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INTEGRATING COMMUNITY POWER IN ENERGY ISLANDS

Overview of international approaches for Local Energy Systems and Energy Communities

COMPILE Working paper

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Acronyms

Abbreviations and Acronyms List	
BTM	Behind the meter
CEC	Citizens' energy community
CEP	The Clean Energy for All Europeans package
CSC	Collective self-consumption
CCA	Community Choice Aggregation
DG	Decentralized generation
EMDII	New electricity market directive
MS	Member States
O&M	Operation and maintenance
PPA	Power purchase agreement
REC	Renewable energy community
REDII	New Renewable Energy Directive
RES	Renewable energy sources
SME	Small / medium enterprise
VNM	Virtual net metering
VEC	Village energy community

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EXECUTIVE SUMMARY

Decentralized energy solutions are emerging around the world. Drivers are falling costs for renewables, rising energy prices or the aim to supply remote areas with electricity. Decentralised solutions have been promoted in some countries by governments, in others they grew in a bottom-up manner. While several US states adopted virtual net metering already years ago, the EU adopted a comprehensive legislative package during 2018 and 2019 defining diverse types of energy communities focusing on community, social, and environmental value creation and attributing a significant role in decision-making to the community. Australia is discussing a similar approach, the primary purpose of the projects would be to provide economic benefits in terms of local employment, skills, income sources, investment opportunities and social benefits. India has introduced the concept of village energy communities ensuring accountability and sustainability of the local energy systems. In China, the focus of decentralized energy projects put into operation is transforming vertical market models gradually into a horizontal interconnection mode of one-stop services with customer demand at the centre while integrating a range of new technologies. As in Australia also in India and China one of the drivers for energy communities or decentralied energy systems are energy security issues. In India renewable powered energy communities are gaining a strong role in remote areas as well as the Indian agriculture including community-based solar irrigation.

Several issues are being discussed across jurisdictions such as the boundaries of energy communities. In the planned Australian scheme, a community is defined by living in the same place or region and sharing a common characteristic or sense of identity. The EU member states have set different kinds of boundaries for renewable energy communities such as grid segments, municipalities or regions. This heterogenity can also be found in the US virtual net metering schemes that mostly use the same electric service territory, but in some cases also administrative or geographical boundaries. India defines villages as suitable entities.

Another issue that is being discussed in several countries is the balance of benefits for participants of energy community initiatives versus possible increasing system cost burdens for non-participants, as some jurisdictions exempt or reduce energy communities' contributions to system costs. There are ongoing discussions in the US but also in the EU on moving from support schemes aiming to initialize investment in RES (feed-in /net-metering) towards support schemes that reflect the actual value to the grid. In addition, discussions on how to mitigate energy poverty via energy community models have gained attention in several of the analysed schemes.

Creating efficient and inclusive decentralised renewable energy systems seems to be a challenge in most of the assessed countries. Even if political and economic preconditions are different a range of issues are comparable as the report showed and a global exchange on experiences will be of high importance.

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1 INTRODUCTION

This report is part of the activities within the COMPILE Task 7.5 on international cooperation activities.

The paper covers global approaches to decentralized RES deployment and as far as applicable to energy communities. This includes the regulatory frameworks for decentralized energy deployment, governance provisions, as well as technical operation of local energy systems. These approaches are heterogeneous and depend on the economic and political systems. The document, while outlining the diversity of national frameworks, aims to facilitate a know-how exchange between the EU, other industrialized countries, as well as India and China. While the COMPILE partners JR and UL investigated approaches in industrialized countries, Asian project partners carried out the analysis for India and China.

First, this document presents the status, the frameworks used and the drivers for decentralized energy systems and energy communities in the studied countries and then it provides a comparison of the different approaches and an outlook on future developments.

2 ENERGY COMMUNITIES IN THE EUROPEAN UNION[1]

2.1 INTRODUCTION AND STATUS QUO

The Clean Energy for All Europeans package (CEP), a framework for the EU's 2030 Energy and Climate targets, sets the framework for the establishment of "energy communities" in the EU to accelerate the deployment of decentralized renewable energy sources. Specifically, two directives, the recast of the Renewable Energy Directive (REDII) and the Electricity Market Directive (EMDII) foster the development of energy communities. Within these directives, the terms "Renewable Energy Communities (REC)" and "Citizen Energy Communities (CEC)" are conceptualized permitting citizens to become an active part of the energy system.

RECs focus on the expansion of renewables, while CECs are entities to engage in generation, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles.

For both concepts, the primary purpose is to provide environmental, economic or social community benefits for shareholders and members rather than financial profits. EU Member States need to design a framework under which energy communities can be sustained without discrimination compared to existing types of market players.

Each Member State is required to implement these provisions in its national legislation. While most EU countries have related regulatory frameworks already in place, currently established legislations are sometimes at an early stage, either not being very detailed or only addressing certain aspects of the EU legislation. In both concepts of REC and CECs, energy communities need to be legal entities and the membership is voluntary and open.

[1] If not differently stated, this chapter is based on the paper "Collective self-consumption and energy communities: Overview of emerging regulatory approaches in Europe, 2019" from the COMPILE project.

The REDII requires that RECs are "effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects". Moreover, RECs in their decision making process should be able to be autonomous from individual members and other traditional market players that take part in the energy community as members, shareholders, or investors. While RECs are limited to renewable energy, CECs are not. The way an energy community is operated depends on the activities the energy community aims to fulfil. Within the two directives, the following potential activities are mentioned: production, consumption, storage, sales, distribution, aggregation, and energy efficiency services. The sale of energy allows for the formation of renewable power purchase agreements (PPAs) and peer-to-peer trading[2].

Major characteristics differentiating the two concepts can be summarized as below[2]:

Citizen Energy Communities:

- No geographic limitation (i.e. no proximity of the "effective control" to the energy project required).
- Large and medium size enterprises excluded from effective control.
- Electricity only
- Technology neutral (not necessarily renewable energy).
- Create a level playing field for the CECs as a new market actor.

Renewable Energy Communities:

- Proximity requirement (to be defined in national law).
- Limited membership (shareholders or members do not include large companies).
- Open to all sources of renewable energy (e.g. also heat), but renewable energy only.

The CEP also defines 'Jointly acting renewables self-consumers' as a group of at least two jointly acting renewables self-consumers who reside in the same building or multi-apartment block. In this paper we use the commonly adopted term "collective self-consumption" (CSC) for such initiatives of joint generation.

