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Regulatory Framework for Renewable Energy Communities in Austria, France, and Italy: Evaluation, Investment Analysis, Comparatives and Gaps

THESIS FOR MASTER'S DEGREE IN
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Abstract

Efforts have been put some decades ago to beat, or at least mitigate as much as possible, climate change. Since the European Green Deal, empowering energy communities have been recognized as a way of involving and committing average citizens in the energy transition. As part of the Clean Energy for all Europeans package, the recast of the Renewable Energy Directive (REDII) entered into force, finally recognizing legally within the concept of Citizen and Renewable Energy Community (CEC and REC respectively). Member States are obliged to transpose the European provisions in national laws for these communities.

The present work examines in detail the regulatory framework for Renewable Energy Communities, centred in residential photovoltaic projects, in Austria, France, and Italy, which are countries advanced in the transposition process. Subsequently, two different hypothesized REC configurations, maintaining the main general assumptions constant, were analysed from an investment perspective, to implement the already-explained legislation frameworks to identify the main revenues and costs sources for the establishment and management of RECs, in each single country. Furthermore, a cross-country comparison was conducted in terms of regulatory provisions and investment analysis results, enabling the identification of further recommendations for future concerned studies. At the end, based on the present work findings and state-of-the-art examined, there were identified main key issues and gaps to be addressed by national and, in general, by European laws regarding RECs for the near future.

The analysis revealed that the main left-open aspects for member states to transpose into national laws are the proximity criteria of the REC, which quite often relies on the public network connection and/or the plant installed capacity; cost-reflective network charges for the REC shared energy and incentive and support schemes to promote and facilitate RECs deployment. For the years to come, European countries should focus on complete regulatory frameworks for RECs, including non-discriminatory REC-specific support schemes covering all-income levels participants, the cooperation of RECs with DSOs and contemplating proximity criteria, facility installation capacity and diverse members and shareholders in a legal support basis that is flexible enough to keep the innovation potential needed for different REC configurations to emerge. Finally, a proper way to manage a wide coupling of RECs in the overall European energy system for reaching the decentralization objectives is crucial, so that all players involved are affected at least possible by the transition.

Contents

Introduction

Climate change has been accelerated last decades due to, mainly, the ever-increasing CO2, and in general, greenhouse gas emissions worldwide [1]. Humanity must act immediately to prevent further irreversible consequences and to mitigate the existing and future critical ones. More than two decades ago, scientists have noticed and have tried to foresee the negative impacts that the aggressive and uncontrolled human development will bring to the present and future generations. Starting from the Kyoto Protocol in the 97's, passing through the different global agreements, such as the Paris Agreement in 2015, and the lasts Conference of Parties (COP), humanity has been pushing towards holding back from past years.

At first, the impacts of climate change where not clear and thus, the commitments to reverse it were not representative nor accomplished. It was in 2016, with the COP21 (in which the Paris Agreement was firstly issued) that the global community acknowledged the real problem of global warming, recognizing it through the Special Report 1.5 wrote specially for the Conference, by the IPCC (Intergovernmental Panel on Climate Change). This document, presented for the first time the main goal that has been maintained over the last years, which is: limiting global temperature rise above 1.5°C compared to pre-industrial levels, along with the negative consequences, that surpassing such limit, will bring to the environment, society, ecosystems, and life itself [2]. Nevertheless, the report has drawn paths that will help into achieving such a challenging goal.

Alongside with the IPCC, five years later, the IEA (International Energy Agency) with the Net Zero Emission report specially delivered for the COP26, highlighted the lack of real commitments and policies from previous global deals to fight Climate Change. The NZE-2050 strongly relies on the decarbonization and the energy transition from fossils to alternative sources, with a transition mainly driven by the big players [3]. Yet, not only companies, or the whole industrial sectors, are decisive for the energy transition, but citizens are also playing a key role.

In the last years, the European Union has proved to be leading the commitments when it comes to fighting climate change. In 2019, the European Commission disclosed and approved its game changing plan, called the "Green Deal", to become the first carbon neutral continent/region by 2050, with a very first ambitious goal of 55% reduction on GHG emissions by 2030 [4]. This objective is supported by three main pillars: Fight climate change, digital transformation, and inclusive growth. It is in this sustainable action plan where the role of people begins to gain strength, as said in the Green Deal:

"The involvement and commitment of the public and of all stakeholders is crucial to the success of the European Green Deal. (…) work to empower regional and local communities, including energy communities". These last-mentioned energy communities are the ones expected to play a crucial role on accelerating the energy transition, as well as a more pluralized and decentralized European energy system.

To properly talk about energy communities, we should introduce the Clean Energy Package (CEP) and its main components regarding this specific topic. The CEP was first conceived in 2016, but it did not see the light in the European Parliament until 2019, when it was finally adopted. It is centred in five key dimensions: Energy security; Internal energy market; Energy efficiency; Decarbonization of economy and; Fostering research, innovation and competitiveness. All together work to facilitate the clean energy transition [5]. Here, it is formally recognized the concept of community energy projects, by bringing on board the concepts of Citizen Energy Communities (CEC) and Renewable Energy Communities (REC), which were previously defined in the Internal Electricity Market Directive (IEM) and the Renewable Energy Directive recast (RED II) [6] [7]. The last one has its origins in 2009 with the previous RED I, that served as the legal framework for the development of renewable energies in the EU, it raised the targets from 12.5% shares of renewable energy to 21% [8]. Then, in 2018, a revision was conducted, and targets were augmented to 32%, and currently the goal is set to 55%, according to the optimistic and ambitious Green Deal objectives. It is particularly in the RED II where the concept of "Renewable Energy Communities" is introduced, defined as an autonomous legal entity [9]:

"(a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity;

(b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities;

(c) the primary purpose of which is to provide environmental, economic, or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits."

The concept of REC revolves around the idea that user is no longer pure-consumer, but rather the so called "*self-consumer*", which is defined in the same Directive as 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 renewables self-consumer, those activities do not constitute its primary commercial or professional activity"*.

In terms of Citizen Energy Communities, the afore-mentioned Directive 2019/944 (the IEM Directive), states that a CEC is a legal entity that [10]:

"(a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises;

(b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and

(c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders."

Both CECs and RECs tackle more than environmental and economic issues for major participants, but they also have a positive impact on social and territorial inclusion, since they allow low-income, vulnerable groups and forgotten communities the accessibility to energy [7]. RECs and CECs present many similarities, but the main differences can be distinguished in Table 1.

