipped with its own standard electric meter (in green) to record individual consumption;

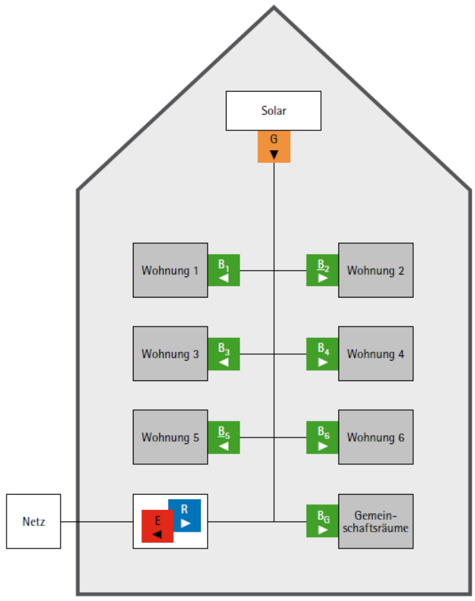
[22] Presented on the right is an illustration depicting an example of cost components for traditional grid electricity. Notably, Mieterstrom projects are exempt from grid charges, taxes, and levies, leading to reduced production costs, as shown on the left. Nevertheless, Mieterstrom operators have the flexibility to establish their electricity prices, which can reach up to 90% of the local electricity cost (as demonstrated by the example rate of 37.41 ct/kWh), presenting an opportunity for potential profit.

[23] Mieterstrom white paper, Polarstern GmbH (GER); Key issues paper on tenant electricity, Federal Ministry for Economic Affairs and Energy (GER).

while the entire building has a single connection point to the electric grid through a bi-directional meter (in red and blue), which measures both incoming and outgoing electricity flows to and from the public grid.
Under this billing system, tenants who opt not to participate in the *Mieterstrom* project are billed at the standard electricity price for their consumption. For tenants actively participating in the project, billing follows this procedure:

1. In order to calculate the amount of solar power consumed by the building's residents, the amount of solar power sent to the public grid is deducted from the total solar power generated.
2. Each apartment is billed for the solar energy based on its proportionate share of electricity consumption.
3. The remaining portion of their electricity bill is charged at the standard electricity price.

Figure 2: summation meter billing system



Source: [Virtual metering points: Metering concepts for solar power supply in rental buildings](), SonnenEnergie, Jun-Jul, p. 32-35, 2014 (GER) / reprinted with permission

Neighborhood Scale

In 2021, an amendment was enacted to enable the expansion of Mieterstrom projects to a neighborhood scale[24]. End consumers in a Mieterstrom project were allowed to include residents within the same building or buildings, in ancillary facilities in close proximity to these buildings, as well as in the same neighborhood as the buildings. The eligible structures encompass multi-apartment residential buildings and building complexes, allowing for a maximum of 60% commercial usage per building[25]. Regarding neighborhood-scale projects, there is no explicitly defined maximum distance to the generation facility.

However, neighborhood projects that rely on the public grid to distribute solar electricity to end consumers do not qualify for economic incentives such as grid fee reduction, the granting of a tenant electricity surcharge[26], and exemption from other taxes, charges and levies. To address this, a company may establish a private network infrastructure for the neighborhood. As such, the neighborhood-scale application of Mieterstrom is most attractive for new neighborhoods with private grid installations or a few buildings already interconnected behind a shared summation bi-directional meter.

GERMANY

- ✔ Building & neighborhood scale
- ✔ 1 electricity contract
- ✔ Offers a special subsidy

[24] What exactly is landlord-to-tenant electricity?, Federal Ministry for Economic Affairs and Climate Action, 2021.
[25] Renewable Energy Sources Act (EEG 2017), The German Federal Ministry for Economic Affairs and Climate Action.
[26] Renewable Energies Act (EEG) § 21 Abs. 3(2), The Federal Office of Justice (GER).

Austria[27]

Austria introduced collective self-consumption in multi-apartment buildings in 2017[28], promoting energy sharing in both private and commercial multi-party buildings, including apartment buildings, office buildings, and shopping centers, encouraging joint consumption of solar energy generated from these buildings' rooftops. Austria has even established its own federal coordination office for energy communities[29].

