Collective Self Consumption projects: The lever to unlock access to local renewable electricity

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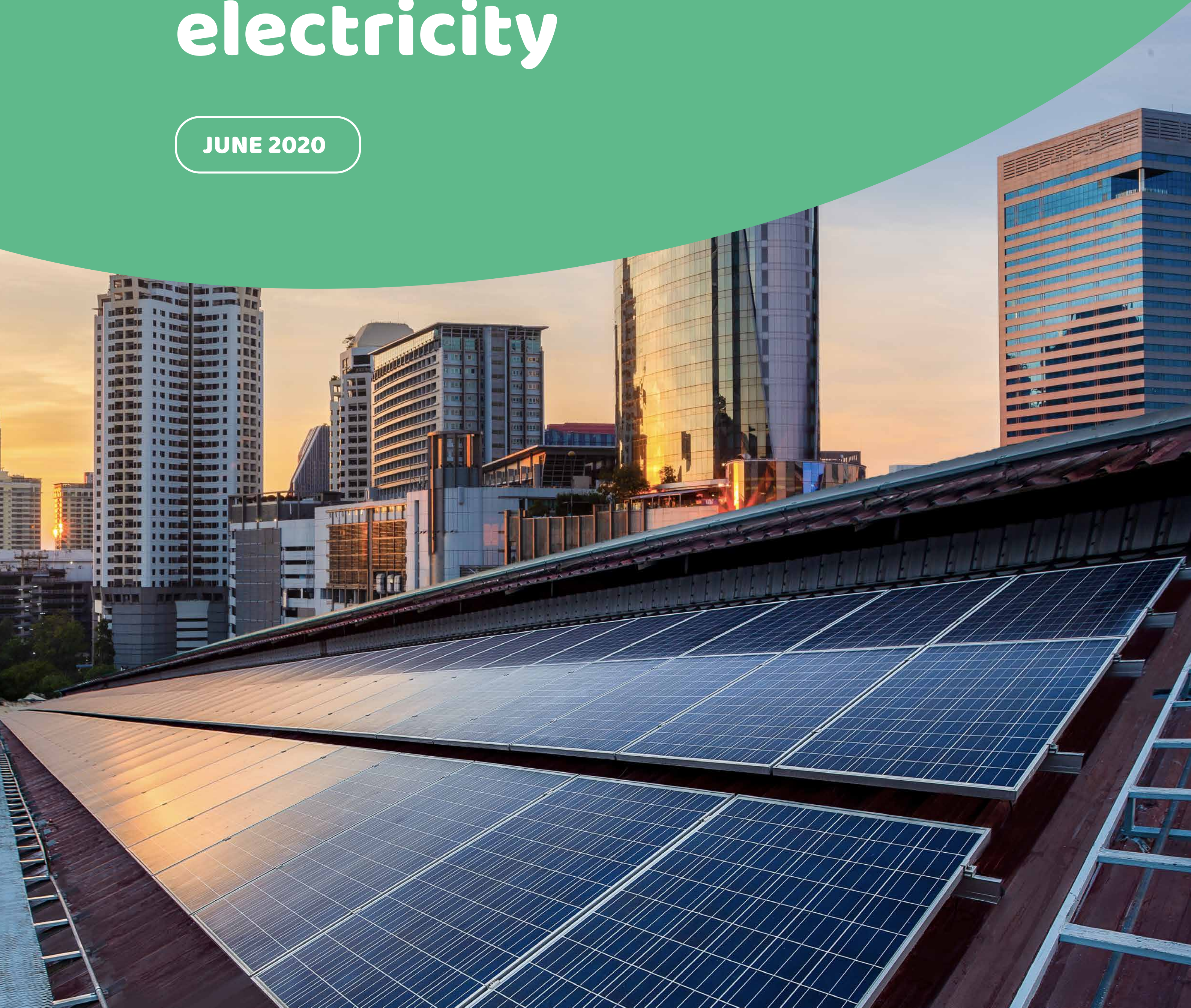

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Executive summary

Collective Self-consumption (CSC) is a framework that supports the energy transition in the electricity sector by facilitating the collective sharing of renewable electricity generation assets within a community of prosumers[1]. The boundaries of the community are generally restricted to a neighbourhood, a district or an industrial consortium. Unlike microgrids, a CSC project is always connected to the public network, does not intend to allow end users to disconnect from it (islanding) and allows multiple (rather than single) end users benefiting from shared distributed generation installations. Unlike VPP[2], CSC relies on consumption and generation nodes located in the same area.

The primary role of CSC will be to stimulate local electricity generation technology uptake, like solar energy, by addressing market segments which would be excluded from distributed generation otherwise, including some of the four billion energy consumers currently living in urban areas. For end users in buildings' flats or businesses without space to install their own distributed generation, a CSC project is indeed the solution to make them benefit from local electricity resources installed in their neighbourhood. **On the other hand, CSC also allows owners of distributed generation to maximise the value of the electricity they generate by monetising it locally.** In many regulation frameworks that did not implement net metering scheme or removed it, the surplus of electricity locally produced within an end user's premises and exported onto the public network is indeed monetised at a price close to the wholesale electricity price (which is much lower than the retail price). As such, it does not deliver enough value to incentivise end users to maximise the local generation on their premises. This is for example the case for large rooftops not being fully covered with PV to avoid any surplus to be injected onto the public network.

CSC projects around the globe are highly dependent on local energy regulation and suffer from uneven market conditions (mostly driven by the level of the electricity retail tariff). For example, modelling of projects in France and Germany shows huge discrepancies in project profitability: with low retail tariffs, France does not generate profitability on CSC projects in current market conditions whereas Germany does, mainly thanks to high retail tariffs along with tax and network tariff incentives. CSC emergence also needs basic regulatory framework conditions like the ability to share electricity between prosumers at a reasonable cost. In most countries, sharing electricity flows between consumers using the distribution grid requires the intervention of an electricity retailer, which adds up to the project costs and damages its profitability. Some countries such as Germany, Switzerland or Australia allow sharing electricity either within the same building or within the same area, provided the network used remains privately operated. Only a few countries, such as Brazil and France, were identified as having implemented a scheme to allow electricity to be shared through the public network without having to go through a retailer.

For those reasons, global CSC development is at its very early stage with less than 100 MW of CSC projects currently installed and concentrated on few hotspots, namely Australia, Switzerland, France, Germany with very specific regulation leading to high specificities in the projects observed. Even when key regulatory barriers are removed, projects' development is limited: France implemented a dedicated regulation allowing prosumers to use the public electricity network. There are still under 20 projects in operation with a French ambition to have 50 CSC projects by 2023. In Germany, the government introduced the much simpler *Mieterstrom* regulation targeting single buildings (where the public network cannot be used), allowing landlords to set up a very simplified supply business and financially incentivising

1 Electricity consumer producing its own electricity for its own needs and/or to share it with other consumers.

2 Virtual Power Plants

projects. The regulation only generated 162 projects amounting to 4 MW on the first year of regulation introduction.

Among distributed energy production technology, solar energy is and will be the easiest technology that can be collectively self-consumed. **As such, CSC projects could take a large market share among the 150 GW residential and commercial PV to be installed between 2019 and 2024**[3] **without feed-in tariff support or net metering regulation. They will first emerge in countries with high electricity prices, good solar conditions and no key regulatory barriers.** Countries like Germany for example show a positive business case on *Mieterstrom* CSC project, principally due to the high retail tariff and, to a lesser extent, favourable regulatory conditions. In other countries with less favourable electricity price conditions but with regulation allowing their development – and provided the regulation allows such projects to exist – it can be foreseen that small and 'simple' projects - focused for instance on residential customers restricted to single buildings and fed with ~100 kW rooftop PV - will naturally emerge in the next five years thanks to external factors such as declining solar CAPEX, improved solar efficiency and possibly reduced taxes and network tariffs.

In addition to good solar conditions, proper retail conditions and regulation support, the success of CSC projects scale up will rely on two key business conditions: value chain organisation and standardisation of project business models. These conditions are crucial in that CSC projects may be perceived as complex in their structure: they involve multiple end users decorrelated with generators, a value chain of players not accustomed to work together and rely on a recent and still evolving regulatory framework.

In this context, an essential success factor for CSC is the existence and strong involvement of a project facilitator. CSC projects are indeed B2C / small B2B projects by nature: customers are distributed and can have a risk-adverse stance towards CSC projects (too much risk for too small benefits). There is thus a need for trusted parties initiating and promoting the CSC project and facilitating end users' involvement through being their single point of contact. Project facilitators can be easily identified by project developers as, in most project configurations, they are existing parties such as municipalities, landlords, cooperatives… with a historical interaction with end users. These players are also very well positioned to stimulate the CSC scale up as they already engage with end users (e.g. as part of their own business) but also have strong drivers such image, marketing, politics to develop CSC projects.

Industrial service providers are well positioned to foster the scale up of the market on a number of key conditions: they should clearly identify and treat project facilitators as strong partners and as their primary customers. They should specifically understand what their key drivers are: energy is not their primary focus; however they can see CSC projects as ways to differentiate themselves. Success of industrial service providers will thus come with identifying the right type of project facilitators (commercial landlord, social landlord, municipalities, real estate companies…) on which they can rely on to easily replicate other projects. Besides, they should develop new skill sets and act as an integrator of various technological components. Finally, they should strive to have a long-term implication in the project to avoid seeing their margin squeezed in the long run: build simple, standardised, turnkey offers encompassing financing facilities and long-term services (EMS, operations and maintenance, energy efficiency…).