[2] Frieden et al. 2020: Collective self-consumption and energy communities: Trends and challenges in the transposition of the EU framework

2.2 NATIONAL APPROACHES AND REGULATORY FRAMEWORKS

Most EU countries have already prepared draft or final regulatory frameworks for RECs, a few also for CECs. The degree of details in the respective legislative documents however strongly differs among member states. Note that implemented frameworks (having green hooks in Figure 2.1) can range between having elaborated frameworks or just basic definitions.

Country	Renewable energy communities	Citizen energy communities
Austria	✓	✓
Belgium: Wallonia	✓	-
Belgium: Flanders	✓	✓
Czech Republic	-	-
Croatia	draft	draft
Denmark	✓	✓
Estonia	draft	draft
Finland	✓	-
France	✓	✓
Greece	✓	✓
Hungary	draft	-
Ireland	draft	draft
Italy	✓	✓
Lithuania	✓	-
Luxemburg	✓	-
Portugal	✓	-
Poland	draft	-
Romania	-	draft
Slovenia	✓	✓
Spain	draft	-
Sweden	draft	draft

Tab. 2.1: Status quo of REC and CEC implementation, May 2022

The way Member States transpose the EU energy community provisions are very diverse. As an example, the different approaches to physical boundaries for Renewable Energy Communities and Collective Self-Consumption are presented below in Table 2.2 [1].

Country	Approach to physical boundaries for RECs and CSC
Austria	LV/MV (REC)
Belgium/Wallonia	LV/MV and distance
Belgium/Flanders	LV/MV and activity
Hungary	MV/HV
Slovenia	LV
Italy	MV/LV
Ireland	LV, MV
Croatia	Municipality, LV
Lithuania	Municipality
Greece	Regional or system-related, depending on location. Associations and federations allowed.
France	Distance (up to 10km) (for CSC)
Spain	LV, cadastral area, distance (500m) (for CSC)
Portugal	System-relation, individual decision (RECs), same voltage level (CSC)

Table 2.2: Differences in physical boundaries for RECs and CSC in various MS

The support mechanisms that EU Member states plan or have implemented also vary strongly. Some countries have implemented reduced grid surcharges, others defined investment or operational support schemes [1]. Greece has introduced virtual net metering but contrary to many US schemes (see chapter 4) only the energy is netted, while grid tariffs and charges must be paid. Also Finland plans to introduce such a scheme.

2.3 OUTLOOK

Currently, a wide range of approaches is tested in the EU Member States. Many countries consider the current regulatory frameworks as a testing phase to be consolidated, expanded and detailed after first experiences are made. So far, only a few economically viable business cases have been found. The current gas crisis however may be an important trigger to speed up the development of energy communities in the EU.

Stepwise implementation and review processes, as partly explicitly defined in the national frameworks of the EU MS, suggest longer-term learning-, development- and adaptation processes of regulatory frameworks over the coming years. In particular supporting policy frameworks will have to be developed and a better consistency between energy community provisions and existing policy instruments ensured.

3 AUSTRALIA

3.1 INTRODUCTION AND STATUS QUO

The Australian energy system is characterized by naturally abundant solar and wind resources, a regulatory framework that not yet sufficiently facilitates consumer participation and a quite old but extensive electricity network infrastructure serving several small and remote communities [2]. This can be very expensive, considering that up to 100,000 km of network is needed to serve only around 25,000 consumers [3]. Falling investment costs and insecure supply suggest that decentralized renewable energy solutions could be economically more attractive and efficient [4]. Next to security of supply concerns, several other drivers are leading to the creation of energy communities in Australia, such as the wish to reduce greenhouse gas emissions, support of education and benefits for the local economy [5]. Energy self-sufficiency, resilient local communities, reduced electricity bills, and better asset utilization infrastructures are further motivations for the creation of community energy projects [4], [6]. This is illustrated in Fig. 3.1 visualizing the number and location of several community power groups in Australia that have emerged in the last years.

Fig. 3.1: Community power groups in Australia, Status November 2021 [7]

While currently, most community projects are based on solar PV generation, several community wind farm projects have also been operationalized and a few small-scale hydro projects have taken off [8]. One example for a community-owned wind farm is Hepburn Wind, which was established in 2007 with a total power of 4.1 MW [6]. Hepburn Wind is volunteer-run, the volunteers are members of the project and thus receive returns on investment. The wind farm has an agreement with the energy retailer Red Energy, who has committed to buying the entire output of the turbines, and has developed a scheme to encourage people to choose Red Energy as their provider, and in return Red Energy contributes part of their earnings back to the Hepburn Wind Community Fund [6].

There are also several pilots of energy community projects employing community storage such as the Alkimos Beach Energy Storage Trial (ABEST) [9]. This project aimed to demonstrate the feasibility of a new energy servicing model that virtually connects individual households' solar photovoltaic (PV) systems with a community-scale energy storage system (1.1 MW) for more than 100 participants. Participating households that had access to the virtual battery had to pay 11 AUD (7 EUR)/month and on average saved 680 AUD (430 EUR) on their electricity costs over the duration of five years [9]. Another community storage (1.1 MW) has been set in two shipping containers in a neighbourhood in

Perth, where more than 100 homes have PV panels feeding into the batteries and are estimated to save about 15 % on their electricity bill [10].

The current primary model for solar energy communities in Australia is setting up an installation of 80-300 kW directly behind the meter. Excess energy is fed into the grid and bought by a retailer through a PPA for a fixed price or the spot market price [8]. To sell electricity directly to a third party a retailer authorisation or an exemption granted by the Australian Energy Regulator is needed [11].

The first trial for net-metering (peer-to-peer) has taken place in Byron Shire in 2015, where the excess production from the solar array of one building could be credited against the consumption of another building. Customers can set their buy and sell rates for the distributed energy over an online portal [12]. But there is currently no general law in place permitting this. For that reason, collective self-consumption is only possible through the three options presented in Fig. 3.2.

- Within an individual behind the meter (BTM) solution (Schema (a), each apartment is connected to an independent PV system, which could lead to a lower self-consumption rate.
- In an embedded network (Schema (b)) in which the owners cooperation sells electricity to the residents through a “child meter” to each apartment. Next, to the generated on-site electricity, the owner cooperation can use the aggregated demand to achieve better tariffs for the purchase of electricity.
- Shared BTM solution (Schema (c)), where a secondary metering arrangement is used to distribute on-site generation, while continuing to purchase off-site generation could allow overcoming restrictive regulations for embedded networks [13].