Neighborhood Scale

So far Austria has not implemented neighborhood-scale CSC, and the electricity produced through a CSC cannot be transferred through the public grid infrastructure. However, sharing renewable energy on a neighborhood scale can take place through renewable energy communities, which can function at both low-voltage ("local renewable energy communities") and medium-voltage ("regional renewable energy communities") levels of the electricity grid[30].

Economic Incentives

Certain states and municipalities within Austria offer support schemes for CSCs[31].

Moreover, Austria introduced reduced grid fees for electricity exchange within CSCs and other energy communities. Consequently, entities within the electricity system operating at different operational levels receives different incentives (see figure 3)[32]:

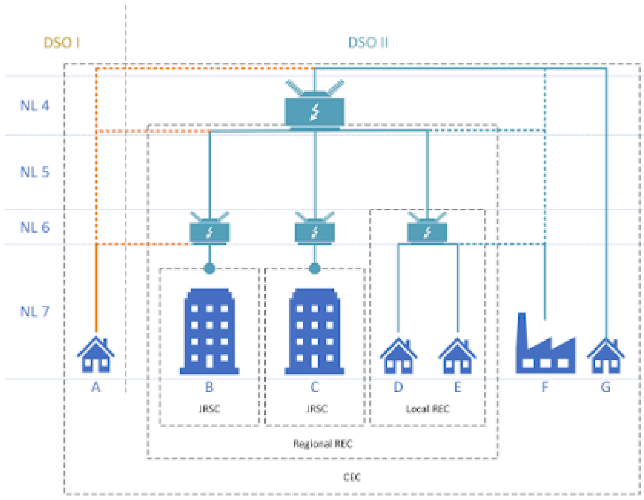
- Joint Renewable Self Consumption (JRCS, the Austrian model for CSC) are exempt from paying grid fees since they don't use the public infrastructure.
- Local Renewable Energy Communities (local REC) are eligible for grid fee deductions of approximately 60% for electricity shared via

[27] This chapter synthesizes information from the sources listed below.
[28] Austria: Collective self-consumers, Energy Communities Hub.
[29] See: Austrian federal coordination office for energy sharing (GER).
[30] S. Cejka, D. Frieden and D. Kitzmüller, "Implementation of self-consumption and energy communities in Austria's and EU member states' national law: A perspective on system integration and grid tariffs," *CIRED 2021 - The 26th International Conference and Exhibition on Electricity Distribution*, Online Conference, 2021, pp. 3254-3258, doi: 10.1049/icp.2021.1526.
[31] See example: The CSC municipal support scheme in the city of Graz (GER).
[32] S. Cejka, D. Frieden and D. Kitzmüller, "Implementation of self-consumption and energy communities in Austria's and EU member states' national law: A perspective on system integration and grid tariffs," *CIRED 2021 - The 26th International Conference and Exhibition on Electricity Distribution*, Online Conference, 2021, pp. 3254-3258, doi: 10.1049/icp.2021.1526.

the public grid.

- Regional Renewable Energy Communities (regional REC) qualify for grid fee deductions of around 30% for electricity shared via the public grid.
- Citizen Energy Communities (CEC) pay full grid fees, as they may utilize various network levels and even the infrastructure of multiple DSOs.

Figure 3: operational scopes for actors in the electricity systems in Austria [33]



Source: S. Cejka, D. Frieden and D. Kitzmüller, "Implementation of self-consumption and energy communities in Austria's and EU member states' national law: A perspective on system integration and grid tariffs," *CIRED 2021 - The 26th International Conference and Exhibition on Electricity Distribution*, Online Conference, 2021, pp. 3254-3258, doi: 10.1049/icp.2021.1526 / reprinted with permission.

Austria

✔ Building scale
✔ Neighborhood scale – only through RECs
✔ Differential grid fee

[33] Network levels (NL) 4 to 7 of the electricity grid, based on the voltage level:
• NL4: transformation from high to medium voltage;
• NL5: medium voltage (1kV to 36kV);
• NL6: transformation from medium to low voltage;
• NL7: low voltage (≤1kV).

Portugal[34]

Portugal introduced a legal definition of CSC in 2020 and made subsequent amendments in 2021 and 2022[35]. The Portuguese regulation largely follows the EU definition of CSC but includes certain variations, especially regarding the geographical limit on CSC.