Although their current implication is rather limited, third-party investors will also play a key role in projects and benefit from large potential benefits through their participation in CSC projects. A fair and competitive sizing of their financing offer will require them to deeply understand potential risks and financial upsides on CSC projects. Although financial risks exist, they should not be seen by investors as a barrier as they can clearly be measured and there are already levers to mitigate them.

Finally, as CSC projects deployment seems inevitable, public network operators should see them as opportunities rather than threats. They have a key role to play in the project as their network is often used to distribute shared electricity flows. They should position themselves as key participants (through provision of added value services) and look at how they can leverage CSC projects to reduce their own network CAPEX.

3 Source: International Energy Agency, *Renewables 2019 Market Analysis and forecast from 2019 to 2024*

Table of contents

1

Context and definition

Context

Ambitious renewable targets and exit of subsidies require project developers to find new business models such as collective self-consumption projects.

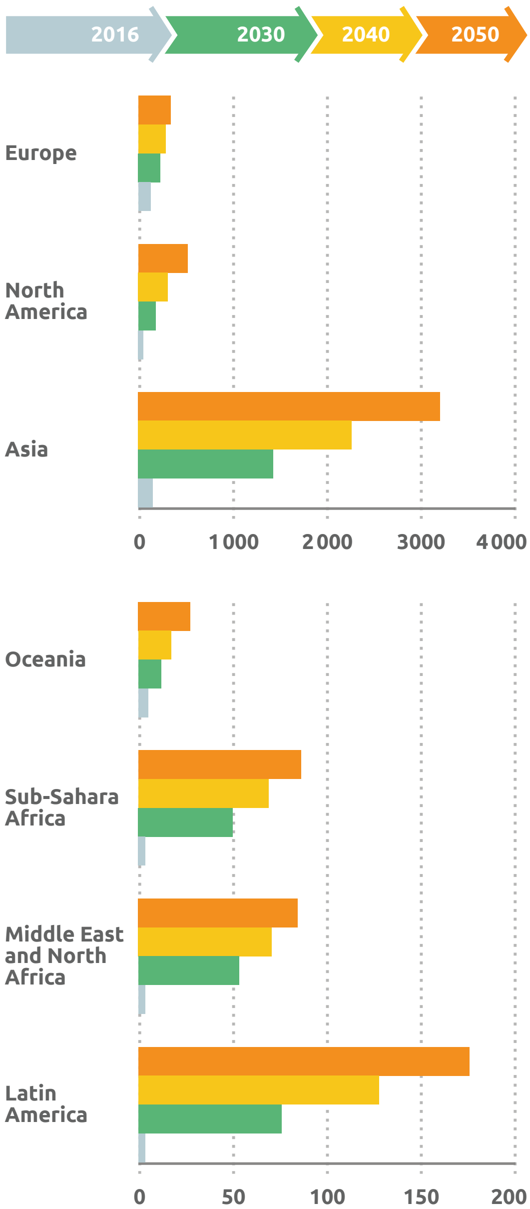
Against climate change emergency, countries seek to transform their fossil-dependent energy systems by fostering the development of renewable energy capacities. In particular, many countries have set ambitious objectives for solar capacities development. The forecasts for 2030 or 2050 of the International Renewable Energy Agency (IRENA)[4] postulate massive capacity deployment and the creation of gigawatt-scale solar markets as shown in **Figure 1**.

Most of the required solar capacity should be met by large scale solar plants of which costs are now amongst the cheapest for electricity generation. However, the electricity system transformation goes along with consumers' willingness to benefit from local sources of electricity; meanwhile power grid operators seek to alleviate the operational constraints created by intermittent sources. This leads to much expectation for the development of decentralised renewable capacity. Public authorities in many countries have set up support mechanisms which favour the emergence of small-scale production assets and decentralised infrastructures.

For instance, a growing number of regulations incentivise buildings and household owners to install renewable capacities (mostly solar) by offering preferential pricing schemes for self-production such as feed-in-tariff, net metering or net billing. In most cases, these models are implicitly funded by public authorities and eventually passed on final consumers, like the EEG fee in Germany.

Figure 1

2030 to 2050 forecast of PV installed capacity of IRENA (GW)*



* 2019 reference case scenario. An other scenario is available ("Remap") with much higher expectations

4 International Renewable Energy Agency, 2019

During the last few years, regulatory mechanisms have evolved to incentivise not only the production of local renewable electricity but also onsite consumption of locally produced electricity. The objective of this evolution is to limit the amount of renewable electricity transferred to the public grid. The most visible example of such adaptation is the progressive exit of feed-in-tariffs and associated subsidies for renewable electric production in some European states. Project developers are now looking for new business models associated with this gradual switch in regulation, from a complete support of all renewable production to a more selective "self-consumption only" support.

Self-consumption creates an incentive to optimise the amount of electricity locally consumed. Indeed, as a single consumer often cannot self-consume all the electricity which is produced by its onsite generation, he tends to generate an electricity surplus being injected onto the grid without providing local benefits. Consumers can also decide to limit their onsite generation asset size to match the consumption and production curves. In this context, various frameworks emerged around the world to allow the collective self-consumption of onsite generation: Citizen Energy Communities and Renewable Energy Communities in the European Union (CEC / REC), the utility model (GRD model) and the *Regroupement de Consommation Propre* (RCP or ZEV for *Zusammenschluss zum Eigenverbrauchin*) in Switzerland, Smart Communities in Japan, Community Solar in the United States, Embedded Networks in Australia, etc.

Description of CSC projects

CSC is a technical framework that facilitates the collective sharing of renewable electricity generation assets within a community of prosumers[5] linked together through a legal entity. The boundaries of the community are generally restricted to a neighbourhood, a district or an industrial consortium. The group of consumers remains connected to the main electric grid either to purchase the necessary complement of electricity that is not covered by self-consumption or to feed the grid with a generation surplus, valued, or not, by the public operator or a market player. The typology of the projects (type of production assets, members types, etc.) may vary significantly amongst projects.

Many legislations have started to characterise the concept of CSC. In the "Clean Energy for all Europeans" package (CEP), the EU regulation for instance provides basic legal definitions for individual self-consumption and CSC.

In the 2018/2001 Directive on the promotion of the use of energy from renewable sources (often referred as RED II), "renewable self-consumer" *means a final customer operating within its premises located within confined boundaries or, where permitted by a Member State, within other premises, who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewable self-consumer, those activities do not constitute its primary commercial or professional activity.*

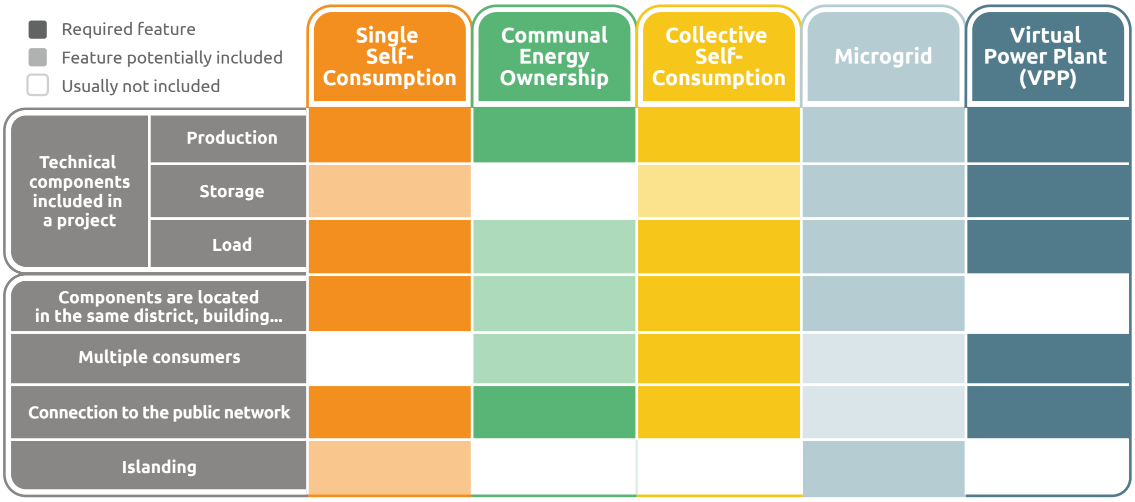
A CSC project may be carried out by several types of legal entities: local energy communities, cooperatives, private companies, associations, social landlords, co-ownership syndicates, etc. Similarly, a CSC project may be financed and managed by the participants (consumers and producers) via a specifically designed legal entity, which is administered by an external cooperative or by a private third-investor. In Europe, the RED II specifies that *the renewable self-consumer's installation may be owned by a third party or managed by a third party for the installation, operation [...], provided that the third party remains subject to the renewables self-consumer's instructions.*

This wide range of organisational opportunities reflects the variety of drivers motivating the setting up of CSC projects. Enabling green and local electricity consumption is not the only goal of a CSC project. Indeed, a CSC can also be a financial opportunity for its participants. Indeed, the expected long-term increase of retail price in most developed countries, the public financial support for the renewables sector, and the steady decrease of PV panel and storage solutions costs are creating the conditions for CSC profitability in the medium to long run. This context is furthermore supported by the development of low-cost data, energy management and peer-to-peer trading software made operable by the massive deployment of smart metering devices.