Starting from these concepts and the dynamics of the different Business Models that can be found or created, many other actors are able to arise. "Prosumers" are an example of this mutation, since these actors, apart from consuming from their own generation, can receive profits from the excess of energy. RECs and CECs enable the spread of business models that benefit, in many ways locals, governments and markets in many aspects.

Energy Communities are growing with long-term positive and representative expectations, at least for the European Union and their energy transition goals. In fact, forecasts anticipate that by 2050, half of the citizens could produce a big share (almost half 45% from which 37% could come from collective projects of EU's renewable energy, with a direct impact not only in the decentralization of the energy markets, but also on the reduction of environmental impact, low energy bills and local job creation [7] [11] [5]. However, the optimistic depicted future may not be achieved if some segments of society are left out of the equation. Moreover, to allow this participation, the European Union should ensure the buy-in into the energy transition, by leveraging awareness from citizens, the spread of transparent/homogeneous legal frameworks, the accessibility to financial support schemes (incentives, tax benefits or tariffs) and, of course, the proper disclosure of benefits. In this final point is where more attention should be given, the development of energy communities has been jeopardized by the incorrect spread amongst the Member States due to different transpositions of the EU regulatory frameworks, resulting in regulatory and enabling framework barriers, leading to heterogeneity in terms of business models, and of course risks in their incorrect implementation [7] [5] [12].

Table 1. Characteristic differences between Citizen Energy Communities and Renewable Energy Communities [6]

	Citizen Energy Community	Renewable Energy Community
Membership	Natural persons, local authorities, including municipalities, or small enterprises and microenterprises	Natural persons, local authorities, including municipalities, or small enterprises and microenterprises, provided that for private undertakings their participation does not constitute their primary commercial or professional activity
Geographic limitation	No geographic limitation, MS can choose to allow cross-border Citizen Energy Communities	The shareholders or members must be located in the proximity of the renewable energy projects that are owned and developed by the Renewable Energy Community
Allowed activities	Limited to activities in the electricity sector. Electricity generation, distribution and supply, consumption, aggregation, storage or energy efficiency services, generation of renewable electricity, charging services for electric vehicles or provide other energy services to its shareholders or members	Can be active in all energy sectors. Production, consumption and selling of renewable energy
Technologies	Technology neutral	Limited to renewable energy technologies

The present work is giving its focus to Renewable Energy Communities in Austria, France, and Italy, which are countries with an advanced transposition process of the EU regulation for these communities. Particularly, provisions for rooftop-mounted solar photovoltaic installations for residential configurations are analysed. Firstly, for each country, the main features of the regulatory framework for REC are analysed, specifically, definitions, electricity public network considerations and support schemes. Afterwards, an evaluation and identification of the main revenues and costs sources for two different REC configurations are conducted. In addition, a cross-country comparison is performed to examine the parameters that mainly changes from country to country. Finally, a discussion regarding the main issues and gaps not only for these three countries but also at a European level is carried out.

1 Austria

The main provisions regulating Renewable Energy Communities, but also Citizen Energy Communities in Austria are covered by two main consolidated federal laws called: the *Elektrizitätswirtschafts- und -organisationsgesetz 2010 - EIWOG 2010* (in English known as The Electricity Industry and Organization Act 2010) and the *Erneuerbaren-Ausbau-Gesetz 2021 – EAG 2021* (in English: The Renewable Energy Expansion Act 2021) [13] [14]. In addition to the mentioned laws, some other key provisions stated by the *Ökostromgesetz 2012 – ÖSG 2012* (translated to English as Green Electricity Act 2012) refer to RECs and CECs [15]. The major regulations within these laws impacting RECs development, are going to be explained in the following sections.

1.1. The Electricity Industry Expansion Act – EIWOG 2010

This federal law was firstly issued in 2010, but has been amended multiple times in 2013, 2017, 2021, 2022 and finally in 2023, which is the last version and the one the present study refers to.

Within the European Union enactments this act considers, can be found: the Directive 2009/72/EC on common rules for the internal electricity market and the Directive 2008/27/EC on the promotion of energy from renewable sources.

This legislation aims at providing the regulations for the generation, transmission, distribution, and the supply of electricity, along with the provisions for the whole organization of the electricity industry in Austria. Also, regulations on billing, internal organization, unbundling, and transparency of the electricity companies are laid down in the present act. In terms of goals, this federal law has the ambition to guarantee sustainable network conditions, and to further develop the electricity generation from renewable energy sources while ensuring their access to the already mentioned electricity grid.

1.1.1. Network operation and access: provisions for energy communities

Part 4 of the EIWOG 2010, specifically chapter 1, establishes the obligations and rules to guarantee network operation and access, making mention of generation facilities within a community configuration and introducing definitions and provisions for both Citizen Energy Communities and Renewable Communities (jointly referred as energy communities).

Within the context of the organization for the network access, section 16a present the conditions for join (or collective) generation plants (covering both CECs and RECs), which are previously defined in the federal law as the ones that generate electrical energy to cover the consumption of participating beneficiaries. A crucial consideration made is that communities generation facilities are not entitled to own and operate distribution grids anymore, which was the case before the amendment of June 2021 [16]. In terms of the plant management, an operator can be designated by the participants and reported to the grid operator, and who must be contractually obliged to operate the joint generation facility.

Regarding the network operator obligations, this must provide the collective generation plant (or plants if it is the case) and the participating beneficiaries' systems proper measuring devices to quantify the feed-in electricity into the grid line and the withdrawals from the same. The electricity generated and fed into the network must be a static or dynamically allocated among the community participants considering the energy community so-called distribution key, which is contractually agreed and defined by the participating parties and must be informed to the network operator. This distribution key, when dynamically allocated, may also be dependent of the community participants consumption. Therefore, the measured value of the energy consumption at beneficiary's system metering point must be reduced by the allocated energy generated by the joint production plant. The energy fed into the grid by the common generation plant that has not been allocated to the energy community participants is entitled to be sold to an electricity trader through a purchasing agreement. This community-produced energy surplus is the result of deducting the community-allocated energy generated from the measured value of the energy fed into the grid line. For accounting purposes, fed-in electricity from the joint generation plant and withdrawn electricity of the different participating beneficiaries, must be measured, read, and allocate every quarter-hour, and the values must be available to the operator and to the freely chosen suppliers of each party.