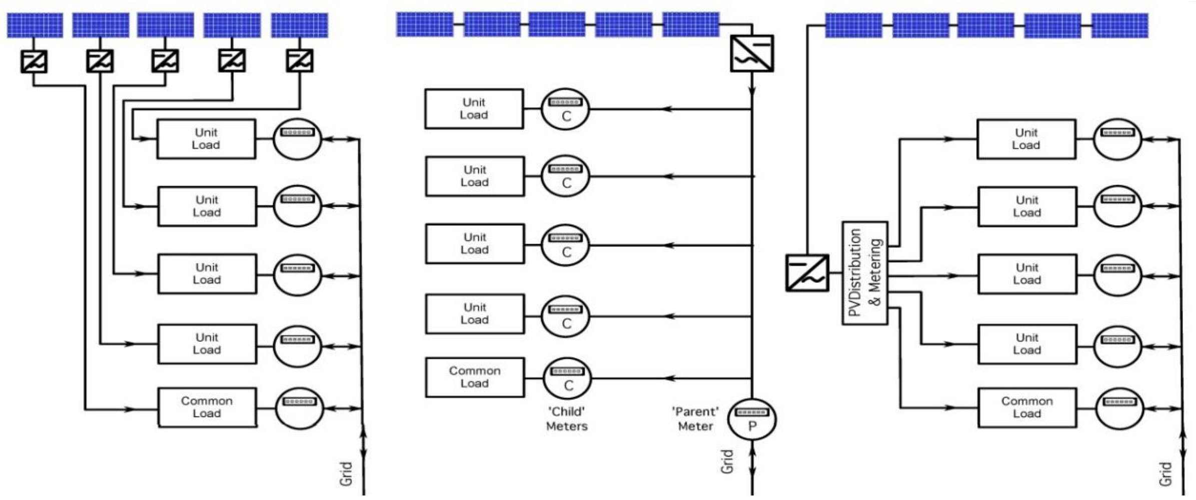

Fig. 3.2: Models for collective self-consumption in Australia; (a) Individual BTM, (b) Embedded network (EN), (c) Shared BTM

There are five organisational models applicable in Australia mentioned by the Coalition for Community Energy (C4CE) for the creation of community energy [14]:

- **Donation/community organisation model:** The community raises funds through donations to install renewable energy projects, typically at community organisations such as schools.
- **Community investment model:** community investors fund renewable projects with the expectation to get a certain return on their venture.
- **Community-developer partnership:** the community cooperates with a commercial energy developer to initiate a community energy project. This could result in dual ownership between the company and the developer.
- **Commercial-council partnership:** the council grants access to land or administrative resources to the developer to establish a community energy project.
- **Multi-house model of community energy:** households are congregating to jointly implement sustainable energy solutions, such as solar bulk-buys [14].

Most projects are created as non-profit associations or as a special purpose vehicle which allows up to 20 community members to invest in projects at their beginning (total of 50) [14]. If more than 20 community members are to co-invest in a project, an Australian financial service licence and significant annual reporting are necessary, which increases costs and could lead to the financial breakdown of a project [14, 15]. One option to tackle this is to form a cooperative which allows for an unlimited number of investors but avoids stringent reporting required for public companies [16].

An important community energy initiative is the Victorian Community Power Hubs Programme, a state government initiative to support the creation of community renewable energy hubs. It is funded by grants from Sustainability Victoria, a statutory authority established by the Victorian Government in 2005 with the objective of facilitating and promoting environmental sustainability in the use of resources. [17] The Community Power Hubs Program aims to bring together locals to develop and operate community-owned renewable energy projects. The hubs provide services including building local knowledge and participation in community energy, increasing local capacity and skills, and ensuring the benefits remain local. [17] The program also funded the delivery of implementation-ready community energy projects that will be delivered by their respective regional community energy hub. In 2021, funding from the Victorian Government of 428,500 AUD to 857,000 AUD was available for the establishment and operation of each community hub and applicants were required to make a co-contribution of 1 AUD for every 5 AUD in government funding. The program has further funded community renewable energy projects at 16 sites. In total, 800,000 AUD of funding was made available across the implementation-ready projects. [18]

There are also other regional support programs such as the New South Wales regional clean energy program or funds which could support the establishment of an energy community [8]. In New South Wales the Regional Community Energy Fund provides grants to community energy projects that create innovative and/or dispatchable renewable energy and benefit the local community [19].

3.2 NATIONAL APPROACHES AND REGULATORY FRAMEWORK

So far, the main supporting policy in Australia is a renewable energy target which requires retailers to buy a certain amount of electricity from renewable sources via renewable energy certificates, sold by renewable energy generators [14]. This lowers the risk of investment for energy communities, as it could already cover 20-30 % of the costs for installations below 100 kW [14]. Under the Small-scale Renewable Energy Scheme, small-scale technology certificates are calculated based on system location, installation date, and if they are created over one or five years, or a single maximum deeming period. [20] Small scale technology certificates were priced at approximately 3.3 AUD c/kWh (0.02 €/kWh) in 2017. This payment is received up-front and results in an effective discount to the cost of purchasing the solar system. For bigger installations, the share covered by these certificates is lower and therefore the risk is higher [14].

In 2021, the Australian Local Power Agency Bills were proposed and publicly discussed aiming to accelerate the development of community energy projects [21]. The laws would establish a new corporate entity, the Australian Local Power Agency (ALPA), which would be responsible for driving investment into community energy projects and ensuring that regional communities share in the benefits of renewable energy.

The Bills set out a definition of community energy projects, which are renewable energy projects (including energy storage and energy efficiency) that have to fulfil the following criteria [21].

- The main activity of the project is generating renewable energy, storing energy or increasing energy efficiency.
- The project is carried out mainly by the community or by community organizations.
- The main purpose of the project is to benefit the community or community organizations.
- The community has a significant role in decision-making on the project.

The meaning of “benefit” is intended to refer to both, economic benefits in terms of local employment, skills, income sources and investment opportunities, and social benefits in terms of community development, social cohesion, energy security and local empowerment. The meaning of “community” is intended to refer to a group of people living in the same place or region and sharing a common characteristic or sense of identity [21]. The concept thus has similarities with the EU concept of renewable energy communities.

According to the bills, community organizations can include the following:

- a not-for-profit body corporate or unincorporated association;
- a local council;
- a for-profit body corporate or unincorporated association, if the main purpose of the body or association is to profit:
    - one or more other community organizations; or
    - a wide membership consisting exclusively or predominantly of other community organizations or members of the community.
- any entity or business arrangement (including a partnership or joint venture) controlled (whether directly or indirectly) by:
    - one or more other community organizations; or
    - a large number of persons, all or most of whom are other community organisations or members of the community.