5 Electricity consumer producing its own electricity for its own needs and/or to share it with other consumers.

Figure 2

CSC projects within the broader family of local electricity projects



Positioning within the local electricity business models

CSC projects are part of a broader family of local energy community projects such as communal energy ownership projects, virtual power plants (VPP) and microgrids, each of which serves different objectives. CSC projects should not be confused with other local electricity business models like communal energy ownership, microgrids and VPP. Their main characteristics can be summed up as follows:

- **Communal energy ownership:** local community members, via an association or a cooperative, have direct stakes in a local production asset, usually renewable (typically a wind turbine located in the municipality's land). The power generated may be self-consumed locally or sold to the market. The members benefit from the financial returns of their investment. Members of the community are not restricted to individual citizens: municipalities, local utilities, small businesses or agricultural cooperatives can also be members.
- **Virtual Power plant (VPP):** several electricity production plants are located at different grid nodes. They are virtually grouped together to sell their electricity and capacity to the grid in order to supply more stable and reliable power to the main grid.
- **Microgrid:** a group of customers located in the same neighbourhood or premises uses a private network operated by a microgrid manager, in charge of electricity supply and asset maintenance in his delimited electricity infrastructure. The microgrid manager is also in charge of load and generation optimisation, often using "smart grid" technologies to regulate grid characteristics (voltage and frequency) and to improve overall network efficiency. A microgrid may or may not be connected to the main grid: if it is, the consumers benefit from a larger and more profitable subscription handled by microgrid manager. In any case, a microgrid can operate in islanded mode either because there is no public network nearby (e.g. in remote areas) or because it detects fault signals from main grid. Once in islanding mode, load and generation must be balanced and kept balanced at all times.

CSC projects often share some of the features described above like local ownership of production assets, customers grouping, or self-consumption of power produced. However, they cannot be assimilated to the other projects aggregating load or generation like VPPs which do not rely on simultaneous consumption and generation in a defined location like in CSC.

The key feature of CSC projects is to be connected at all time to the main grid: CSC projects are not designed to operate in islanding mode. CSC operation does not require highly complex smart grid technologies thus making them substantially simpler and cheaper to develop than microgrids and to a less extent VPPs. CSC business models rely on the exploitation of possibilities offered by this connection: mostly benefit from a cheaper self-produced electricity in a period of growing retail prices. Unlike microgrids, CSC projects are not designed to promote a safer access to electricity, they are driven by financial and environmental objectives, not by stronger self-sufficiency or security of supply.

Furthermore, location restrictions for participating into a CSC project are stricter than for VPPs or communal energy ownership projects. The purpose of communal energy ownership is to promote renewable local production and to local benefit redistribution, while CSC aims at increasing self-consumption. In all CSC regulation, it is requested that participating consumers live within a maximum perimeter, to make sure the public network is not used or almost not used for project internal flows; it may be at building scale like in Germany or at neighbourhood scale like in France. This constraint does not exist for communal ownership projects and VPPs in which participants may have stakes in a common asset but live distant from each other. These constraints add a degree of legal and commercial sophistication to CSC projects.

The three types of existing CSC projects

In the current market context, three main types of CSC projects can be identified: projects based on a single asset collectively operated on a multi-tenancy building, projects based on shared distributed electricity generation assets and projects with peer-to-peer trading on existing assets.

Single asset collectively operated on a multi-tenancy building: a PV system on the roof of a multi-tenancy building generates power that is split between the members of the self-consumers group. Self-consumers have to live in the building and may partner through a cooperative, an association, an energy community or any legal entity fit to carry out the CSC project. As much electricity as possible is self-consumed and the electricity surplus is either injected to the grid or stored by various devices (heat domestic water tanks, batteries…). Several regulations in Europe promote this type of projects: *Autoconsommation collective non-étendue* in France, *Mieterstrom* in Germany, *Regroupement de Consommation Propre* in Switzerland, *Ofgem's regulatory sandbox 'Innovation Link'* in Great Britain, etc.

Shared distributed electricity generation assets: several distributed generation assets, sometimes accompanied by batteries, are distributed in different sites of a predefined perimeter, a neighbourhood for instance. The electricity produced is either self-consumed by the producer himself, self-consumed by another participant of the CSC or injected into the grid in last resort. This model requires the use of the public network for the CSC project in a specific perimeter, which is forbidden in most regulations. It is allowed for instance in France under the *Autoconsommation collective étendue* and Brazil under the Net Metering scheme. Some models like *Regroupement de Consommation Propre* in Switzerland or embedded networks in Australia authorise the sharing of electricity between several buildings but on a private network.

Peer-to-peer trading on existing assets: a software platform operator is set up to allow electricity trades between self-producers of a community. The platform balances supply and demand. It also displays all the market data so that participants can make their offers and manages the financial flows. In this model, participants own their generation assets.

Figure 3

CSC projects within the broader family of local electricity projects

Single asset collectively operated on a multi-tenancy building	Shared distributed energy generation assets	Peer-to-Peer trading on existing assets
A rooftop PV installed on a building, locally produces electricity locally, which is split between the building's tenants	Multiple PV systems are distributed among different prosumers, installed on their buildings' and houses' rooftops	Each prosumer participating to the P2P owns or usually self-financed its own generation asset
The electricity surplus generated by the single asset is injected into grid	The surplus of each asset is shared with other pro- and consumers	The P2P trading enables electricity transaction between existing prosumers and other prosumers or consumers
The single asset can be owned by the tenants, landlord or any other third party	The distributed assets can be owned by the prosumers or by a third party investor	A software platform operator using a blockchain technology manages the different flows and trades
		This type of project can be plugged on the other two types of project

2

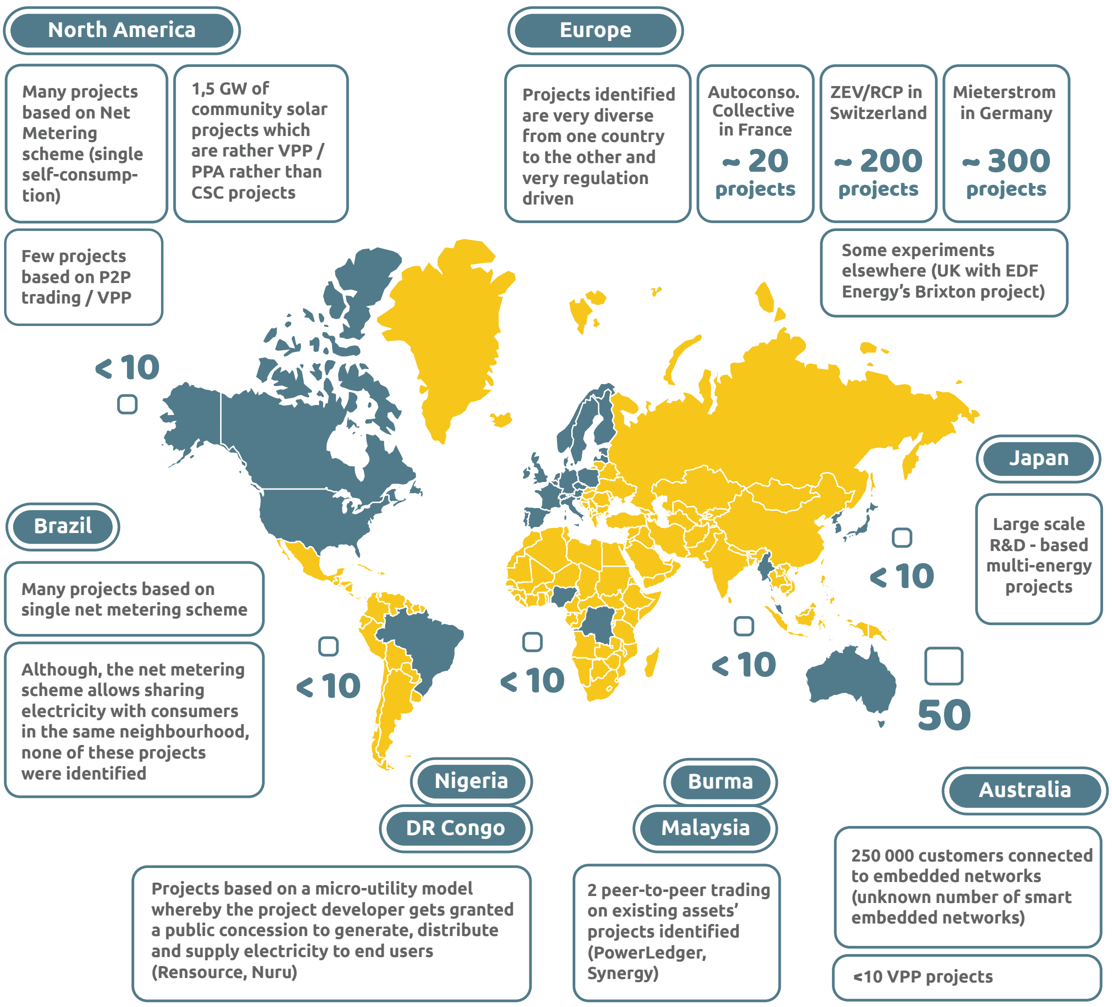
State of the art of CSC projects

CSC projects emerge on a small-scale basis, often as pilot projects

ENEA conducted a global mapping of operational or developing projects, identifying around 500 CSC projects around the world with important public communication (Including the ~300 German *Mieterstrom* projects[6] and the ~200 RCP projects in Switzerland and assumes most Australian embedded networks[7] do not have self-generation).