1.1.2. System usage fees: considerations for Renewable Energy Communities

All network users, including those within a CEC or REC framework, must pay the system usage fee for the network operators to provide the obliged services respecting the regulations of the present federal law.

The system usage fee is mainly composed by grid usage fee, grid loss charge, network access fee, grid provision fee and fee for measurement services. These charges are determined by E-Control, which is the electricity and gas regulatory authority in Austria that enables the cost-efficient, high-quality, and secure energy system [17]. The independent Transmission System Operator of the high-voltage grid in Austria is called Austrian Power Grid (APG) and it is obliged to operate and maintain the network safely, reliably, efficiently and with due regard to environmental protection, and to expand it in accordance with the demand for line capacities [18].

The present law explains in section 63 that the electricity grid network in Austria is divided by levels from 1 to 7, starting from the highest voltage until the lowest possible one. Network level 1 refers to extra-high voltage (380 kV and 220 kV including the transformation station 380/220kV) and with a stepwise decrease until grid levels 5, 6 and 7, which correspond to medium voltage, medium to low voltage conversion and low voltage network, respectively. An important distinction when talking about RECs refers to local network area and regional network area. The first one relates to communities where the participants are linked together through the grid level 7 (low voltage), while the second one refers to the parties connected viathe grid levels 5, 6 and 7 (medium-low voltage).

The grid usage fee is set to compensate the costs for setting up, expanding, maintaining, and operating the network system, borne by the network operator. It is related to the network area and the network level of the system's metering point. This fee is monthly paid and composed by a fixed amount and by a variable part given by low-hours and peak-hours tariffs dependent also on seasonality [19] [20]. The EIWOG 2010 states that for grid users participating in Renewable Energy Communities, the grid usage fee must be alternatively determined considering only the participants' consumption covered by the allocated energy produced by the joint generating plant that has been injected into the grid. This fee is going to be reduced by a percentage discount on the variable (work-related or energy-related) part, which is the one affected by the allocated produced energy within the REC configuration. These percentage discounts are set by the regulatory authority for both local and regional areas (being higher the discounts for the local ones), and they can be updated, when necessary, based on the data they were calculated upon.

The grid loss charge is intended to offset the costs that the network operator bears for procuring the amounts of energy required to compensate for grid losses [21]. It is paid for both extractors and feeders on a monthly basis, and it is only composed by an energy-related part [20] [22].

Network access fee is paid once and it counterbalances the network expenses incurred by the network operator associated to the initial establishment of a connection to a network, or the reinforcement of an existing network due to the capacity increased of an existing user [20] [23].

Grid provision fee is a one-off charge for consumers for the pre-financed or already carried out expansions of the network [20] [24].

Fee for measurement services is paid on a monthly basis by the network users to compensate the network operator with for expenses of metering devices installation and operation, calibration , and data reading and processing [22] [25].

1.2. Renewable Energy Expansion Act – EAG 2021

This federal law was firstly enacted in 2021 but had been amended once in the same year and then multiple times during 2022. It implements some crucial European directives related to the electricity market and electricity generation from renewable sources, such as the Directive (EU) 2018/2001 on the promotions of the use of energy from renewable sources, the Directive (EU) 2019/944 with the common rules for the internal electricity market, among other European regulations.

Pursuing the achievement of the Paris Agreement 2015 and the Austrian climate neutrality by 2040, the aim of this federal legislation is to promote, set the requirements for and increase the proportion of the production of electricity from renewable sources by means of ensuring the efficient allocation of investment and funds on these green sources. In addition, this federal law has the purpose of encouraging the energy sharing when produced within a community context and of enabling citizens and other member figures to associate for the establishment of renewable energy communities.

1.2.1. General provisions for Renewable Energy Communities

According to the EIWOG 2010 and the EAG 2021, a Renewable Energy Community is basically a legal entity that enables the sharing production, consumption, storage and selling of self-generated energy from renewable sources, with the possibility of being active in the field of aggregation and to provide other energy services, remaining unaffected the right of the REC participants of freely choosing suppliers.

Regarding the parties composing the community, members and shareholders may be natural persons, municipalities, legal entities of authorities with regard to local authorities, other legal persons under the public law and small and medium-sized enterprises [26]. The REC must be composed by two or more members or shareholders organized as an association, cooperative, partnership, corporation, or a similar association with a legal personality. The participation within a REC must be voluntary and open.

The main purpose of the legal personality representing the Renewable Energy Community must not be financial gain and must be stated within the articles of the legal form unless it is already clear from the legal form itself. In fact, the main purpose of a REC must be giving environmental, economic, and social benefits to its members or to the areas in which it operates.

In terms of proximity, the EIWOG 2010 Austrian federal law establishes the constraint criteria based on the grid levels, thus mainly for RECs involving self-generated electricity from renewable sources. The joint generation plants and the REC participants' consumption systems must be connected to the same low-voltage distribution network and low-voltage transformer, that is, the same local area. Moreover, the same connection to the medium-voltage network and medium-voltage transformer, which is the same regional area, is equally permitted.

1.2.2. Funding and Financial incentives eligible by Renewable Energy Communities

The information outlined in this section focus on funding and financial incentives for which Renewable Energy Communities implementing rooftop-mounted solar photovoltaic systems for self-generation of electricity, are eligible.

The EAG 2021 and ÖSG 2012 state that RECs entailing the construction of photovoltaic systems with a peak power capacity up to 1 MW (with and without storage) are eligible for an investment subsidy. The photovoltaic system must be attached to or on a building, a structure or on a business area (excluding green space), and connected to the public grid, in order to be eligible for this investment grant. The funding is divided by four different categories: category A for a peak power up to 10 kW, category B from 10 kW to 20 kW, category C from 20 kW to 100 kW and category D up to 1 MW. The amount of the investment subsidy is limited to a 30% of the investment volume directly required for the construction of the PV system, but no more than 250 euros per kW peak for systems up to 100 kW peak capacity (categories A, B and C) [14] [15].

Renewable Energy Communities, when fulfilling the requirements, are eligible for a Market Premium ("*Marktprämie*" in German). The Market Premium is a subsidy applicable to the marketed electricity produced from renewable energy sources that has been injected into the public electricity grid for which Guarantees of Origin has been issued. It aims at offsetting for 20 years the difference between the production costs of the electricity produced by the specific renewable energy source (reference market value) and the average market price for electricity. By this mean, the Austrian government safeguards the electricity production from renewable sources in case electricity prices drop again [27]. The electricity generation plant must be connected to the public electricity grid and must have a power capacity up to 100 kW. The Market

Premium is paid monthly and for REC configurations, it is calculated based on the self-generated electricity fed into the grid that has not been allocated among the REC participants as long as this amount of electricity represents up to 50% the total amount of self-generated electricity within the community. That is, quantities consumed by or allocated to the members or shareholders of the REC are not considered for the calculation of the Market Premium.