Participating in a CSC does not require significant changes to electricity devices and infrastructure, except for the installation of smart meters; these are provided free of charge by the DSO in the framework of the national transition to a smart grid program. As of 2023, 60-70% of the citizens in Portugal already have smart meters[36].

End consumers involved in a CSC are required to enter two distinct contracts: one with the local DSO and another with the CSC operator or managing entity.

The Operator

Each CSC appoints a managing entity ("EGAC"), which represents the CSC among grid operators and administrative entities. The EGAC manages energy sharing, surplus selling, as well as the CSC's data.

The EGAC can be a company, association, non-profit association, building operator, or even a group of individuals. It can operate without registering as a legal entity, although this may pose specific operational challenges, particularly related to issues such as identification, VAT, and decision-making processes.

In Portugal, large energy companies can also serve as CSC operators. Those companies can both finance the PV installation and have the knowledge and the time to operate such projects.

In these projects, The local DSO is in charge of the grid line maintenance[37]. The operator must provide the DSO with the data of each member's energy consumption or with the respective sharing coefficient for deduction from the consumption measured by the electricity meters.

Collectively owned rooftops are very common in Portugal, and pose a challenge for CSCs. The local law requires consent of 2\3 of the households in a building to install a PV system. In addition, most residents don't want to have the initial investment for the PV system. Therefore, the option of large electricity companies managing the CSCs are more attractive.

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[34] This chapter synthesizes information from the sources listed below

[35] Portugal: Collective self-consumption and renewable energy communities, Energy Communities Hub.

[36] An interview with Miguel Macias Sequiera, Nova university of Lisbon, September 26th 2023.

[37] An interview with Miguel Macias Sequiera, Nova university of Lisbon, September 26th 2023.

Neighborhood Scale

In neighborhood CSCs, all end consumers and production units must use the same voltage level. Geographic limitations are imposed based on voltage levels. For low-voltage CSCs, the maximum geographic distance between production and consumption points is 2 km, unless both are connected to the same low-voltage transformer substation. For medium voltage, the limit is 4 km. Typically, PV panels are installed on one building, which can self-supply and sell surplus energy to neighbors within 2 km.

Licensing / Registration Process

CSC operators must license or register the CSC with the local DSO. The licensing process involves the submission of a file listing all members, specific electricity meter identification codes, and other specified information. The DSO must map all end-consumers to ensure they are within the specified geographic limits. This process is sometimes done manually, and therefore can be time-consuming, especially on a neighborhood scale. Due to a lack of personnel, licensing is a lengthy process, often taking 6-8 months[38].

Economic Incentives

CSCs on a building scale are exempt from paying all grid fees. CSCs on a low-voltage (2 km) or medium-voltage (4 km) neighborhood scale are exempt from transmission grid fees only. This payment is owed by the operator to the DSO.

CSCs also benefit from the deduction of CIEG charges associated with the costs of energy policy, sustainability, and general economic interest. Furthermore, government funding is available for CSC initiatives, with varying levels of financing for different types of buildings (e.g., residential buildings, public buildings)[39].

CSCs may establish a local price for the renewable energy they produce, which is typically lower than the market electricity rates, since solar energy is the cheapest energy source, and the production costs for CSCs are low. The local price can easily be more attractive than direct feed-in to the grid, since Portugal removed its feed-in tariff a few years ago.

Portugal

- ✔ Neighborhood scale – 2 km
- ✔ 2 electricity contracts
- ✔ Smart meters

[38] An interview with Miguel Macias Sequiera, Nova university of Lisbon, September 26th 2023.
[39] Portugal REC & CEC definitions, Enabling frameworks & support schemes, RESCOOP.EU.

Switzerland[40]

There are two distinct models for Collective self-consumption in Switzerland. The first model, the Communauté d'Auto-consommateurs (CA) model (also known as "DSO" or "DNO" practical model) supports CSC in multi-apartment buildings. This model wasn't clearly legislated, rather it was enabled by a change of the law, and spreaded with the help of different DSOs. The second model, "ZEV" (or "RCP") enables CSC between neighboring buildings. ZEV model was legislated in 2018.