Figure 4

Overview of main projects identified



6 SolarPower Europe, 2019
7 The embedded network regulation allows some sites (typically apartment blocks, retirement villages, caravan parks and shopping centres), to install their own electrical wiring so that the owner of the site can sell energy to all the tenants or residents. According AEMO in 2018, more than 250 000 citizens are part of an embedded network. When an embedded network has self-generation, the terminology smart embedded network is used.

They are carried out in the context of diverse business and regulatory models. Most emerging CSC projects are relatively small in installed capacity (<500 kW), based on mature technologies and located in developed countries.

Some projects are built upon standardised economic models and regulatory frameworks (in France, Switzerland, Germany and Australia for instance) while others are based on "regulatory sandboxes" (like the 'Innovation Link' in the UK which allowed EDF Energy to develop a community electricity trading project in Brixton in the UK). In any case, most projects involve PV panels sometimes coupled with batteries but rarely multi-fluid or multi-energy installations.

North America

Around 20 CSC projects were identified in North America, some based on net metering schemes and others on P2P trading like the Brooklyn microgrid project[8]. A model close to CSC is meeting a growing success in the US: the community solar model[9]. Community solar refers to local solar facilities shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced. US community solar capacity has more than quadrupled since 2016, increasing from 300 MW to around 1.5 GW as of end 2018 (involving more than 250 000 homes). Community solar projects do not follow the same logic as CSC: the community does not self-consume the electricity it generates. Instead, it injects the entirety of its production into the electric grid and the community members are remunerated via net metering or net billing policies. The subscribers do not see any reduction in the amount of electricity they consume from the grid, instead they receive credits to offset their monthly electric bills.

South America

Only a few projects are reported in South America. Although CSC is theoretically allowed in Mexico[10], its success has been limited with no more than 5 projects set up since its introduction in 2012.

In Brazil, around 10 projects close to CSC scope are in development or in operation, most of them being under a net metering scheme allowing net metering credits being shared with other consumers in the same neighbourhood.

Asia

In Japan and South Korea, about 10 CSC projects were spotted, including the large multi-fluid R&D projects in Japan (Smart Communities) while 2 pilot projects based on peer-to-peer trading are in development in Thailand and Malaysia.

Australia

In Australia, CSC has specifically developed through the embedded networks regulation. Embedded networks correspond to the sites (typically apartment blocks, retirement villages, caravan parks and shopping centres), in which the electrical wiring is configured in such a way as to enable the owner of the site to privately operate a local electricity network and sell electricity to all the tenants or residents. A report published by Australian Energy Market Commission estimates there are currently 4 500 embedded electricity networks, serving c. 500 000 customers[11]. The electricity sold by the owner to the tenants is usually bought from an electricity retailer. However, a few of embedded networks include distributed electricity resources (mostly PV) for self-consumption making them "smart" embedded networks. Furthermore, several local power trading solutions are being developed in Australia, for example the ones carried out by the private company Power Ledger.

Europe

The EU offers a favourable context for the development of CSC. In 2018, 11.3 GW solar PV capacity were added, representing a 21% rise year-to-year. This growth is partly due to the 2020 EU RES targets. The association Solar Power Europe forecasts a yearly addition of c. 20 GW per year to reach around 200 GW of installed capacity in 2023[12].

8 Brooklyn Microgrid, s.d.
9 Solar Energy Industries Association
10 Sitiosolar, 2014
11 *Updating the regulatory frameworks for embedded networks*, AEMC, 2019.
12 Solar Power Europe, EU Market outlook 2019-2023.

These capacities should be thrived for a large part by utilities but also by large C&I rooftops (which may be remunerated by PPA systems or by CSC) and distributed rooftop solar.

In this context of strong growth for the solar markets in Europe, several regulatory frameworks specifically promote CSC. As reminded above, the EU recognised formally the concept of CSC in 2018 and introduced a legal definition of "energy communities", described as legal entities that can be set up for collective electricity projects. Furthermore, supportive national regulations like in France, Germany and Switzerland have favoured the development of various CSC projects. In France, the CSC model allows several consumers located on the same low voltage grid and linked together through a legal entity to share the electricity produced through a distributed generation plant. Regulation is evolving to allow larger projects to emerge: a ministerial decision from November 2019 firstly loosened the distance restriction and the installed capacity cap of CSC projects[13]; another ministerial decision draft, designed to further ease these constraints, was announced in April 2020[14]. 16 CSC projects are in operation while around 100 projects were being developed in 2019[15]. The French government's ambition for CSC is to have 50 projects running by 2023, which may appear as rather modest in regard to the apparent attractiveness of the sector (many municipalities or social landlords are indeed investigating CSC project deployment. In Germany, the Mieterstrom regulation introduced in 2017 enables CSC of PV installations on apartment buildings. The success of the scheme is below the German authorities' expectations with around 300 systems of a cumulative 6.8 MW capacity installed as of 2019. The German law had implicitly fixed an annual objective of 500 MW by introducing a limit to the PV extension allowed to benefit from a complementary remuneration. In Switzerland, CSC with PV was introduced in the law in 2014 via the RCP/ZEV and utility models and reinforced in 2018. RCP/ZEV model allows the building owner to assume the full retailer role towards its tenant while in the utility model, each consumer keeps a contract with the local utility supplying the area or a private retailer.

In other European countries, although specific CSC regulatory frameworks have been set up, no projects have yet emerged. In Spain, a decree published in 2018 allows collective self-consumption and eliminates the "Sun Tax", a tax which used to weight on solar projects. As of early 2020, there is no CSC installation in operation but the first project was announced in January 2020 in Madrid[16]. In Greece, in accordance with the CEP, the legislation introduced the concept of energy communities in 2018 and collective net metering in 2019 with no actual energy community projects launched yet. In the UK, even though the regulatory framework does not allow CSC nor permit power trading between consumers, several peer-to-peer local markets have been authorised as regulatory sandboxes" by the regulator. In the Nordic countries, Denmark and Sweden could become a small market for CSC in the next years, specifically with close to 4 GW of additional PV capacities to be installed by 2023[17]. The local tradition of collective ownership has historically supported various energy technologies in the Nordic countries. As an example, the communal wind farm model and, to a lesser extent, the cooperative district heating model have been supported by the Danish governments over the last years. Regarding the CSC model specifically, sharing the electricity from a PV system in an apartment building is for instance allowed in Sweden provided all the apartments share the same grid subscription. In Wallonia, Belgium, a decree was adopted in May 2019 to

13 The maximal distance between two participants was extended to 2 kilometers and the maximal capacity installed was increased up to 3 MW in mainland France.
14 As of early May 2020, the decision's project is still in drafting phase. This new decision intends to respond to criticism from rural areas which judged the previous restriction rules unfit to their local context.
15 *http://www.consultations-publiques.developpement-durable.gouv.fr/IMG/pdf/ppe_pour_consultation_du_public.pdf*
16 *https://www.eseficiencia.es/2020/01/17/primeros-tramites-instalacion-autoconsumo-colectivo-comunidad-propietarios-madrid*
17 *Solar Power Europe, EU Market outlook 2019-2023.*

allow CSC projects to use the public distribution network. Practical modalities are still expected to be adopted by the Government for the first CSC projects to emerge[18]. Finally, in the Netherlands, a model called *Postcoderoos* was introduced to allow people to invest in PV installations close to their home and benefit from a tax rebate on the electricity that is produced and locally injected[19].

Africa

In sub-Saharan Africa, the demand is more likely to be met by islanded microgrids rather than by CSC projects. Indeed, microgrids offer a safer access to electricity, a stronger self-sufficiency and security of supply which are only secondary drivers for CSC. The most optimistic IEA forecast predicts that close to 300 million people should be served by microgrids in 2035. No specific CSC framework has emerged in African countries, besides the micro utilities business models which flourish in dense urban areas, like in Nigeria or the Democratic Republic of Congo.

Perspectives for CSC projects

Although the current number of projects is limited, there are good perspectives and a promising market potential for CSC. In the next five years, CSC is very well positioned to help stimulate the 150 GW[20] of residential and commercial new PV capacity that will no longer benefit from a net metering scheme nor a feed-in tariff. Feed-in tariffs were originally used to stimulate the growth of renewable distributed generation. Although they still exist in some countries to stimulate specific market segments (such as small installations) they tend to disappear. Net metering regulations were designed to improve the business case of single self-consumption by ensuring a monetisation of the locally produced electricity surplus at a price close to or equal to the electricity retail tariff. Again, these regulations tend to be phased out and replaced by support schemes incentivising real-time single self-consumption or no support schemes at all. In this context, a natural successor of the net metering schemes and feed-in tariffs would be the CSC framework which would offer similar economic advantages for local renewable asset owners (electricity surplus monetised at the price close or equal to the retail price) but would have the advantage to physically (rather than virtually as this is the case for net metering) use the surplus of electricity produced to power neighbouring end users.

More broadly, CSC can be the most relevant solution both from a technical and economic perspective to reach households or businesses who cannot be prosumers i.e. who do not own available space such as a rooftop to install local renewable electricity generation assets. CSC could develop in the next five years by addressing this specific market segment. The three following examples illustrate the market potential of this market segment:

- The community solar model in the US is comparable to CSC. It targets households without access to rooftops. In 2018, 1.5 GW of solar capacity was installed as part of this scheme which shows a strong wish from households without rooftops to engage with innovative schemes in order to gain access to local renewable electricity.
- Looking at Germany, Mieterstrom CSC projects could target a theoretical market potential of 100 GW to power all households living in a flat[21].
- Finally, four billion people are currently living in urban areas in the world, a large share of them can be assumed to be living in a flat without direct access to renewable electricity.