The Standing Committee on the Environment and Energy in early 2022 however concluded that the creation of another new bureaucratic agency (i.e. ALPA), with all the costs and administration that entails, would not be of benefit to Australians and recommended the Bill not be passed [22]. The Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC) are deemed to be appropriate agencies to undertake the work of providing support to renewable energy projects in Australia [22]. As reaction, modifications of the bill were proposed such as substantially increasing the financial support available to community energy groups by establishing a dedicated Local Power Fund endowed with 300 million AUD. The fund would be allocated to ARENA and focused exclusively on supporting regional community energy projects and establishing a properly resourced technical assistance program, to be delivered by ARENA, to provide direct on-the-ground support to community groups in regional Australia to develop their own community energy projects. That technical assistance program should be based on the successful Victorian Power Hub program and should seek to establish properly funded community energy hubs in regional centres nation-wide [22].

3.3 OUTLOOK

The Australian Local Power Agency Bills bills opened a discussion in Australia to support and better coordinate emerging community energy initiatives. At the same time regional initiatives will gain further momentum. Already in 2020 a planned national Local Power Plan identified 50 Local Power Hubs, bringing jobs, investment opportunities and supply of cheap, clean, and local power to regional Australia [23]. NGOs such as the Community Power Agency highlight that a special focus shall be put on community energy in areas devastated by floods, droughts and bushfire, currently struggling from electricity price increases. [24].

4 USA

4.1 INTRODUCTION AND STATUS QUO

The electricity system of the U.S. is characterized by quite a heavy reliance on fossil fuels and an increasing energy demand levering out energy efficiency measures [25, 26]. In 2020, about 1/6th of power capacity is attributed to decentralized generation units and is expected to increase due to renewable technologies becoming cost-effective for homeowners and businesses, policies fostering the deployment of renewable technologies and DG as secure options in case of blackouts [27]. It is estimated that nearly half of U.S. households and businesses are unable to host PV on their rooftops. Therefore other options such as collective ownership and shared renewables could become important options for increasing renewable generation [28]. Moreover, it should be mentioned the regulatory framework for community energy projects depends on the specific state, differing quite substantially [29].

4.2 NATIONAL APPROACHES AND REGULATORY FRAMEWORKS

The expansion of renewables is mostly supported within the support system for renewable energy production, where there is a 26 % investment tax credit (tax credits for solar from business taxes and a production tax credit of 2,2 $c/kWh for wind) [30]. These credits are however often not accessible for community energy projects, as they are often founded by the local government or non-profit organizations which do not have to pay federal taxes anyway and therefore do not benefit from tax credits. For that reason, often big companies are included, which can receive tax credits and provide investment, however also receive the main share of the revenues [30].

A concept that has been existing for a long time is Community Choice Aggregation (CCA), which refers to initiatives (e.g. from local governments) uniting demand from residents and businesses for a certain area (e.g. town/village). The main effect is a reduction of the cost of electricity and sometimes offering a higher share of renewable energy by a different supplier, while the utility continues to be responsible for transmission and distribution. Electricity prices could be lowered (15-20%) due to collective buying power [31]. Participation in CCAs is always voluntary with either opt-in or opt-out options. CCAs have been anchored in the law for example in California, to prevent conventional energy suppliers to prohibit the establishment of a CCA (AB 117 and SB 790). Besides California, also Illinois, Ohio, New York, New Jersey, New Hampshire, Virginia, Maryland, Massachusetts, and Rhode Island have approved CCA legislations in place [32].

State	Name	Year
Massachusetts	Municipal aggregation	1997
Ohio	Government energy aggregation	1999
Virginia	Municipal aggregation	1999
California	Community Choice	2002
Rhode Island	Energy aggregation	2002
New Jersey	Government energy aggregation	2003
Illinois	Municipal electricity aggregation	2009
New York	Community choice aggregation	2014
New Hampshire	Community power	2019
Maryland	Community choice energy	2021

Tab. 4.1: States with approved CCA legislation. [32]

Fig 4.1 visualizes the working principle of a CCA. The operation of the energy system remains similar, but a greener power generator is often chosen, and costs could be reduced for the end-users without a lot of effort.

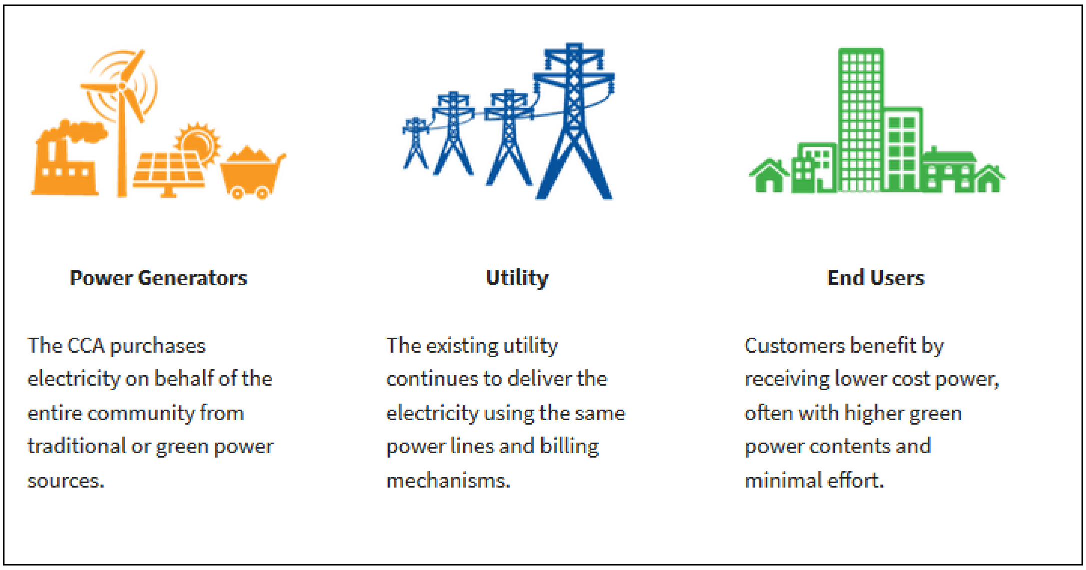

Fig. 4.1: Working principle of CCAs [31]

Presently, the exit fee, the former provider sets, is a decisive factor if CCAs are economically feasible or not [33]. The regulatory aspect hampering the establishment of energy communities is the lacking possibility to share the electricity output of an energy project with consumers that may not be at the same location. Several states, therefore, have introduced a virtual net metering (VNM) policy, which would overcome this issue [30]. For a state-to-state description of virtual net metering provisions, please see Annex A.