Along with the grid usage fee from the system usage fee, all electricity network users are charged with a Renewable Subsidy that aims at supporting market premiums and investment grants for promoting electricity production from renewable energy sources. This subsidy must be paid monthly by the network operators to the electricity settlement office and is calculated based on the respective grid usage and grid loss fees paid by the network user [28]. As an extra financial incentive, within a REC configuration, no Renewable Subsidy must be paid by the community participants for the amount of electricity self-produced and consumed by the members or shareholders within the REC context.

It is worth mentioning that the EAG 2021 recognizes the ongoing necessity of evaluation through cost-benefit analysis to identify whether an appropriate and balance participation and deployment of RECs is ensured given stated provisions and regulations so far.

1.3. Establishment and management of a REC in Austria: Investment analysis

The present section has the objective to analyse the changes on energy flows and revenues and costs associated to the establishment and management of two distinct possible REC configurations for a 20-year period, considering the already-explained regulatory framework in force.

Both configurations are going to be examined based on a 100% prosumers' equity investment, composed of 20 participants with different consumption profiles and whose metering devices are provided by the same distribution network operator. All of them and the assumed installed PV facilities with an aggregated capacity of 30 kW, are connected to the same low-voltage distribution network (local area, network level 7). In addition, the PV systems are assumed to present a degradation rate throughout their lifetime, and to be installed on rooftops, so that the facility is eligible for the investment grant. These general assumptions for the two cases are summarized in Table 2.

Table 2. General assumptions for the investment analysis of REC configurations, Austria

General assumptions	
Business model	100% participant's equity
Proximity	LV ntwk (level 7 - local area)
PV type	Rooftop-mounted
PV aggregated installed capacity	30 kW
PV lifetime	20 years

1.3.1. Condominium configuration

In this arrangement, the participants are 20 residents of a multi-apartment building directly connected to the PV facility and whose surplus is fed into the public distribution grid to be sold within the market premium context, as seen in Figure 1.

Considering the configuration, the energy flows in terms of consumption and production are the following:

1. The electricity produced by the rooftop-mounted PV facility covers as much of participants' load as possible, having a self-consumption at no cost.
2. The energy surplus after in-site consumption is injected into the grid to be sold and to be considered for market premium payment.
3. The remaining consumption of each participant is covered by their freely chosen electricity supplier at full cost.

The revenues can be identified as all those savings or avoided costs arising from the decision of creating, joining, and managing a REC, in contrast to the base-case in which all the consumption is met by the usual supplier contract. In the same way, the costs correspond to all the expenses needed for the creation, joint and management of a REC (investment), compared to the case in which no REC gives rise. For the analysed configuration, the revenues and costs identified are listed in Table 3.

Figure 1. Condominium configuration, Austria

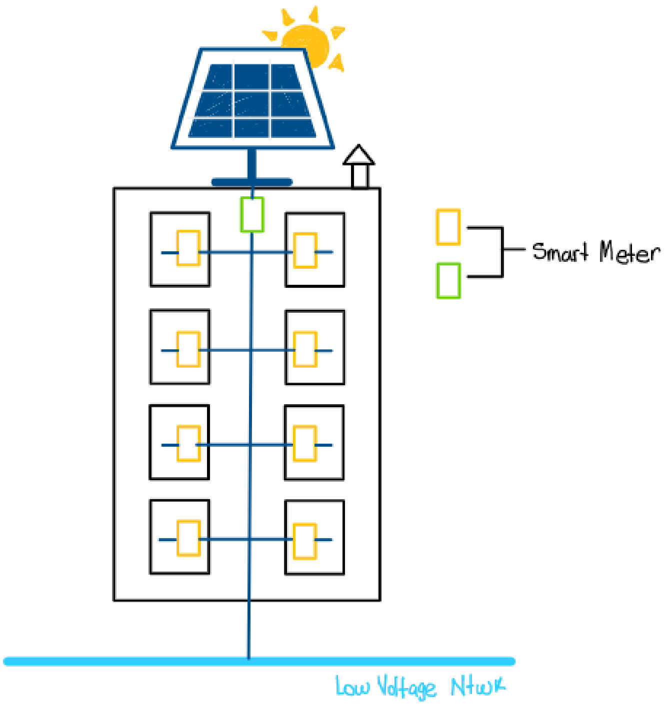


Table 3. Revenues and costs for the condominium config., Austria

Revenues	Costs
Savings from in-site self-consumption	CapEx
Surplus sales	OpEx
Market Premium	O&M
Investment grant	Other costs

Savings coming from the electricity self-consumed in-site are calculated considering the total electricity price from the supplier subscribed offer, which consist of energy cost, network usage charges and taxes and levies, provided that there is no electricity transfer through the public distribution grid. Among the taxes and surcharges that changes due to the REC investment and that must be considered, can be found the electricity levy, usage fee (around 6%) and VAT (around 20% on all component of the electricity prices) [29]. It is expected that, over the years and depending on the consumption trends, these in-site self-consumption savings decrease due to the degradation of the PV facility translated into the diminution of the produced electricity.

Surplus sales are given by the remaining electricity after REC participants' consumption, for which by law, there is a small remuneration. These surplus sales are expected to decrease as well because of the degradation on the PV system production, as explained before. Based on the same energy surplus amount the Market Premium is applied.