The CA Model

The amendment to the Swiss Energy Act in 2014 enabled residents' direct solar self-consumption at a building scale[41]. Multiple DSOs have taken up the opportunity to offer CSC contracts to their customers, including tenants in rental properties, introducing the "CA model". Since the CA model is not clearly defined by law, it doesn't have a strict structure. Rather, it must address the demands of the local DSO and adhere to fundamental regulations governing the self-consumption of electricity.

According to the CA model, owners and residents of residential or commercial buildings can jointly consume locally produced renewable energy. The CA members must appoint a representative, and inform the DSO of their formation as such. The CA representative is responsible for managing the billing of self-consumption but can delegate this responsibility to a third party. Nevertheless, each member of the CA is considered by the DSO as a separate end-consumer, keeping the DSO actively engaged in its electricity procedures.

CA members agree on the price of self-consumed electricity within the legal framework. Since electricity is directly consumed by CA members, they are exempted from grid fees. Participation in a CA is relatively flexible, as members can enter or exit the community in different conditions.

However, not all DSOs have opened up the CA model possibility for its customers. For this reason, the federal government progressed further with the revision of the Energy Act at the beginning of 2018, introducing the Association for Self-Consumption (the "ZEV" model).

[40] This chapter synthesizes information from the sources listed below.
[41] FAQ: What will happen to the KEV in 2014?, Federal Department of the Environment, Transport, Energy and Communications (GER).

The ZEV Model

The ZEV model was introduced in 2018 as part of an amendment to the Energy Act and has clear legislative provisions[42]. Parties from one or more buildings can form a self-consumption association (ZEV) to jointly generate and consume solar power.

Options for the association's formation include a property owner/landlord establishing a ZEV and selling electricity to tenants/lessees, or a group of property owners establishing a ZEV together[43]. It does not have to become a legal entity to operate energy sharing activities[44]. In rental properties, a ZEV agreement can be incorporated as an addendum to the apartment rental contract, offering renters an accessible option for joint consumption of renewable energy.

ZEVs are suitable for neighboring buildings that share an internal or private grid infrastructure, and they must have one single connection to the distribution grid[45]. To establish a ZEV, the production capacity of the system(s) within the ZEV must constitute at least 10 percent of the total connected load for the community[46].

The ZEV functions as a single end consumer in relation to the DSO[47]. Consequently, the ZEV as a whole has one single contract with the local DSO, and the ZEV is responsible for all electricity supply to its members. ZEVs are to assign a representative responsible for measuring individual consumption, splitting electricity costs, and billing for individual electricity costs. However, the ZEV has the option to outsource these responsibilities to a third party, such as an electricity supplier.

No grid fees are required for the electricity produced within the ZEV, and the price ZEV members are charged must not exceed the price they would pay on the conventional network. Flexibility in ZEV membership is limited; it's only possible to opt-out at the establishment of the ZEV, as membership will be transferred to new tenants[48].

Switzerland

- ✔ **Building scale**
- ✔ **Neighborhood scale – one grid connection**
- ✔ **1 electricity contract**

[42] Most important changes to the energy law from 2018, Federal Department of the Environment, Transport, Energy and Communications (GER).
[43] Swiss Energy Act Energiegesetz, EnG: SR 730.0 Art.17 (GER).
[44] Self-consumption guide, EnergieSchweiz, 2023 (GER).
[45] Swiss Energy Ordinance Energieverordnung, EnV: SR 730.01, Art 14.2.
[46] Swiss Energy Ordinance Energieverordnung, EnV: SR 730.01, Art 15.1.
[47] Swiss Electricity Supply Ordinance Stromversorgungsverordnung, StromVV: SR 734.71, Art. 23.
[48] Swiss Energy Act Energiegesetz, EnG: SR 730.0 Art.17 (GER).

Case Studies

Residential CSC in the French Harmon'Yeu project

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In Luesslingen, a small town located midway between the Swiss cities of Bern and Basel, an industrial collective self-consumption project for renewable energy has been successfully implemented since 2018. This initiative is centered on an industrial production and commerce site where a remarkable installation of 280 kWp installed capacity solar system covers a timber company's rooftop. The operation of this solar installation is overseen by a cooperative known as *OptimaSolar*. In exchange for offering their rooftop space, the timber company receives a share of the cooperative, equivalent to five percent of the net investment costs. They also gain access to the electricity generated by the solar panels. This renewable electricity is primarily consumed by the timber company itself and three neighboring companies[49].