Regulations such as tenant aggregation would also allow for shared solar concepts, even if not on the same level as virtual net metering. Tenant aggregation allows parties mostly in multi-family/multi-tenant buildings to aggregate their meters and offset them according to the share they own of the solar system. Meter Aggregation/Aggregated Net Metering is a form of net metering, which allows a single customer to offset several meters at different locations [34].

Based on the previously mentioned options the concept of shared solar/community is emerging typically meaning electricity is shared by multiple customers. Community solar programs allow customers to purchase solar-generated electricity from off-site solar facilities through subscriptions or upfront payments, giving people who cannot or prefer not to install rooftop solar a way to participate in the solar economy. However, the ownership of the system is likely not to be in the community, but mostly utility-based. Some of the shared solar programmes such as in Virginia require that shared solar projects must serve at least 30 % of low-income customers [35]. In offsite/onsite shared solar concepts participants invest in a share of the solar arrays owned by a third party and earn in return credits on their electricity bill. In this case, the participation and engagement of the community are quite low, but the reduced risk and investment costs make it a valid option for consumers [30].

Fig. 4.2: Shared solar consumption models [36]

Also community wind projects have emerged either using the produced electricity directly or sell it to local utilities at a fixed rate, securing long-term prize stabilization [37]. These projects are often smaller than utility ones, possibly avoiding transmission upgrades and can often be directly connected to the distribution grid [38]. At the moment, no example of community-owned shared storage is known but could play a role in the future [39]. Currently, most community energy storage projects refer to storage at the distribution level owned by the utility.

4.3 REFORM OF (VIRTUAL) NET METERING PROGRAMMES

In several states, there are ongoing discussions to reform their (virtual) net metering programmes. Utilities can pay net metering (NEM) customers as much as the full "retail rate" charged to customers. Across the country, the rate paid to NEM customers varies from place to place and from utility to utility [40]. As solar becomes more affordable and is implemented by more customers, discussions about the need and usefulness of retail rate NEM have increased. When compensated at the full retail rate within net-metering, this would unfairly subsidize solar power-generating consumers by transferring their share of the costs of grid infrastructure maintenance and investment to consumers unwilling or unable to install expensive generation equipment [40].

The California Public Utility Commission has recently presented a reform of its (virtual) net metering programmes [41]. In the new scheme, customers are required to pay charges that align their costs more closely with non-participating NEM customer costs. For example, customer-generators must pay a one-time interconnection fee and monthly non-waivable charges. Further, NEM 2.0 customers must take service under a time-of-use rate (net billing). For the electricity they receive from the grid, the net billing customers are charged based on high differential time-of-use tariffs: This creates more benefits for customers who install storage and incentivizes them to store solar energy and consume or export it later in the day [42]. Further, the VNM is revised to allow multiple solar arrays on one property to be treated as one generator, with credits allocated across the property. Low-income customers may also participate in the net billing tariff but will be exempt from the grid participation charge.

4.4 OUTLOOK

The CCA concept often only provides traditional bulk procurement strategies to consumers. The evolving model of shared solar/community solar comes closer to the EU concept of energy communities in particular if administered by cooperatives. Distributional aspects and energy poverty mitigation are getting increased attention such as in the reform of virtual net metering programmes towards net billing aimed to prevent a high grid fee burden on non-participating customers or by providing special provisions to assist energy-poor households. Despite an expected strong growth of community energy initiatives it seems to be challenging to reach the Biden's administration goal of 5 million homes to be powered by community solar projects by 2025, representing a 700 % increase from 2021 capacity [43].

5 INDIA

5.1 INTRODUCTION AND STATUS QUO

In the Indian setting, one of the earliest implementations of energy community microgrids through a government initiative was the Remote Village Electrification Programme (RVEP) by the Ministry of New and Renewable Energy (MNRE). The MNRE created the RVE division in October 2003 with the aim of completing the time-bound programme of electrification of all 'remote' census villages in the country by 2007 [44]. Remote villages are those in which electrification through the conventional grid is either not feasible or uneconomical (because of the geographical location of the villages). These villages were to be electrified by community-managed off-grid renewable energy systems such as small hydro, biomass gasification or solar photovoltaic. Where such decentralized electricity generation is not feasible, the households would be electrified through the use of isolated lighting systems (such as solar PV). However, regarding the implementation, the Standing Committee on Energy (2010) reported that approximately 7 % of 10,101 villages had microgrids: micro-hydro in 230 villages, biomass gasification in 37 villages and solar power plants in 410 villages [45]. As per Niez (2010), a large majority (>95 %) of the villages considered under the Remote Village Electrification Programme were provided with only solar PV home lighting systems and the rest with decentralized electricity generation systems [46]. Also, as per the CSE (2012) RVEP review study, MNRE has provided Solar PV to at least 95 % of the villages, however less than 5 % of projects are community power plants [47]. Policies like *Rajiv Gandhi Gramin Vidyutikaran Yojna* of 2005, aimed at creating decentralised distribution-generation system, had limited success [48]. The less prevalence of microgrids relative to the home-based system was because of the higher cost of plants and larger infrastructure requirements, besides they also suffer from the tragedy of commons, a situation where a common resource is overexploited by individuals for personal gain, and ultimately, the common resource gets ruined [49]. While less than the expected number of villages had community microgrid installations, the RVEP is one of the earliest accounts of government-initiated community-level village microgrids in India.

From Western India, there is a unique example of a solar-powered energy community project driven through cooperatives. With support from the CGIAR's research program on Climate Change, Agriculture and Food Security in partnership with the local power distribution company (Madhya Gujarat Vij Company Ltd. – MGVCL) and IWMI-Tata Program (ITP) a pilot in Dhundi Village, Gujarat, has been implemented to test the viability and to quantify benefits arising from this model [50]. ITP helped organize a small group of farmers in the village into *Dhundi Saur Urja Utpadak Sahakari Mandali* (Dhundi Solar Power Producers' Cooperative Society) and registered as the world's first solar farmers' cooperative in early 2016 [50]. The six initial members of the cooperative together installed 56.4 kWp capacity solar pumps, connected through a micro-grid and the cooperative pools surplus solar power from its members and evacuates it to the grid at a single evacuation point for which MGVCL pays it 4.63 INR/kWh (0.06 EUR/kWh) under a 25-year power purchase agreement [50]; [51]. This tariff represents the lowest bid for solar power by corporate entities investing in MW-scale solar plants and to encourage member farmers, ITP is offering the cooperative an additional 1.25 INR/kWh (0.02 EUR/kWh) as a 'Green Energy Bonus' and 1.25 INR /kWh (0.02 EUR/kWh) as 'Water Conservation Bonus' [50]; [51].