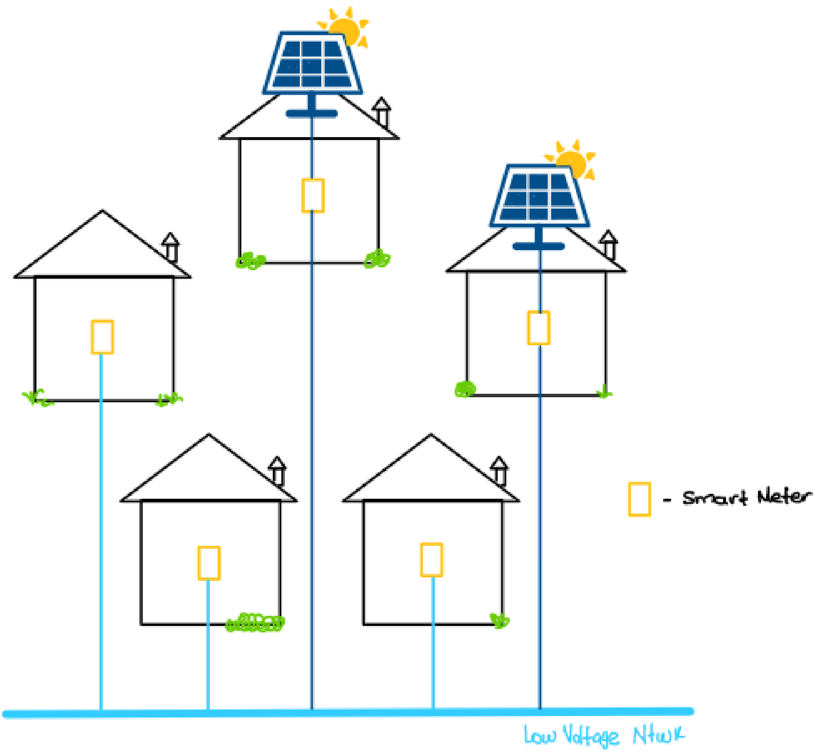
Lastly, the investment grant, as explained before, is given by 30% the investment for the PV installation, but not exceeding 250 €/kW, for installations below 100 kW.

In terms of costs, all those turnkey-related costs are included for the initial investment and for the following years, the operating, maintenance, and administrative expenses are considered [30].

1.3.2. Multi-household configuration

This type of operation consists of 20 households connected to the public distribution grid, some of whom are considered prosumers, since they own the PV facilities installed on their rooftops, and have an in-site consumption, as seen in Figure 2. The aggregated PV installed power capacity is 30 kW.

Figure 2. Multi-household configuration, Austria



Given this arrangement, the energy flows in terms of consumption and production among the REC participants are the following:

1. The rooftop-mounted photovoltaic installations generate electricity to cover the most possible prosumer's consumption (in-house or in-site consumption), having no cost.
2. At each timestep, after in-site consumption, the remaining produced electricity within the REC is injected into the LV network and allocated to each pure consumer participant of the REC, considering the distribution key. This electricity is billed by owners of the PV systems, while the remaining consumption load is covered by the freely chosen suppliers, paid at a full cost.
3. After the allocation of the REC's electricity produced, there is an electricity surplus to be sold at a small remuneration price.

The revenues and costs this households' configuration can be analysed from the side of a household owning one of the generation units (prosumer), or from the perspective of a pure consumer, who is receiving an invoice from the first one and from the chosen supplier. Revenues and costs from the prosumer side are listed in Table 4.

Table 4. Revenues and costs for multi-household config. – prosumer side, Austria

Revenues	Costs
Savings from in-site self-consumption	CapEx
Sales to REC participants	OpEx
Surplus sales	O&M
Market Premium	Other costs
Investment grant	

Savings from in-site consumption, Surplus sales, Market Premium, Investment grant and, in general, costs, are given by the same considerations as for the condominium case. In terms of revenues from sales to REC participants, prosumers earn from the billing of the cost of the electricity produced by the generation units, which should be lower or equal to the energy cost REC consumers receive from the invoice of their chosen supplier, so that joining the community represents a saving. However, for the concerning amount of electricity, from a REC pure-consumer side, joining the community would represent a revenue due to the difference, if it is the case, of the energy cost charged by their chosen supplier and the one charged by owners of the PV system in the REC. In addition, there is a saving from the percentage reduction of LV grid charges and the no-payment of related taxes and levies, as it was explained in previous sections. For pure consumers, there is no cost since it is assumed that the action of joining the community does not have related costs.

2 France

The main legislations and provisions in France defining and regulating the Renewable Energy Communities, which in fact are covered by the collective self-consumption framework are *Code de l'énergie* (in English: Energy Code), *Arrêté du 6 octobre 2021* (in English: Order of October 6, 2021) and *Arrêté du 21 novembre 2019* (in English: Order of November 21, 2019). Considering each of the previous legislations, the following sections are intended to describe the definitions, possible energy sharing configurations, proximity criteria and financial benefits RECs, precisely RECs producing electricity with photovoltaic systems, are eligible for.

2.1. Energy Code

The *Code de l'énergie* aims at implementing the European law within the energy context, by building a low-carbon and competitive economy through the implementation of renewable energy sources, and by increasing the flexibility of the electricity system [31].

Book II, Title IX of the Energy code lays down the provisions for Energy Communities in general, including the definitions and boundaries for Renewable Energy Communities (chapter 1).

2.1.1. Renewable Energy Communities: Definition and provisions

A renewable energy community is defined as an autonomous legal person, based on open and voluntary participation, whose shareholders or members are natural persons, small and medium-sized enterprises, local authorities or their groupings or associations and, in the case of private companies (no households), the REC participation must not constitute their primary commercial or professional activity. The major objective of the renewable energy community must not be financial gains generations, but rather bringing economic, social, and environmental benefits to its members or shareholders, or to the local areas in which it operates.

Regarding the activities RECs are allowed to carry out, are identified the production, consumption, storage and selling of renewable energy, including renewable energy purchase agreements, and the access directly or by aggregation to all relevant energy markets with no discrimination. Moreover, it is allowed the sharing of energy produced within the REC configuration among the participants, as long as they keep their rights and obligations as end consumers. In the specific context of electricity, when it comes to renewable energy production within the REC framework (being the focus of the present study the electricity produced from photovoltaic installations), the sharing and production is regulated by the provisions and rules for self-consumption.

Unfortunately, energy communities in general are not allowed to own or operate distribution networks for electricity or natural gas. In fact, the main operator of the public electricity distribution network in France, precisely 95% of the low and medium voltage one, is called Enedis [32].

2.1.2. Self-consumption: Definition and provisions for individual and collective operations

Book III, Title I of the Energy code states the definition and provisions for both individual and collective self-consumption operations, which cover and determine existing REC configurations in France.

Individual self-consumption operations arise when a so-called self-producer consumes in his own site all or part of the electricity produced by his own installation. The facility can also be owned and managed by a third party, who is not considered a self-producer, but is rather subject to the instruction of the above-mentioned self-producer that consumes in-site the generated electricity. In case the self-consumer is not a household, the self-consumption activity must not represent his main professional or commercial activity.