[49] Industrial area in Lüsslingen, Strausak wood construction company (GER).
Solar self-consumption association: Challenges and success factors, Energie Zukunft Schweiz, 2019 (GER).Solar Power, OptimaSolar (GER).

Residential CSC in the French Harmon'Yeu project

The residential CSC pilot project known as Harmon'Yeu on Île d'Yeu, an island located just off the western coast of France, has demonstrated such success that participants have chosen to continue and manage the project themselves. The project was originally launched in 2020 for a two-year trial period and was spearheaded by the international utility company *ENGIE*. The innovative initiative involved the installation of 23.7 kWp on the rooftops of five participating households. These households collectively produced and consumed the energy generated alongside another 18 nearby participating households. The project was equipped with a 15 kWh battery storage system in one home. What sets this collective self-consumption community apart is the inclusion of a unique software system that facilitated smart electricity distribution. The renewable energy generated by this community managed to cover 28% of their energy requirements. Recognizing the value and potential of the project, participants decided to acquire the infrastructure from *ENGIE* at the conclusion of the pilot period. One year later, the operation and distribution responsibilities were fully transitioned to an association, which now serves as the legal entity overseeing the CSC[50].

[50] Solar Energy- Harmon'Yeu, Engie.
Sophie Fabrégat, Harmon'Yeu: collective self-consumption on a residential district, Actu Environnement, 2023 (FR).

CSC on an university campus in Grenoble, France

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In 2022, Université Grenoble Alpes became the first French higher education institution to actively participate in collective self-consumption of renewable energy on its campus. The university installed a solar capacity of 195 kWp on one building, and plans are in motion to introduce an additional 150 kWp on a second building in 2024. The university is aiming to expand its solar energy production over the coming decades, promoting collective self-consumption within its educational community[51].

[51] First experience of collective self-consumption in a university, Grenoble INP- UGA, 2023 (FR). Thomas Richardson, University of Grenoble: a pioneering collective self-consumption system in France, L'essor newspaper, 2023 (FR).

Decentralization in the United States[52]

The United States's approach toward decentralization of the electric grid is different from the European one. The Federal administration encourages decentralization mainly by financial incentives, such as 30% tax credit for residential solar systems[53]. The U.S facilitates various projects that promote energy sharing among neighbors.

Microgrids

The U.S Department of Energy (DOE) views microgrids as an essential part of the electricity system by 2035[54]. The DOE defines microgrids as: *"a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode[55]."* The DOE is currently preparing to integrate microgrids in the electricity market.

Community Solar

A Community Solar project, also known as Shared Solar, is defined by the U.S Department of Energy as a purchasing program for solar power by multiple customers[56]. Community solar customers buy or lease a share of the renewable energy generated by a solar array, and receive an electric bill credit commensurate with their share in the solar system, as the local DSO pays the community solar energy supplier for the energy generated. This credit is generally used by consumers to reduce their electricity expenses, and it is directly applied to the customer's electricity bill. The projects' PV systems may be located on private, industry, commercial or public buildings, or any location with suitable solar resources. The systems may be installed near or afar from the customers, who may be individuals, businesses, nonprofits, renters, or residents of multi-tenant buildings, including those without a suitable roof for a PV system or the financial option to

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[52] This chapter synthesizes information from the sources listed below

[53] Homeowner's Guide to the Federal Tax Credit for Solar Photovoltaics, Solar Energy Technologies Office, The U.S Department of Energy.

[54] Microgrid Program Strategy, Office of Electricity, U.S Department of Energy.

[55] DOE Microgrid Workshop Report, Office of Electricity Delivery and Energy Reliability Smart Grid R&D Program, 2011.

[56] Community Solar Basics, Solar Energy Technologies Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

purchase one. In terms of ownership, the projects may be owned by a community, investor, or a partnership of a community with a third party. Some projects, then, can be jointly owned and operated by a community within a specific geographic area or in a multi-apartment building.