18 *Commission wallonne pour l'Energie, www.cwape.be/?dir=4.9.6*
19 *https://www.postcoderoosregeling.nl/wat-houdt-de-pcr-regeling-precies-in/*
20 According to the IEA, on the 320 GW distributed capacity that will be installed on commercial buildings or residential dwellings, 150 GW will be self-consumed on real time at a value-based price (usually between the wholesale and retail price) i.e. without accessing a feed-in tariff or benefiting from a net metering scheme.
21 As of 2017, about 46 million people lived in a flat. Solar is assumed here to cover 30% of their needs and has an 11% load factor.

3

Projects' economics, risk and associated perspectives

Costs and revenues of a CSC project

The revenues of a CSC project can be complex to assess as they aggregate multiple components. Table 1 shows the three main revenue streams that a CSC project can access[22].

Table 1

Description of revenue streams of a CSC project

Revenue stream #1	**Savings generated from the electricity produced and consumed by the same prosumer.** The end user would benefit from a similar revenue in a single self-consumption framework. The savings are measured against the retail price of electricity the end user is paying for the electricity purchased from the main grid.
Revenue stream #2	**Savings generated from the electricity produced by a prosumer and purchased by another consumer in the same neighbourhood.** Depending on the regulatory framework, the consumers can be within the same building (*Mieterstrom* case in Germany or RCP in Switzerland), connected to the same private network (smart embedded network case in Australia or RCP in Switzerland) or in the same neighbourhood (Brazil net metering scheme case or French *Autoconsommation collective* case). The savings are measured against the retail price of electricity the end user is paying for the electricity purchased from the main grid.
Revenue stream #3	**Revenue from the surplus of electricity injected in the grid** and sold either at wholesale market price or at a feed-in tariff.

22 It excludes extra revenue stream from, for example, monetisation of CSC project flexibility on the power markets as no project with this revenue feature was identified in the study.

The cost of a CSC project is the result of many factors. Many of them are specific to CSC projects as detailed in the table 2.

Table 2

Description of cost components of a CSC project

Cost component		Description	Specific to self-consumption project
CAPEX		Costs related to equipment purchases (modules, inverters, roof structures), installation, interconnection and project development	Similar to other distributed generation projects
OPEX	Network tariffs	Network tariffs applied to the electricity locally shared between pro- and consumers	Specific
	O&M of generation asset	Cost associated with the operation and maintenance of the generation assets	Similar to other distributed generation projects
	Project administrative management	Administrative management of CSC projects including SPV* management, billing of end users, contract management	Partially specific as CSC project implies a complex contracting and billing of end users
	EMS	Energy management system which can optimise onsite dispatchable generation, batteries or enable demand response to maximise self-consumption rate, for example	Specific although EMS are not always required on a CSC project
	Peer-to-peer trading platform	Software enabling pro- and consumers to exchange local electricity	Specific although such a platform is not required on a CSC project.
Taxes		Taxes applied on the electricity locally shared between pro- and consumers.	Specific

* Special Purpose Vehicle

Economics are very context dependent

As part of this study, two residential projects, comparable in size, were studied: one project under the *Autoconsommation collective* regulation in France and one project under the *Mieterstrom* regulation in Germany. Table 3 below presents their main characteristics:

Table 3

Comparison of *Autoconsommation Collective* and *Mieterstrom* projects

	Autoconsommation Collective, France	*Mieterstrom*, Germany
Production assets size	99.9 kWp	445.5 kWp
Share of total consumption covered by PV production	20%	30%
Number of participants	100 dwellings	116 dwellings
Regulatory framework	*Autoconsommation collective*, France	*Mieterstrom*, Germany
Real life project used for inspiration	*Soleil de Rochebelle* project in France	*Neue Heimat* project in Germany

Figure 5 and Figure 6 (next page) are displaying the revenue generated on a project and the associated breakdown of costs this revenue should cover. Revenues and costs are displayed on a euro per MWh basis following a methodology similar to the one used to calculate levelised costs of energy. Results show the impact of the CSC project on the sourcing cost from the end user perspective. To make this calculation, revenues, costs and electricity production were discounted over a period of 20 years. Each item (should it be a revenue or a cost) is calculated as follows:

The main methodological features which were followed to make those calculations and build the charts displayed in Figure 5 and Figure 6 are as follows:

Cost (C) or Revenue (R) shown on the chart

$$= \frac{\text{NPC/R}}{\sum_{i=0}^{n} \frac{\text{Energy produced in year i}}{(1 + \text{WACC})^{i}}}$$

Where:

$$\text{NPC/R} = \sum_{i=0}^{n} \frac{\text{(Costs or Revenue) in year}}{(1 + \text{WACC})^{i}}$$

- Both projects were assumed to have the same initial investment of 1.2 k€/kWp.
- The solar irradiation is similar in the two projects.
- OPEX such as taxes, network tariff are annual recurring costs.
- CAPEX was assumed to be fully paid on the first year of the project
- CSC project revenue corresponds to the financial savings made by the end users through avoiding consuming electricity from the grid at the retail tariff plus the revenue from the surplus of electricity generated and exported onto the grid and monetised at the country feed-in tariff [23].
- The power production was calculated for each year, taking into account a 0.5% yearly decrease factor in production.
- EEG fees and premium on Figure 6 corresponds to the net between the taxes and premium applied by the German government on self-consumed volumes.

23 The perimeter of the calculation thus only includes the energy self-produced which is either self-consumed or injected into the grid. It excludes the rest of the consumption served through a traditional retailer and taken from the grid.

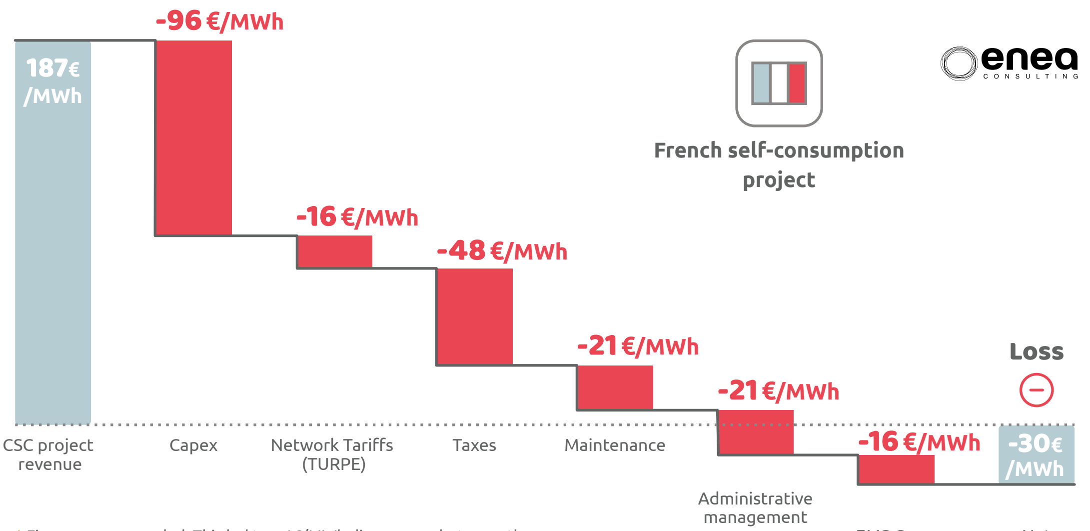
The category called 'Net benefit/loss' represents the margin between the generated revenue and all the costs which should be borne by the CSC project.

- In case of a benefit, it can be assumed it will be shared between both the end users (which will have a discount on their electricity bill) and, potentially a third-party investor investing in the project.
- In case of a loss, it is an extra cost that the end users would be willing to pay to access local, self-generated PV production.

The two projects show large differences in their economics. The French project is not profitable: the revenue amounts to 187€/MWh whereas the sum of all costs to be covered amount to 217€/MWh resulting in a net loss for the project. The German project is profitable: the 246€/MWh revenue generated on the end users' electricity bill and from the surplus exported onto the public grid covers the 189€/MWh cost to be borne by the CSC project.

Figure 5

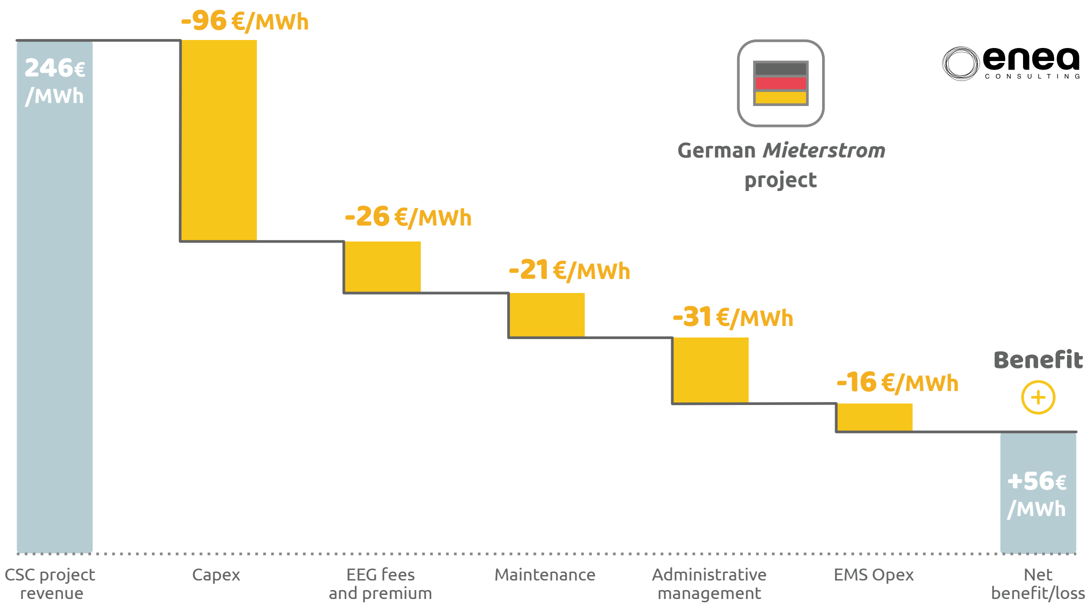
Simplified project revenue and costs breakdown per MWh for a French self-consumption project on a 20-year period.