In addition village-level community initiatives have renewed India's biogas initiative by unlocking the potential of the dung produced by the bovines, which has also catered to the agricultural needs of organic manure and bio-fertilizers [52]. The initiative led by the National Dairy Development Board at Mujkuva, Anand, is a case in point [53].

At CoP 26 in 2021, the Prime Minister of India announced that India will meet 50 % of its energy requirement from renewable sources by 2030 with an installed capacity of 500 GW of energy from non-fossil-fuel sources. The Government of India's 100 GW solar capacity target for 2022 has already provided a stimulus to India's nascent solar industry. The Government of India's ambitious scheme — *Deendayal Upadhyaya Gram Jyoti Yojna* (Scheme of Govt. of India for Rural Electrification) launched in 2015, aims at energy access and security in rural areas with segregation of agricultural and non-agricultural feeders [54]. A large number of decentralized micro-grid innovations could prove to be alternatives to this ambitious scheme. Recognizing the importance of such local-level, innovations the Government of India launched *Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan* (PM KUSUM) scheme in 2019 with the following components [55]:

- Component A: Setting up of 10,000 MW of Decentralized Ground/ Stilt Mounted Grid Connected Solar or other Renewable Energy-based Power Plants;
- Component B: Installation of 1,750,000 Stand-alone Solar Agriculture Pumps; and
- Component C: Solarisation of 1 mio. Grid Connected Agriculture Pumps.

5.2 NATIONAL APPROACHES AND REGULATORY FRAMEWORK

To ensure sustainability and accountability, the concept of a Village Energy Community (VEC) emerged as the important 'actor' for managing the overall functioning and governance of energy community projects. Solutions to the tragedy of the commons include the monitoring role of VECs who are primarily involved in load management and tariff setting, revenue recovery through billing and collection, O&M work for the project, local monitoring of the system to check for any form of malpractice [56]; [57]; [58]; [59].

The VEC is not the only actor, neither does it work in isolation. For instance, the VEC of the Community Solar Power Plant at Rampura Village, Uttar Pradesh involves local communities, civil society and industry [56]; [57]. The VEC involves the participation of local communities and members of *Gram Panchayat*, a constitutional entity, who hold the ownership of the plant and are responsible for O&M and financial management of the solar project (8.7 kWp capacity) [56]; [57]). In another example, the Chhattisgarh Renewable Energy Development Agency (CREDA) executed a joint-venture energy community project with a private player in Chhattisgarh [57]; [58]. Here, the CREDA does the overall monitoring, the VEC is also involved in local monitoring, resolving social conflicts, controlling theft and other management aspects of the project [57]; [58].

Multiple pieces of literature suggest that energy communities in a local setting are also managed by other actors such as Self-help Groups (SHGs), NGOs and cooperatives. To name a few - DURGA - India's first solar module manufacturing unit owned and operated by local tribal women focused on sustainable livelihoods through women empowerment and local entrepreneurship [58]. This energy community project is jointly owned by cluster-level SHG federations from the district of Dungarpur, Rajasthan [58]. The other actors involved are: as knowledge and technology partner - the IIT Bombay and as funders Rajeevika NGO, Tribal Area Development, Idea Cellular Corporate social responsibility, District Administration, Dungarpur and Nagar Parishad, Dungarpur (Urban Local Body) [58]. Similarly, the success story from the Harpur Village, Bihar, reveals how community contribution and participation ensured strong ownership in a solar irrigation project that focused on poverty reduction and food security. This project witnessed the participation of women in all stages of implementation, where the entire setup and operations were owned, headed and managed by the women SHGs. In the lines of community participation, 'Barefoot College'- located in the Tilonia Village, Rajasthan, is owned and operated by women from rural communities committed to creating localized solutions combining traditional skills and experiential learning, development through indigenous knowledge, skills and wisdom, facilitating convenient technology for poor communities so that they are not dependent or exploited [56]; [58]. Barefoot solar is one of the solution strategies which envisions training women to become solar engineers, even if they are illiterate or have no formal education, to build rural resilience [60]. The barefoot communities have multiple collaborators such as UNESCO's Global Partnership for Girls' and Women's Education, Indian Technical and Economic Cooperation and Skoll Foundation [56]; [58]. Similarly, in Sundarban, the community solar microgrid set up by WWF India (2022) functions in close partnership with the local communities and other stakeholders. This project (84.12 kW capacity) was beneficial during the recent cyclone Amphan [61].

Private sector large-scale investments are also planned in terms of partnership between Tata Power and Rockefeller Foundation to set up 10,000 microgrids by 2026. This initiative aims at supporting 100,000 rural enterprises, creating 10,000 green jobs and providing irrigation for over 400,000 local farmers.

5.3 OUTLOOK

Apart from the community wellbeing and livelihood support renewable energy-powered communities have a promising role in the agriculture sector. The community-based solar lift irrigation system demonstrated its potential in tackling climate change and bringing prosperity to the tribal communities in Jharkhand and Madhya Pradesh [62]; [63]. Similarly, in the village of Chandrapur, Jharkhand, the community-based solar lift irrigation project aims to encourage smallholder farmers towards vegetable cultivation and to improve the overall farm productivity of the region resulting in growth in the net income of the farmers [64]. Off-grid systems, solar pumps tend to be adopted as backup/additional pumps rather than substitutes for existing electric or diesel pumps. There are however also risks: With rapidly falling PV prices, zero marginal cost of pumping, no alternate use possible for the solar-generated electricity and immature regulation, there is a real danger that in the near future, the quickly increasing numbers of solar water pumps are left running even when the pumped water is not locally needed, needlessly spilling vast quantities of water and thus causing damage to India's already fragile aquifer ecosystems.

6 CHINA

6.1 INTRODUCTION AND STATUS QUO

As the world's largest energy producer and consumer, China's power generation far exceeds that of the United States, India and other major energy producers. According to a report released by the International Energy Agency IEA, China's power generation in 2018 was about 6.8 trillion kWh, with a global share of 25.49 %. Moreover, China's power system relies heavily on fossil fuels. In 2018, China's thermal power generation accounted for 73.23 %. With the rapid development of China's economy, the demand for electricity continues to grow, and problems such as insufficient energy resources, increased supply pressure, and environmental protection conflicts have gradually become prominent. In order to ensure energy supply and achieve low-carbon emission reduction, China has begun to vigorously develop distributed energy in recent years. China's north-western region is rich in renewable energy, but due to the lack of a corresponding transmission and distribution network, renewable energy generation is difficult to absorb. Distributed energy is an important means to solve the bottleneck of renewable energy power generation in remote areas where the connection with the large power grid is weak, which is conducive to advancing energy reform, energy-saving and emission reduction, and improving the utilization rate of distributed power generation [65]. Distributed power can be connected to the power grid through the microgrid, which can optimize the use of various distributed power sources and realize the complementary advantages of different distributed power sources.