As regards collective self-consumption, it is possible to distinguish two scenarios: the simple collective self-consumption and the extended one. A self-consumption operation is defined as collective when the energy supply takes place between one or more producers and one or more self-consumers linked together within a legal figure. The withdrawals points of the participating consumers and the injections points of the production facilities of the operation must be situated in the same building, including residential buildings.

On the other hand, the self-consumption operation is qualified as extended when those withdrawals and injection points are located on the low-voltage network of a single operator of the public electricity distribution network and respect the two kilometres distance requirement between the two furthest participants, as stipulated in the Order of November 21, 2019 [33]. However, the Order of October 14, 2020 modifies the previous one by allowing extended collective self-consumption operations located on the mainland metropolitan territory to reasonable request a proximity limitation up to twenty kilometres, considering the remoteness of the project, the separation among participants and the low population density of the area [34]. Another criterion stated in the same Order that must be complied is the cumulative peak power of the production installations, which cannot exceed 0,5 MW for non-interconnected areas and 3 MW when in the continental metropolitan territory. For both the collective configurations permitted, the non-constitution of the main professional and commercial activity for the self-producers and the self-consumers, still applies.

The *Commission de Régulation de l'Énergie* (in English: Energy Regulatory Commission), known as CRE, is entitled to regulate the networks for the natural gas and electricity markets in France, to ensure the quality of the service for consumers and in line with the objectives of the Energy Code [35]. According to Article L315-3 of the Energy Code appoints the CRE to determine specific tariffs for the use of public electricity distribution networks for end-users participating in individual or self-consumption operations. The purpose is not to bill end-users with network access charges that, due to the nature of the self-consumption operation, are no longer borne by the network operator. This special provision for self-consumption operations is going to be further explained in the subsequent chapter regarding the composition of the tariff for the usage of the public electricity distribution network.

2.1.2.1. Collective self-consumption: legal entity responsibilities, distribution key definition and measurement of energy flows

The organizing legal figure thought which participants of a collective self-consumption operation must be linked together is also known as *personne morale organisatrice* (PMO). In accordance to Article L315-4 of the Energy Code, the PMO is entitled to collect the agreement among the participants of the operation and to be the reference person before the distribution network operator for all essential information, among which can be found the so-called distribution key, defining the allocation of the self-produced electricity between the consumers concerning the collective self-consumption operation [36].

The distribution key may be fixed or variable depending on the set up chosen by the participants of the operation. When fixed it can be proportional to the investment on the joint generating plant, to the ownership shares or any other specific rule decided by the parties involved. The upside of this option is the simplicity allocation of the electricity to be shared within the configuration, but this does not properly reflect at every measurement step that not all users present the same consumption rates which may be respected by the allocation of benefits [37]. The allocation coefficient may also be variable on the basis of a calculation formula, or proportional to the consumption of the different participants which, in fact, is the default allocation of production for the configuration by the public distribution network operator in absence of distribution key provided by the PMO, as reported in the Article D315-6 of the Energy Code [37]. Therefore, for each consumer, the allocated production is equal to the total production of the installations participating in the collective self-consumption operation times the established distribution coefficient.

For billing purposes and energy surplus calculation, the measurement of the electricity flows must be well specified. The Energy Code lays down that within collective self-consumption configurations, at each measurement step (typically 30-minutes), the defined amount of energy self-consumed by the operation cannot exceed the sum of the quantities produced by the installations being part of the configuration. In this way, the supplier of choice for each single participant must invoice the difference between the measured consumption and the allocated production within the collective self-consumption configuration, as indicated in Article D315-7.

2.2. Order of 6 October 2021: *Nature de l'exploitation* and eligibility for financial benefits

The *Arrêté du 6 octobre 2021* sets the conditions for the purchase of electricity produced by installations located on buildings, hangars or shade houses using photovoltaic solar energy, with a peak installed power less than or equal to 500 kW and located in mainland France [38]. It is worth mentioning that the present work report set the direction towards solar photovoltaic facilities installed on buildings, hangars, or shade houses with a peak power capacity lower or equal to 100 kW, and whose provisions are the ones described in the following paragraphs.

Within the scheme of both individual and collective self-consumption, the definition of the "nature of exploitation" or "nature of operation" (in French: *nature de l'exploitation*) of the photovoltaic installation is crucial to determine the conditions for the electricity injected into the public distribution network, that is eligible for purchasing; and to identify as well, the financial benefits the solar PV system is compliant with. There exist two types of natures of exploitation: *Vente avec injection du surplus* (in English: sales with surplus injection) and *Vente avec injection en totalité* (in English: sales with full injection), which are going to be described below.

Sales with surplus injection operation arises when all or part of the produced electricity by the photovoltaic installation is consumed in-site within the context of an individual self-consumption operation, and when the producer's consumption points and the facility injection point that are part of the individual self-consumption operation, are connected to a single delivery point of the public distribution network and equipped with a single metering device. A producer involved in this nature of exploitation is also allowed to participate in a collective self-consumption operation, providing that the eligible volumes of electricity to be sold, are only the ones injected into the distribution public net of the self-consumed amounts within the framework of the collective self-consumption operation. This balance can result in values equal to zero.

On the other hand, sales with full injection operation emerges when the electricity produced by the PV installation is fully injected into the public distribution grid, given the possibility as well to the producer of participating in a collective self-consumption operation, for which the quantities of electricity eligible for selling are those resulting once the self-consumed amounts within the framework of the collective self-consumption operation have been subtracted.

The tariffs for the purchase of the above-mentioned eligible electricity (in France: *Tarifs d'achat*) for both natures of operation are defined as well by the CRE and have a duration of twenty years from the date of the commissioning of the PV plant. In addition, the Commission determines the *Prime à l'Investissement* (in English: Investment Premium), which is a grant intended only for installations within the operation of sales with surplus injection, and it is given depending on the installed capacity of the PV facility. These tariffs and premiums are updated quarterly [39].

For photovoltaic installations with a power capacity lower than 9 kWp in the context of sales with full injection operations, the *tarif d'achat* Ta is applicable, while for power capacities between 9 kWp and 100 kWp with non-eligibility to tariff Ta, tariff Tb is the applicable one.

Within the nature of exploitation of sales with surplus injection, installations with power capacities below 100 kWp are eligible for a surplus *tarif d'achat*. In terms of investment grants, below 9 kWp installed capacities, the Pa premium is applicable and 100% paid on the first billing. Instead, between 9 kWp and 100 kWp, it is the Pb premium the eligible one, which is 80% paid one year after the contract becomes effective and then through 5% annual payments over the next four years [40].