* Figures were rounded. This led to a 1€/MWh discrepancy between the sum of benefits and costs and the actual loss displayed on the chart

Figure 6

Simplified project revenue and costs breakdown per MWh for a German *Mieterstrom* project on a 20-year period.



The main discrepancy on the two projects' economics comes from the difference in the generated revenue: 187€/MWh in the French case versus 246€/MWh in the German case which is mainly due to the difference in the retail tariff (although different feed in tariffs on exported electricity also contribute in the difference in revenues).

The other key driver for the two different projects' economics is the network tariff and the taxes applied to the volume of electricity locally produced. While it only represents a discounted cost of 26€/MWh due to the relatively favourable German regulation, taxes and network tariffs represent a 64€/MWh cost in the French case. This last feature in the project cost breakdown illustrate the different approach that countries adopt:

- Germany only allows electricity to be shared within the same building with rather limited tax conditions and no public network tariff.
- On the other end, France allows using the public network but, in the meantime, applies network tariffs on the self-consumed electricity along with taxes amounting to approximately 25% of the generated revenue.

Expected economic improvement

As seen on the previous part, not all projects deliver financial benefits. However, it can be expected economics will gradually improve as a number of external factors evolve. Table 3 shows the impact of four main external factors evolution on the 100 kW French *Autoconsommation collective* project.

Overall, the results displayed in Table 3 show external factors will generate a more attractive economic context for CSC projects. Still, large discrepancies will exist between countries currently showing diverging market and regulatory conditions:

- In countries with important levels of taxes and network tariff as well as low retail tariff like France, projects will hardly become profitable without introducing a significant reduction of both network tariffs and taxes.
- Alternatively, in countries currently showing positive benefits – or close to showing positive benefits – like Germany, the evolution of those external factors will naturally help CSC provide large benefits for both end users and investors in such projects.

Table 4

Impact of external technology and market factors on project net benefit/loss

Potential factors impacting the profitability of a CSC project	Assumption for impact assessment	Impact on net benefit/loss (from the -30 €/MWh initial loss as shown in *Figure 5*)
Increase in retail tariff	+1% yearly increase on retail tariff in addition to the expected rise in retail tariff *	+15€/MWh (loss is reduced to -15€/MWh)
Increase of solar panel efficiency	+6% efficiency on solar PV by 2024 **	+11€/MWh (loss is reduced to -19€/MWh)
Decrease of solar cost	12% reduction in total project CAPEX due to 44% CAPEX decrease of solar panels costs by 2030 ***	+12€/MWh (loss is reduced to -18€/MWh)
Better taxes and network tariff conditions	Overall, amount of network tariff and taxes divided by 2	+32€/MWh (project generates a +2€/MWh benefit)

* In the base case scenario as described in part 3.2, +3.5% increase in retail tariff was assumed which replicates what was observed on the French regulated retail tariffs between 2010 and 2015 - Source: https://www.cre.fr/Electricite/marche-de-detail-de-l-electricite
** Source: International Roadmap PV working group
*** Source: IEA PVPS Workshop

Main risks and mitigation strategies

CSC projects bear risks linked to their specific activities. Developers and investors should be aware of these risks in order to develop strategies to mitigate them. Through project analysis, ENEA has identified three main risk categories:

- **Counterparty and volume:** risks related to the potentially unpredictable behaviour of the end users in CSC projects.
- **Conception and construction:** risks related to all issues arising during the development and operational phases whether administrative, legal or technical.
- **Market and regulation:** risks related to regulation uncertainty and market shifts.

Table 4 shows assumptions of standardised CSC project used as a base case project to evaluate the impact of the risks identified above.

Table 5

Assumptions of the base case project modelled for the risk analysis

Capacity installed	100 kW
CAPEX	120 k€
Retail price	0.14 €/kWh
FiT for surplus	0.06 €/kWh
Annual consumption	637 MWh
Year 1 PV production	133 MWh
Self-consumption rate	~100%
Payback	11 years

The main risks identified are presented below with their probability of occurrence and impact on the payback period. The probability of occurrence was qualitatively assessed with a coloured indicator (red: high probability of occurrence, orange: medium, green: low) whereas the impact on the payback period was modelled using assumptions described in the table. A final criticality indicator in the table allows to rank the various risks incurred on a CSC project.

Table 6

Main risks identified on a CSC project along with their probability of occurrence and impact on the payback period.

Probability of occurrence
- High probability
- Medium
- Low

Impact on payback year
- High impact
- Medium
- Low

Critically of risk
- Most critical risks to address
- Medium level of risk
- Low level of risk

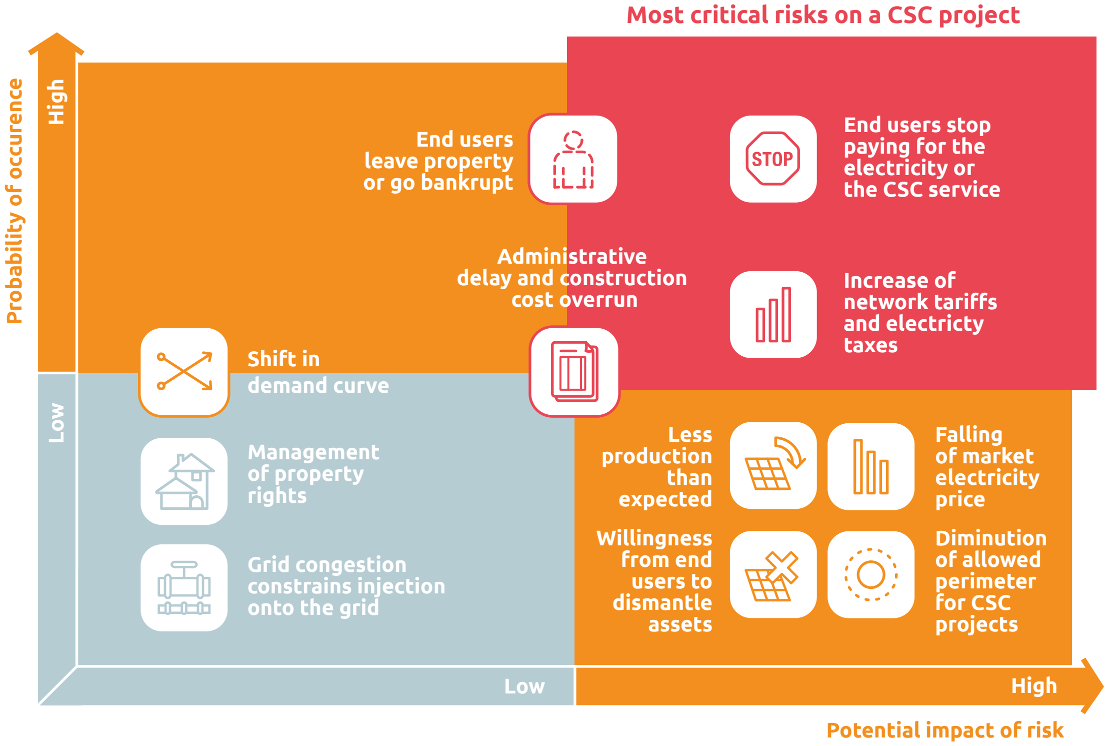
	Risk identified and implementation in the model	Probability of occurence	Impact on payback year	Criticality
Counterparty and Volume	**Description** End users stop paying for the electricity or the CSC service **Modelling** 10% dead loss in earnings		+2y	
	Description End users leave property or go bankrupt **Modelling** Decrease in end-users demand (potentially leading to an increase in injection).		+1y	
	Description Willingness from end-users to dismantle assets **Modelling** Project ends after 10 years		+1y	

	Risk identified and implementation in the model	Probability of occurence	Impact on payback year	Criticality
Conception and construction	**Description** Administrative delay and construction cost overrun **Modelling** First revenue delayed of 1 year		+2y	
	Description Grid congestion constains injection onto the grid **Modelling** 10% of flows that should be injected are lost		+1y	
	Description Less production than expected **Modelling** 10% decrease in production		+2y	
	Description Shift in demand curve **Modelling** Modification of load curve throughout project life: transfer of daytime consumption to the night, decrease of peak load, etc..		+0y	
	Description Management of property rights **Modelling** Yearly OPEX are 2x basecase		+1y	
Market and Regulation	**Description** Diminution of allowed perimeter for CSC projects **Modelling** Decrease in the number of end-users		+4y	
	Description Falling of market electricity price **Modelling** Decrease of retail price		>10y	
	Description Increase of network tariffs and electricity taxes **Modelling** 100% of network tariff and electricity taxes		+3y	

This analysis shows four main financing risks for investors in CSC projects. The counterparty risk is identified as the most threatening for CSC projects, due to the high impact of potential financial disengagement from end users. The profile of the end consumers involved is crucial to assess the criticality of counterparty and volume risks of a project. For instance, if serving electricity business allows to benefit from safer and larger consumption per participant, working with a larger pool of individual consumers is a way to spread the counterparty risks.