California[57]

California's transitioning to a decentralized renewable-based energy market – *inter alia* due to its vulnerability to wildfires and need for energy resilience and independence – are one of the state's greatest efforts. Since 2019, the state of California has required the installation of solar energy systems on low-rise single-family and multifamily buildings[58]. In 2022, California has expanded its standards, requiring the installation of solar photovoltaic and battery storage systems for newly constructed nonresidential buildings and for newly constructed high-rise multi-apartment buildings[59].
California offers different incentives for installations of PV and storage systems. This includes programs for multi-apartment affordable housing[60]; rebates programs[61]; funding program for community microgrids in vulnerable communities[62]; and more.

Community Microgrids

In 2021, California has legislated microgrid tariffs and rules to encourage commercialization of microgrid projects[63]. Community microgrid initiatives are actively operating in California, examples includes:

- The Borrego Springs community microgrid project was established to provide renewable energy to approximately 2,500 residential and 300 commercial and industrial customers. Its location makes the microgrid initiative more attractive as an idea, since it is sensitive to outages both because of extreme weather conditions and because of the electric infrastructure design. The project is integrating community and third party owned PV systems and battery storage[64].

[57] This chapter synthesizes information from the sources listed below.
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- The Menifee community microgrid includes residential smart homes connected to solar systems, battery storage, and bidirectional electric vehicle charging stations. The microgrid is supplying electricity to its members, while assuring energy resilience[65].

New York[66]

Expressing a commitment to energy and climate justice, New York established ambitious goals in terms of the state's transition to renewable energy: 70% renewable-based electricity by 2030 and zero emissions by 2040[67].
Accordingly, it offers different economic incentives for installing PV and storage systems, including a tax credit of 25% for the cost of residential solar systems[68], funding for energy storage paired with solar systems[69], and residential PV systems financing programs[70].

Community Microgrids

New York seeks to incorporate microgrids in its energy market; for example by awarding prizes for microgrid initiatives[71]. Community microgrid projects are active in New York, enabling neighbors to share the renewable energy generated on their homes, including:

- Gowanus and Park Slope neighborhoods in Brooklyn share solar energy produced on their rooftop with their neighbors. This project is focusing on trading renewable energy by a designated platform[72].
- The Long Island Community Microgrid Project, located in East Hampton, New York, contains wind power, solar power and battery storage, thereby help to reduce the need for further expansion of the electric grid, while maintaining energy resilience during outages[73].

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[65] Peter Johnson, The first all-electric community powered by a solar and battery microgrid launches in California, Electrek, 2022.
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Conclusions

Promoting the generation of renewable energy in proximity to consumption sites is pivotal for the integration of renewable energy in the electricity market. Facilitating sharing and trading of renewable energy among neighbors, thereby incentivizing increased consumption of locally produced renewable energy, represents a significant stride in this decentralization process.

Collective Self-Consumption is a regulatory framework that facilitates and encourages sharing of renewable energy among neighbors. This framework operates on the premise that renewable energy generated on building rooftops is directly consumed by the nearest consumers. This approach simplifies the process by eliminating the need to continuously monitor the exact consumption data of locally produced renewable energy.

CSC represents a novel and emerging regulatory framework, and its impact is expected to become more evident in the coming years. Key considerations for the success of CSC initiatives include (1) ensuring its economic viability compared to alternative solar energy selling options, (2) launching a visible campaign to introduce this option to energy producers, and (3) minimizing bureaucratic hurdles.

At this stage, it is challenging to determine which country has established a superior CSC regulatory framework, given the novelty and constant evolution of the concept.

While the American approach to renewable energy sharing among neighbors does not employ a comprehensive model like CSC, it promotes energy sharing through simpler economic models and through microgrids. The increasing prevalence of microgrids in the American electricity market provides valuable experiences to draw upon.

As a more comprehensive economic model, we advocate for Israeli decision-makers to thoroughly explore the local implementation of CSC. Nevertheless, the American models contribute to enriching our perspective on renewable energy sharing and offer opportunities to learn from their practical experiences.