6.2 NATIONAL APPROACHES AND REGULATORY FRAMEWORK

The concept of decentralized energy was first introduced in China in 2002 [66] and officially appeared in government documents in 2004 [67]. Compared with the traditional centralized energy system, decentralized energy is close to the load, and there is no need to build a large power grid for long-distance high-voltage or ultra-high-voltage transmission, which can greatly reduce line loss and save construction investment and operating costs of transmission and distribution. Decentralized energy can also effectively realize the cascade utilization of energy and achieve a higher comprehensive energy utilization rate [68].

At present, the development of China's decentralized energy industry is still in its infancy, and there are many problems, such as the great influence of the existing policies, the lack of overall development planning, and the need to introduce core technology and equipment [69]. In response to this, the state and local governments are actively issuing corresponding policies to improve the guidance and promote the healthy and efficient development of decentralized energy. In 2006, the National Energy Administration of China issued *the Preliminary Opinions on The Implementation of the Outline of the National Program for Medium - and Long-term Scientific and Technological Development*, creating favorable conditions for the large-scale promotion and application of decentralized energy [70]. In order to promote energy conservation, emission reduction and ecological and environmental protection, the State Council issued *the Opinions on Implementing the Division of Labor among Key Departments in the Government Work Report* in 2012, developing smart grids and decentralized energy, and implementing effective management methods such as energy-saving power generation scheduling, contract energy management and government energy-saving procurement [71].

In 2016, *the 13th Five-Year Plan for Energy Development* issued by the National Development and Reform Commission and the National Energy Administration pointed out that great importance should be attached to the development of decentralized energy and the construction of decentralized energy projects should be accelerated [72]. In 2019, the National Development and Reform Commission and the National Energy Administration issued *the Notice on Further Promoting the Reform of Incremental Distribution Business*, proposing that pilot projects of incremental distribution business should be coordinated with the development of decentralized power supply, micro-grid and integrated energy [73]. In 2020, the National Development and Reform Commission issued *the Opinions on Accelerating the Establishment of Green Production and Consumption Regulation and Policy System*, proposing to increase policy support for decentralized energy, smart grid, energy storage technology and multi-energy complementary installations [74].

With the promotion of relevant policies, China's decentralized energy has been able to develop rapidly. China began to develop microgrids in 2015, during which the government issued many incentive policy documents. In August 2019, the Ministry of Industry and Information Technology took the lead in releasing the "Notice on the Pilot Demonstration of Smart Photovoltaics", containing five microgrid demonstration projects and three optical storage demonstration projects. In addition to the National Development and Reform Commission and the National Energy Administration, the third department, the Ministry of Industry and Information Technology, joined the ranks of advancing the development of microgrids [75].

Since 2015, China has approved a total of 108 pilot and demonstration projects, including 23 demonstration projects of multi-functional complementarity integration and optimization, 28 demonstration projects of new energy micro-grids and 55 pilot projects of "Internet +" smart energy projects, gradually shifting from a single model to a comprehensive energy model [76]. China's distributed energy and microgrids are mainly managed by the State Council's energy authority and relevant departments. They negotiate and formulate China's distributed power generation industrial policy, issue technical standards and engineering specifications, guide and supervise the development planning, construction, and operation of distributed power generation in various regions management. The development model has gradually transitioned from a single model to a comprehensive model, and distributed energy can be deeply integrated with market-oriented reforms and promote each other. The development of distributed energy and microgrid in China has also brought about the rapid development of renewable energy. The installed capacity of distributed photovoltaic power generation in China has increased year by year and reached 50.61GW in 2018. As of the first three quarters of 2019, the cumulative installed capacity of distributed photovoltaic power generation in China reached 58.7GW.

Due to the large initial investment in microgrid projects, they face high investment risks, restrict the commercialization of distributed energy and microgrids and require diversified joint capital investment. Distributed energy is frequently used to supply loads in areas with unstable voltage, which is also an important reason for its development. As the pace of smart grid construction accelerates, it is bound to effectively solve the technical problems of distributed energy grid connection and make China's distributed energy development scale to a higher level.

At present, most of the decentralized energy projects that have been put into operation in China are combined and vertical models extending vertically from upstream to downstream of the industrial chain, covering the natural gas network, the power network and the heat network. The development of decentralized energy is gradually transformed into a horizontal interconnection mode with a one-stop service that focuses on customer demand and integrates many new technologies in various forms of business [77]. Most power companies in China seek to rationally deploy decentralized energy resources to achieve greater system value through intelligent inverters, technology deployment of specific distributed energy resources and integration of decentralized energy resource grid service market [78].

In recent years, China's decentralized energy and microgrids have developed rapidly, for which the following main driving factors are responsible:

(1)The proportion of fossil-fueled thermal-generated electricity is high, while the proportion of renewable energy generation is less than 30 %. Under the dual pressure of energy and environmental protection, China has been committed to the optimization and upgrading of the energy consumption structure, which provides good opportunities for the development of decentralized energy and microgrids.

(2) China's economy has entered a new normal state of medium- and high-speed growth in which the power demand has slowed down, entering a critical period of comprehensive deepening of reforms. In order to proactively adapt to the new normal of economic development, developing and constructing cluster-type microgrid into a grid-connected microgrid and the combination of various types of renewable energy, energy storage and high-efficiency energy technologies has become a new development idea [79].

(3) As an important part of the power generation in microgrids, distributed generation in China includes distributed photovoltaic, small wind turbines and renewable heat such as heat pumps and biogas. With the advancement of the energy revolution, the systems are gradually changing from a single energy source to a comprehensive energy vector system.

6.3 OUTLOOK

Distributed energy is an important component of the energy structure transformation in China. A microgrid is a form of further utilization of distributed energy. By optimizing the use of various distributed energy sources, the advantages of different distributed energy sources are complemented. Microgrids can effectively realize a cascadic utilization of energy and achieve a higher comprehensive energy utilization rate. Microgrids are therefore one of the important means to solve the problems of insufficient energy resources and high supply pressure in China. Microgrids can also save investment in transmission and distribution construction, shorten the distance from the load, and reduce transmission losses. In addition, the development of distributed energy and microgrids in China can effectively improve the level of renewable energy utilization and achieve green and low-carbon sustainable development.

7 DISCUSSION AND CONCLUSIONS

Decentralized energy solutions are emerging around the world. Drivers are falling costs, rising energy prices or the aim to supply remote areas with electricity.