2.3. TURPE: Tariff breakdown and specific tariff for self-consumption

In France, all distribution network users must be connected to one of the existing power connections: medium-voltage (MV), low-voltage (LV) > 36 kVA or LV < 36 kVA. Consumers are charged by Enedis with the *Tarif d'Utilisation du Réseau Public d'Électricité* (in English: Public Electricity Network Usage Tariff), briefly known as TURPE, which is constituted by various components that differ depending on the power connection and are set for an average period of four years by the CRE. In addition, the calculation principles of the TURPE tariffs apply in the same way for the entire French territory. As far as the present work extent concerns, the attention goes towards consumers connected to LV networks < 36 kVA and whose TURPE components, therefore, are going to be described below.

The annual management component (CG), the annual metering component (CC) and the annual withdrawal component (CS) establish the TURPE for network connections < 36 kVA [41]. The CG compensates the costs borne by the managers of the public distribution network. The second component is charged based on the withdrawal and/or injection power of the user, and it aims at reflecting all the expenses for supplying, installing, and maintaining the metering devices, and for checking, reading and billing the transmission data. The last component, CS, reflects the network cost due to the withdrawal of the consumer, and it could vary if chosen on a non-seasonality basis or on a 4 time-range seasonality basis. However, the first option will increase its price until its removal in 2024, while the seasonalized option will decrease its prices during the same period to incentive consumers changing to the last one.

The deliberation of the CRE of June 7, 2018, establishes the introduction for the first time of an optional new tariff formula for users connected to the LV network participating in a collective self-consumption configuration [42]. The current tariffs, known as TURPE 6 HTA-BT are in force since August 1, 2021, and applicable for the following four years, that is, until 2024. For these tariffs, also including the new optional one for collective self-consumption operations, the CRE recognizes how the decentralization of the renewable energy production, covering self-consumption configurations as well, will considerably impact the electricity flows in the distribution networks for the year to come [43]. In the case of individual self-consumption operations, the management component has been reduced for the special TURPE tariff option compared to the traditional one, while for collective self-consumption, this one has increased [41]. Considering the withdrawal component, it is currently calculated in a special manner for the optional tariff scheme applied to collective self-consumption configurations.

The above-mentioned annual withdrawal component for the special TURPE tariff applicable to collective self-consumption operations distinguishes two withdrawal flows: *autoproduit* flows (in English: self-produced flows) and *alloproduit* flows (in English: alloproduced flows). The self-produced flows correspond to the electricity generated by the facilities taking part of the collective operation, and for which a lower withdrawal component compared to the traditional one, applies. On the other hand, the alloproduced flows correspond to the consumption net to the production allocated to the concerning participant of the collective operation, for which higher withdrawal component compared to the traditional one, applies [43]. All these calculations are done for each single participant thanks to the metering devices, getting data each 30-minutes timespan, and reporting them to the network distribution operator for energy flows allocation and billing. Furthermore, these changes introduced by the CRE and applying to the special TURPE tariff for collective self-consumption operations, have an incentivizing nature for participants to maximize their self-production rates, and are still subject to seasonality and peak, off-peak hours basis.

2.4. Establishment and management of a REC in France: Investment analysis

This section aims at analysing the energy flows and revenues and costs associated to the establishment and management of two different possible REC configurations for a 20-year period, considering the afore-mentioned legislative framework in effect, in France.

The two configurations will be analysed based on a 100% prosumer's equity investment, composed of 20 participants with different consumption loads and whose metering devices are provided by the same distributor network operator (i.e., Enedis) [44]. For both cases, all participants, and the assumed installed PV units with an aggregated power of 30 kW (withdrawals and injection points), are connected to the same low voltage network. The community is intended to select the optional self-consumption TURPE tariff, being covered by diverse network usage tariff calculation and scheme. Moreover, the PV installations are assumed to be subject to a degradation rate throughout their useful life, and to be installed on rooftops in order to be eligible to *Tarif d'Achat* or *Prime à l'Investissement*, or both. All these general assumptions for both cases are listed in Table 5.

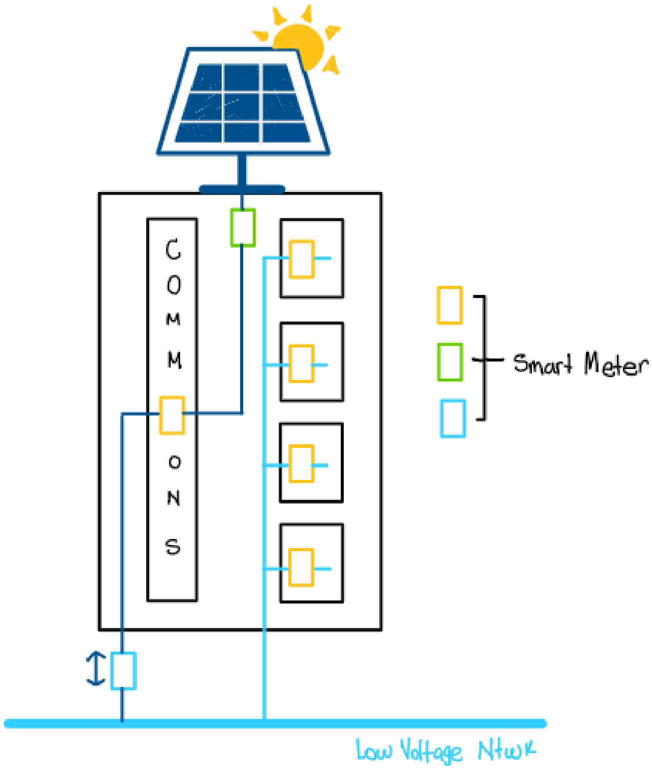
Table 5. General assumption for the investment analysis of REC configurations, Francia

General assumptions	
Business model	100% participant's equity
Proximity	Low voltage ntwk
Ntwk usage tariff	Optional self-consumption TURPE
PV type	Rooftop-mounted
PV aggregated installed capacity	30 kW
PV lifetime	20 years

2.4.1. Condominium configuration

This arrangement is composed of 20 residents in a multi-apartment building whose common consumption is directly connected to a rooftop-mounted PV facility, so that respecting a basic collective self-consumption operation. Through the same metering device, the excess of energy after the commons met load is injected into the grid, and the remaining load is fulfilled by the chosen supplier. The electricity excess that has been fed into the grid is allocated among the REC participants within the same building and then, the energy surplus is sold, specifically, to EDF or any other local distribution company [45]. This configuration has as nature of operation or exploitation, the sales with surplus injection, as depicted in Figure 3.