Appendix: CSC Legislation in Various European Countries

Country	Description	Sources & additional information
France	CSC installations may be situated within the same low-voltage grid, provided that the distance between production and consumption points does not exceed 2 kilometers for a combined power output below 3 MW in urban areas and 0.5 MW in rural areas. It must be operated by a legally recognized entity.	France, Energy Communities Hub. Self-consumption framework in France, Directorate General of Energy and Climate (DGEC), Ministry of Ecological Transition, 2018. What is Collective self-consumption?, Maîtriser Mon Énergie, 2022 (FR). Case study: Ydéal Confluence in Lyon, France (FR).
Spain	Collective self-consumption of solar power is permitted within 2 km between consumption and production points. It can operate either "with surplus", allowing the sale of excess energy to the grid, or "without surplus".	Community energy policies in Spain, The European Commission. Spain, Energy Communities Hub. Clean energy for EU islands:Study on regulatory barriers and recommendation for clean energy transition on the islands:Spain, The European Commission. Collective self-consumption guide, Institute for Energy Diversification and Saving (IDAE), 2023 (SPA).
Sweden	Collective self-consumption in Sweden is only possible within the same multi-apartment building. Typically, CSCs enter one electricity contract with the DSO, incorporating the electricity costs into the rent. Consumption measurements are conducted internally, influencing the monthly rent.	National Survey Report of PV Power Applications in Sweden, Swedish Energy Agency, 2021. Sweden, Energy Communities Hub. Pasina, A.; Canoilas, A.; Johansson, D.; Bagge, H.; Fransson, V.; Davidsson, H. Shared PV Systems in Multi-Scaled Communities. Buildings 2022, 12, 1846. https://

		doi.org/10.3390/buildings12111846
Italy	Collective Self-Consumption is restricted to the same building or condominium. Renewable Energy Communities (REC) are limited to 200 kW, positioned within the low or medium voltage network behind the same transformer station (MV/LV substation).	Community energy policies in Italy, European Commission. Italy, Energy Communities Hub. Energy communities in Italy: legislation and future scenarios, Regalgrid.
Belgium	Belgium permits energy sharing on a building scale, facilitates neighborhood-level exchanges through energy communities, and supports peer-to-peer energy exchange.	Belgium, Energy Communities Hub. Energy communities and energy sharing within the same building, Wallonia Energie SPW (FR). Energy sharing in Brussels, Brugel (FR). The principles of energy sharing in Brussels, Sibelga (FR).
Finland	Energy sharing within a building or among nearby buildings with a single grid connection point is facilitated by energy communities. This includes renewable installations and storage capacities below 1 MW. The local DSO oversees metering measurements in these communities.	Prosumers and Active Self-consumption, Energy Authority. Energy communities, Nordic Energy Research, 2023. Finland, Energy Communities Hub.
Luxemb-ourg	Collective self-consumption encompasses three models: within a single building; among buildings within a 100-meter range; or within 300 meters through local energy communities.	Sharing my photovoltaic electricity in an energy community, Governmental Klima Agence. Sharing solar energy through collective self-consumption, Governmental Klima Agence. Electricity Sharing, Luxembourg Regulatory Institute.

Slovenia	In Slovenia, collective self-consumption is permitted in two modes: within multi-apartment buildings and through Renewable Energy Sources (RES) communities. For RES communities, end-consumers are required to be connected to the same low-voltage transformer station as the production unit.	Slovenia, Energy Communities Hub. Mackenzie Banker, Collective Self-Consumption in the European Union, Master Thesis: MSc Energy for Smart Cities, Escola Tècnica Superior d'Enginyeria Industrial de Barcelona 2020. Case Study: First self-sufficient renewable energy community in Slovenia, Climate Action Network (CAN) Europe.

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The NZO Project

The Net ZerO emissions (NZO) project was founded by the Heschel Center for Sustainability in 2019 with the ambitious goal of promoting Israel's transition towards renewable energy. NZO develops cutting-edge models, tools, and recommendations to accelerate the nation's transition to a renewable-based energy sector. NZO places a significant emphasis on maximizing dual-use installations of photovoltaic systems, and advocates for a Just Transition to renewables. Through data-based research and on-the-ground fieldwork, NZO has successfully presented a valid roadmap towards renewable-based electricity in Israel. The NZO project, composed of volunteering experts, has been a leading civil society effort in the promotion of the Israeli energy transition.

Found a mistake? Please let us know NZO@Heschel.org.il

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[75] Miguel Macias Sequiera, a PhD candidate researching energy communities and energy poverty in the Center for Environmental and Sustainability Research (CENSE), Nova university of Lisbon, and a volunteer for the Local Partnership of Telheiras.

[76] David Ritter, senior researcher, Energy and Climate Protection, the Oeko Research and Consulting Institute for Sustainability.

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