Several US states have introduced virtual net metering schemes and more recently shared solar/community-solar concepts are emerging. In the EU in 2018 a comprehensive energy package was introduced defining different types of energy communities focusing on community, social and environmental value creation and attributing a significant role in decision-making to the community. Australia is currently discussing a similar approach, highlighting as the main purpose of the projects the benefit to the community, but also questions on energy security of remote areas are strongly present in the policy discussions. Similar to the EU, benefits refer to both, economic benefits in terms of local employment, skills, income sources, investment opportunities as well as social benefits in terms of community development, social cohesion and local empowerment. As in Australia, also in India and China one of the drivers for energy communities or decentralied energy systems are energy security issues. Renewable powered energy communities are gaining importance in remote areas in India, as well as in the Indian agriculture including community-based solar irrigation systems. To ensure sustainability and accountability, the concept of Village Energy Communities has emerged as an important actor in managing the overall technical functioning and governance of energy community projects. Decentralized solutions, including microgrids, are also being introduced in China. At present, most of the decentralized energy projects that have been put into operation in China are combined and vertical models extending vertically from upstream to downstream of the industrial chain, covering the natural gas network, the power network and the heat network. The development of decentralized energy is gradually being transformed into a horizontal interconnection mode with a one-stop service that focuses on customer demand. However, active consumer involvement and governance are still less accentuated in China than in the other assessed countries. While in the US and Europe community energy has a strong focus on renewable electricity generation, China and India promote the inclusion of biogas. In particular, China aims to integrate a wide range of technologies to create comprehensive decentralized energy systems.

Issues being discussed across jurisdictions include the boundaries of energy communities. In the proposed Australian scheme, a community is defined by living in the same place or region and sharing a common characteristic or sense of identity. The EU member states have set different kinds of boundaries for renewable energy communities such as grid segments, municipalities or regions. This heterogenity can also be found in the US virtual net metering schemes, that mostly relate to the same electric service territory, but in some cases are limited by administrative or geographical boundaries. Another issue that is being discussed in several countries is the balance of benefits for participants of energy community initiatives versus possible increasing system cost burdens for non-participants, as some jurisdictions exempt or reduce energy communities' contributions to system costs. This led to discussions/decisions in the US but also in the EU on moving from support schemes aiming to initialize investment in RES (feed-in / full retail rate net-metering) towards schemes that reflect the actual value to the grid. In addition mitigating energy poverty via energy community models have gained attention in several of the analysed schemes.

Creating efficient and inclusive decentralised renewable energy systems seems to be a challenge in most of the assessed countries. Even if political and economic preconditions are different, a range of issues are comparable, as the report showed, and a global exchange on experiences will be of high importance.

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9 ANNEX A: Comparison of virtual net metering policies in the USA[3]

State	Policy name	Start	Eligible parties	Boundaries	Bill credit
California	Virtual Net Metering (NEM-V or VNEM)	2012	Residential, commercial and industrial multi-tenant and multi-property	Facility and subscriber must be on same multi-tenant or multimeter property	Full retail rate minus non-by passable chargers
Colorado	Solar*Rewards Community**	2012	Investor owned utility customer;	The facility must be in same municipality or county as subscribers if county >than 20 000 inhabitants	Total aggregated retail rate excluding T&D and administrative charges
Connecticut	Virtual Net Metering (VNM)	2014	State, municipal and agricultural customers	Facility, host, and subscribers must be in the same electric territory	Full retail rate, adjusted in accordance with a declining percentage of D&T component
Distr. of Columbia	Community Renewable Energy Facilities (CREF)**	2013	All customers	The facility must be in D.C.	Full retail rate, incl. generation, transmissions and distribution chargers for residential customers. Standard offer service rate for commercial customers
Delaware	Community Net Metering	2015	All customers	Facility, host, and subscribers must be in the same electric territory	Full retail rate if, suppliers are located on the same feeder (otherwise supply service charges apply)
Hawaii	Community-Based Renewable Energy (CBRE) Program	2015	Residential and commercial customers	Facility and subscriber must be on the same island	Time-varying bill credit rats (mid-day, on-peak, off-peak)
Illinois	Community Renewable Generation Program*	2016	All customers	Same utility service area	Supply rate
Massachusetts	Community Shared	2013	All customers	Same ISO-NE load zone and utility distribution territory	Default service charge+ transmission charge+ transition charge

[3] Based on IREC, Shared Renewables Policy Catalog, 2018

State	Policy name	Start	Eligible parties	Boundaries	Bill credit
	Solar/Virtual Net Metering (VNM)				
Maryland	Community Solar Energy Generating Systems (CSEGS) Pilot Program	2017	All customers	same electric service territory	Full retail rate
Maine	Community Net Metering (Net Energy Billing)	2019	All customers	Service territory of a single utility	Gross output can offset the supply portion of the bill to a 1-1 ratio. Facility output can offset a certain percentage of the T&D portion
Minnesota	Solar*Rewards Community**	2013	All customers	Same or contiguous county	< 40kW: full retail rate > 40kW "value of solar rate" ($/kWh) = avoided fuel/operation/maintenance/generation/transmission/distribution/enviornmental cost
New Hampshire	Group Net Metering	2013	All customers	the same municipality	Small customer-generators: Full retail energy and transmission rates and 25 % of distribution minus non-bypassable charges Large customer-generators: monetary credits equal to utility's default energy service rate
New Jersey	Community Solar Energy Pilot Program	2019	All customers	In the EDC service territory where they are located	Retail rate minus non-bypassable charges
New York	Community Distributed Generation (CDG)	2015	All customers	Same service territory	Tranche 1 100 % retail rate, Tranche 2 95 % retail rate, Tranche 3 90 % retail rate
Oregon	Community Solar	2019	All customers	Same utility service territory	Resource value of solar determined by the PUC

State	Policy name	Start	Eligible parties	Boundaries	Bill credit
Rhode Island	Community Remote Net Metering	2018	Residential customers and accounts associated with affordable housing developments, public entities, educational institutions, hospitals, non-profit organizations, and multi-municipal collaborative	shared Solar Facilities: Facility and participants must be on the same or adjacent parcels of land (exception for public entities, which may allocate credits to accounts within the same municipality)	Standard offer service kWh charge net of renewable energy standard charge/credit, distribution/transmission/transition kWh charge
Vermont	Group Net Metering	2017	same utility service territory	Same elec. service territory	Blended residential rate – lowest of the $/kWh for general residential service Siting adjustors of -0,03$/kWh for non-preferred sites and +0,01 $/kWh for preferred sites

* final rules and tariffs have not yet been approved for these programs

** in these states only/primarily one Investor owned utility offers a shared renewables program