Figure 7

Summary of risks criticality on a CSC project



Mitigation strategies have been implanted in order to limit the materialisation of these risks. To limit the possibility for end users to stop paying for the CSC service, the project developer may conceive technical mechanisms forbidding access to the service when a suspension of payment occurs. The Plico Energy project in Australia which has installed PV and battery packages in c. 1 000 households, has set up such a system cutting the production when bills are unpaid. In any case, a careful due diligence should be carried out on end-users financial situations prior to the start of the project.

Several project developers – in Soleil de Rochebelle project in France or Quartierstrom local market in Switzerland –organised training session to increase end users' awareness about energy efficiency and environmental issues. This is a way to engage participants in a CSC project, thus reducing the incentive or willingness to leave the project.

Other risk mitigation strategies aim at diversifying the project portfolio and users' profiles to spread and mitigate the counterparty risks. A diversified portfolio gathering large residential buildings, small houses and tertiary businesses is more likely to attract financial players.

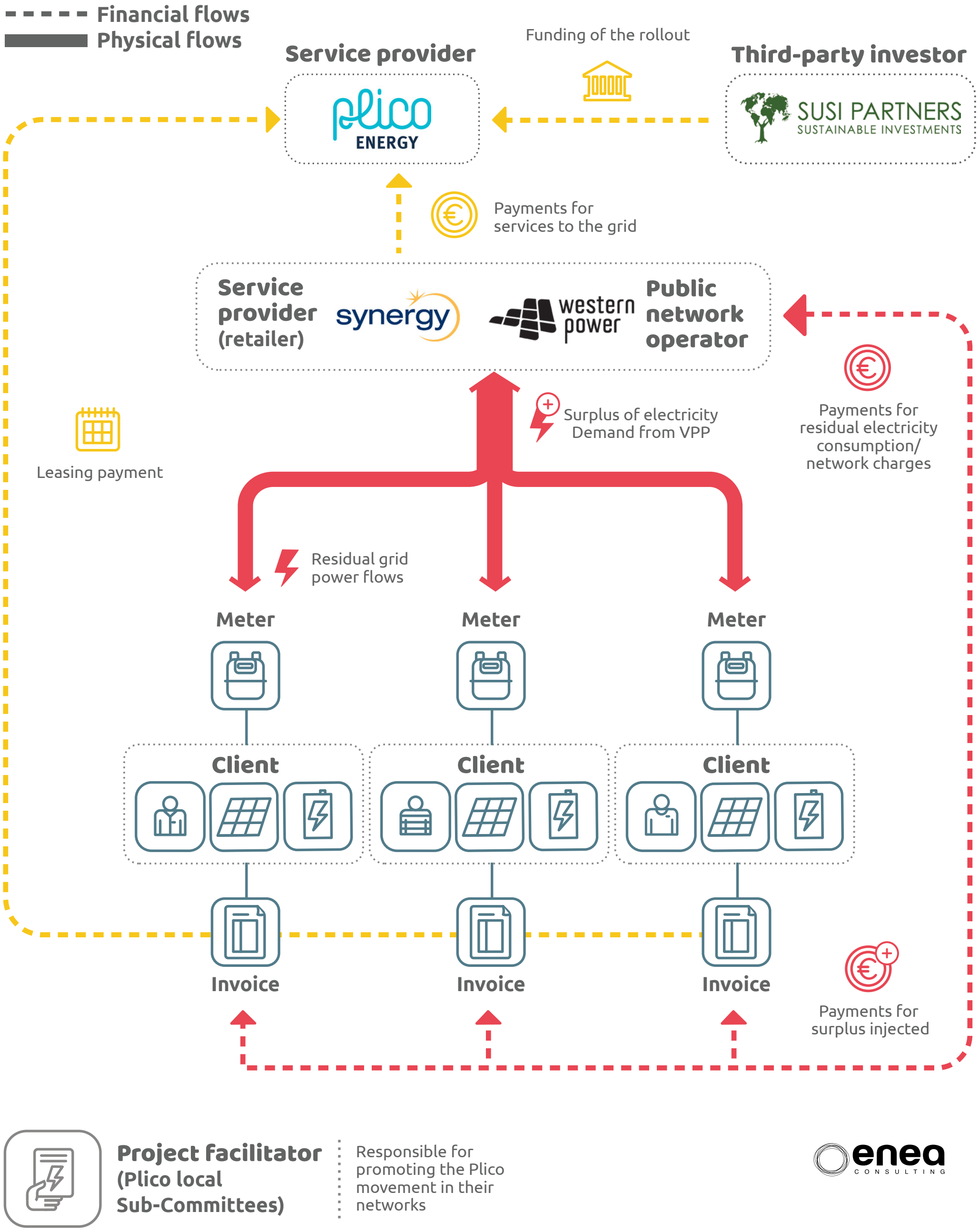
Finally, a mitigation strategy designed to diminish the risks that members lose interest and leave ongoing CSC project is to involve the tenants in the project financing. Offering the possibility for end users to participate to the financing at the beginning or during a project is a way to "capture" a customer base. This participative financing model was implemented for the *Neue Heimat* project in Germany: tenants were offered to purchase a 1 000€ 'package' to contract €800 loan for the cooperative carrying out the project (at 3% interest over 20 years) and 200€ of project shares.

4

Value chain of CSC project

Figure 8

Overview of the four key roles involved in the Dunsborough's Plico Project in Australia



CSC projects favour a local approach to electricity production and consumption. In addition to the involvement of traditional electricity players who can put forward their historical involvement with end users and know how in electricity generation and distribution, CSC offer room for new players to enter the electricity value chain.

The electricity value chain on CSC projects should no longer be analysed with the traditional 'production / transport / distribution / retail' framework but is getting complexified by the involvement of these new entrants with new types of interactions between them. As projects are still emerging, the value chain of CSC is not standardised yet though it is already structured around four key players: the project facilitator, the third-party investor, the industrial service provider, the public network operator.

Project facilitator

The project facilitator initiates the CSC project and often facilitates end users' involvement. In terms of roles, the project facilitator is a trusted third party federating the community of end users participating in the project. Sometimes, the project facilitator directly retrieves the revenues from the end users that are used to remunerate the electricity provided to the community.

This role is usually endorsed by an existing local player such as a landlord owning the residential or commercial building(s) on which the generation assets are located, a housing cooperative, a real-estate manager owning several buildings equipped with distributed generation or a local authority (such as a municipality). As CSC projects have a complex organisation and necessitate the coordination of numerous end users, very few CSC projects emerge in the absence of a project facilitator.

Unlike other project participants, the project facilitator's involvement in a CSC project is not solely driven by profit as it rather sees CSC projects as a differentiating factor in its own market. A CSC project can for example increase the attractiveness of its property for the tenants (as it can be the case for Brisbane Technology Park described below) or generate a positive image for a project facilitator whose business model is strongly exposed to public actors (as it can be the case for social landlords).

A project facilitator in two CSC projects:

In Australia, *industria REIT is the developer and landlord of Brisbane Technology Park (BTP) with approximately 190 businesses. It initiated a CSC project made of 6 large-scale solar PV rooftops (700 kW and possibly 300 kW to be added after project commissioning) built on six commercial buildings. The installations are connected to a private network (embedded network) which is itself connected to the public grid. Industria REIT acts as the electricity retailer for the end users who participate in the collective self-consumption scheme.*

In France, *the Soleil de Rochebelle project consists in the installation of 300 PV panels (99.9 kW) on the roof of a social housing. EDF ENR has been developing this project in partnership with the social landlord, Logis Cévenol. Logis Cévenol acts as project facilitator: it is a trusted party for existing tenants and is responsible for retrieving both increased rents and additional rental charges to cover the CAPEX and OPEX of the CSC project.*

Third-party investor

Many CSC projects are financed by the project facilitator mentioned earlier or the service provider described in 4.3 which are often well positioned to provide financing, especially for small projects. The *Soleil de Rochebelle* project in France was for instance financed at 60% by the social landlord and project facilitator Logis Cévenol. However, in a logic of project standardisation, it is expected that external investment players, here called third-party investors, will position themselves to finance portfolios of project.

The third-party investor is an external player who finances the installation and therefore takes the highest risk in a project. Third-party investors get remunerated thanks to the savings generated throughout the project lifetime. Third-party investors can be "generalist" investment funds with expertise in energy, investment fund specialised in third-party financing, large industrial players (builders, energy utilities, etc.) or public agencies with capacity investment.

In the current state of the market, CSC projects do not generate sufficient returns for third-party investors: they are mainly built on a standalone basis, usually at a small scale (few hundreds of kW) and expose third-party investors to new types of risks linked to the multiplicity of end users (risk of tenants exiting the project, etc.). Hence, the vast majority of CSC have yet not been financed by third-party investors, but through traditional financing methods for early-stage projects (equity and subsidies). Sometimes, alternative financing methods are used such as equity participation for end users or crowdfunding.

A third-party investor in an Australian project:

Plico Energy project, supported by Susi Partners, a Swiss investment fund, aims at aggregating ~1000 households with a solar and battery kits and generating profits through the lease of the kits and potentially through the creation of a VPP accessing market-based revenues (through participation in frequency regulation, spot market, etc.). The project currently does not share all features of a CSC project: indeed, kits are only locally optimised i.e. there is no exchange of electricity between each household. The aim of the project is also to allow each party exchange electricity with neighbours.

Industrial service provider

The industrial service provider role encompasses all industrial or private actors providing equipment and services on a CSC project. This role thus covers many technical bricks on a CSC project including:

- Services in the development phase: feasibility studies, requests for authorisations, detailed design
- Asset related services: EPC, maintenance and operation
- Energy services: EMS operator, local market software provider
- Provider of the electricity surplus from the grid

As CSC projects are complex and necessitate the coordination of various technologies and services, this role is very often endorsed by a single industrial player. It allows the project facilitator to engage with a single counterpart which reduces the risk of exceeding deadlines due to a poor coordination of various service providers or risk of interfacing different technological bricks.

A service provider in two CSC projects:

In Australia, *Plico Energy project is deployed through a single service provider Starling Energy that includes all the technical services and technologies needed for the project: development, EPC, EMS and maintenance.*

In France, *EDF is the only industrial players being involved in the Soleil de Roche belle project. It oversees all technical aspects including development and EPC, maintenance, EMS provision and even energy efficiency advisory.*

Public network operator

On CSC projects, public network operators oversee the management of CSC-related electricity flows transiting through the distribution network which make them a crucial CSC facilitator. Their involvement will depend on the type of CSC projects:

- In some countries, the regulation forbids the use of the public network to exchange electricity between end users. As a consequence, private networks must be deployed between the participants of a CSC project. In this context, the public network operator is only in charge of distributing the surplus of electricity required from the end users and dealing with the injection of the surplus from the local generation.
- In some countries, the public network can be used to exchange electricity between end users. In this case, the public network operator becomes a key player, ensuring electricity flows can be transmitted from prosumers to consumers.

Practically, the involvement of the public network operator on CSC projects is still very heterogeneous, even if there are already concrete ways for them to actively participate in CSC projects. Several types of services and activities could be provided by the public network operator on a CSC project:

- Electricity supply: supplying the surplus of electricity required from the end users.
- Data management: offering metering data services to enable the CSC project operator to accurately allocate CSC volumes and bill end users.
- Optimisation of public network cost: incentivising end users to maximise the local exchange of generation to avoid network reinforcement.

The role of a public network operator in two CSC projects:

In France, *the public network tariff was reduced for locally self-consumed electricity volumes to reflect the fact their use of the public network is limited.*

This has also been implemented on the Quartierstrom project ***in Switzerland.*** *WEW, the local public network operator, has decided to lower network tariffs for local production to reflect the lower grid usage of locally self-consumed electricity flows.*

On the contrary, the injection of local generation into the public network is prohibited in the Brisbane project ***in Australia****, in application of the "Zero net grid export" regulation.*

5

Regulation: a key enabler for CSC projects

CSC projects are more complex than other distributed generation projects and so is the regulation framework that will enable their emergence. ENEA identified minimal regulatory requirements for the development of a CSC project.

First, CSC projects can emerge if electricity can be shared between the different end users by either using the public network or by authorising the operation of a private network. This condition seems obvious but should be mentioned here as many countries forbid the exchange of electricity blocks between private individuals either through the public grid or a private network. A few examples illustrate this diversity:

- France authorises the use of public grid in CSC schemes.
- Denmark authorises exchange of electricity at a building scale through private grid.
- Great Britain so far prohibited the use of public grid for CSC purpose.

Secondly, defining a legal entity status aiming at facilitating the interactions between the numerous counterparts (project facilitator, service providers, public network operator and end users) is necessary for CSC projects. The status of this entity could take many different forms (associations, non-profit company, cooperative, energy community, etc.) and is key for three main reasons:

- Acting as a federator and being the only CSC project's counterpart considered as an independent and neutral third party.
- Governing the allocation of local generation among the various generators and end users.
- Overseeing CSC projects' governance.

In this regard, France defined a legal entity in charge of the project organisation (*"Personne morale organisatrice"*) that gathers all generators and end users participating in a project. This entity oversees the contractual relationship between the CSC project and the public network operator. Through the RCP regulation, Switzerland also defined a legal status on CSC projects for a RCP entity in charge of the allocation of self-generated volumes between generators and end users. This entity is also responsible for the metering activity on the CSC projects.

Third-party ownership of rooftop PV installations enable third-party investors to own and operate an asset on a private house or building. This is a particularly important feature of CSC projects as, most of the time on CSC projects, generation assets will be financed by investors not being the owners of the building or household (It can be for example a pure third party investor, the project facilitator itself or the community of end users through a dedicated investment vehicle). Not having this regulatory feature will restrain CSC projects to emerge. It must be noted that in many countries, third-party ownership is allowed and standardised ('Rent-a-Roof' model in the United Kingdom for instance).

Enabling the project facilitator or a service provider to become a light retailer of electricity also constitutes an important enabler for CSC projects. Without dedicated regulation, participants in CSC projects need to have an electricity retailer overseeing the electricity produced from the shared generation of prosumers and distributed to other consumers. This retailer has very specific features which necessitates developing a dedicated set of rules to govern its activity:

- It produces and supplies a limited amount of electricity.
- The electricity it deals with remains local.
- In many occasions, it is a non-energy player without intention to become one.

In order to facilitate CSC projects, the rules imposed to a CSC retailer should thus be different than those imposed to 'traditional' electricity retailers. This measure is an important step in the deployment of CSC projects as shown by countries such as Australia or Germany through the embedded network and Mieterstrom regulations. In Australia for example, Indutria REIT, the landlord of the premises, is responsible for billing the tenants for their electricity bills without having to be an electricity retailer.

Finally, restrictions on CSC project size can be a barrier for projects to emerge. Overall, much progress can be seen in many countries in this area, but improvements will still be needed for projects to emerge on a wider scale. France for example is currently pushing the size limit and geographic restriction of a CSC project from 3 MW and 1 kilometre to 5 MW and 20 kilometres. With the Mieterstrom regulation in Germany only supporting installations with a maximum size of 100 kW, CSC projects developed as of 2019 only had an average size of 20 kW [24].

24 As of 2019, Germany had approximately 300 Mieterstrom projects for a cumulative capacity of 6.8 MW.

Conclusion

CSC projects are promising projects to facilitate the energy transition in the electricity sector in that they have the capacity to further develop local renewable electricity and reach new market segments. Looking specifically at distributed PV projects, the market has been exclusively stimulated in the past years by rooftop projects on residential houses or large commercial and industrial buildings. Many small businesses or residential customers do not have access to local renewable electricity as they do not own available space to operate their own PV installation. By allowing people to consume electricity from a shared renewable asset, CSC projects will remove barriers for renewable electricity generation to reach every end users and businesses in the world.

CSC projects offer promising economic benefits for both investors and end users in many countries around the world. Within 5 years, it can be expected market conditions – mostly further decrease in cost of PV and increasing retail tariff – will create an attractive playground for CSC projects, generate decrease of electricity prices for end users and provide interesting returns for investors in such projects in most countries in the world. Financial risks appear to be limited, can easily be identified and be, to some extent, mitigated.

As such, CSC project should largely help local renewable electricity reach the 4 billion people currently living in urban areas and could target a large share of the 150 GW of distributed solar capacity which will be installed without support scheme throughout 2024. This will be specifically the case in countries like Switzerland, Germany, Australia, Brazil, Spain, Mexico, France which started authorising CSC projects, countries like the US which introduced similar type of project (namely solar community projects) or countries currently experimenting innovative pilot projects like the UK, Japan, Thailand, Malaysia.

The barriers to the emergence of CSC projects are two folds: first, regulatory conditions can constrain the implementation of these projects. As such, projects are dependent on the possibility to exchange electricity at a local level, use the electricity network to share this electricity and soften technical and financial requirements for local electricity retailers on CSC projects. **Secondly, CSC projects show a high organisational complexity in trying to gather multiple and diversified end users** (households, small businesses, public buildings…) benefiting from the same generation asset.

As such, project developers as well as other players in the value chain have a critical role to play in order to help projects scale up in the medium term. **Industrial service providers are best positioned to foster the scale up of CSC project:** this will come with the development of standardised and simple approaches along with the creation of turnkey offers encompassing financing facilities. They will also need to **identify and involve facilitating non-energy players such as landlords, real estate companies, municipalities** which are trusted parties for end users (should they be residential, commercial or industrial end users) and will thus have a key role in lowering the organisational complexity of CSC projects.

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List of acronyms

CAPEX Capital Expenditure

CEP Clean Energy Package

CSC Collective Self-consumption

EEG *Erneuerbare-Energien-Gesetz* (German Renewable Energy Act)

EMS Energy Management System

EPC Engineering, Procurement and Construction

FiT Feed-in Tariff

NPV Net Present Value

NPC Net Present Costs

O&M Operation and Maintenance

OPEX Operational Expenditure

PV Photovoltaic

RCP *Regroupement de Consommation Propre* (Swiss framework for microgrid)

RED Renewable Energy Directive

VPP Virtual Power Plant

ZEV *Zusammenschluss zum Eigenverbrauchin*

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