Figure 3. Condominium configuration (Sales with surplus injection), France



Given this nature of operation, energy flows to be considered in terms of consumption and production are the following:

1. The electricity is produced by the generation units to cover as much building's common consumption and possible at no cost, to then be fed into the low voltage distribution network. The remaining needed consumption from the commons is met by the electricity taken from the grid within the chosen supplier contract.
2. The injected electricity after commons consumption is allocated among REC participants to be virtually consumed. This amount of electricity allocated and the remaining one covered by the supplier chosen, are subject to the optional network tariff usage, TURPE, for collective self-consumption, as explained in previous sections.
3. The electricity surplus is remunerated at a 20-year fixed tariff set by the CRE for this specific nature of exploitation with a value depending on the distribution network connection date.

The revenues and costs related to this kind of nature of exploitation and considering the type of investment are identified as listed in Table 6.

Table 6. Revenues and costs for condominium configuration, France

Revenues	Costs
Savings from commons in-site self-consumption	CapEx
Savings from self-consumption within REC	OpEx
Saving from optional TURPE	O&M
Surplus Sales	
Prime à l'Investissement	Other costs

Savings from commons in-site self-consumption considers the total electricity price that would have been charged by the supplier chosen if there was no community established, which is composed of the energy cost, the network usage tariff under the classic scheme (in which both withdrawal and injection charges have the same cost) and taxes and levies. Within the levies can be found CTA, the CSPE and the TCFE. In particular, the CSPE is intended to finance the support policies for renewable energies and even self-consumption configurations must pay them, and it is subject to VAT [46].

Savings from self-consumption within REC participants considers the energy cost part of the electricity price. However, given that the network usage tariff under the optional self-consumption TURPE scheme is different from the conventional one, the difference among them could represent whether a revenue or a cost (at each 30-minute measuring step). Based on what was explained in the TURPE section and focusing on the variable part of the withdrawal component, the difference in TURPEs for the electricity consumed by the REC is higher compared to the difference in TURPEs for the electricity taken from the complementary supplier, so the final value to be paid depend on the concerning amounts of electricity. Within this reasoning, there could be times in which the savings due to the choice of the optional TURPE instead of the conventional one, may actually correspond to an extra cost for the parties. Therefore, it is quite important, and it is one of the French provisions' intentions behind this optional TURPE scheme, that participants optimize as much as possible their generation systems and consumption patterns, in order to overlap whenever possible their consumption load and production profile.

Surplus sales instead, are calculated based on the *Tarif d'Achat* and the concerning amount of electricity, while the *Prime à l'Investissement*, as stated before, is paid based on the power installed capacity of the generation unit. Both according to values defined by the CRE, considering the date of the network connection request as well.

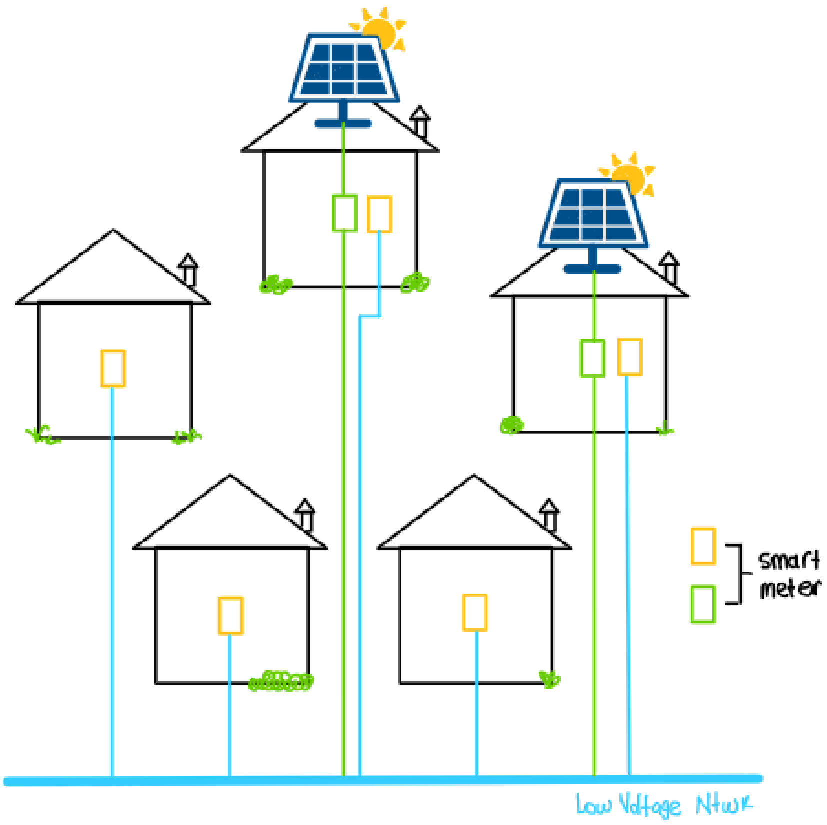
2.4.2. Multi-household configuration

This second configuration consists of 20 households separated among them by a given distance, and connected to the low voltage distribution network, so that respecting an extended collective self-consumption operation. Some of them are owners of rooftop-mounted PV systems and having no in-site self-consumption. They rather inject to the grid all the electricity generated by the PV unit, to be distributed within the REC participants, and taking all the electricity they need from the grid to meet their load, by means of two different metering devices. Similarly, as for the condominium configuration, the electricity surplus after the allocation among the REC participants, is purchased specifically, by EDF or any other local distribution company. This type of configuration adheres to the nature of operation of sales with full injection, as shown in Figure 4.

Considering the nature of exploitation, the energy flows to be considered in terms of consumption and production are:

1. The electricity is produced by the generation units and injected into the grid (through one metering device) to be allocated among the participants of the community.
2. Consumers take all their consumption from the grid, but one part correspond to the electricity allocated within the REC operation, while the other part correspond to the contract with the supplier chosen. From the prosumer side, this consumption is measure by another metering device.
3. The electricity surplus is purchased, precisely, by EDF or any other local distributor supplier, considering the applicable *Tarif d'Achat*.

Figure 4. Multi-household configuration (Sales with full injection), France



The revenues and costs associated to this configuration can be analysed from the side of the household owning one of the PV systems (prosumer), or from the perspective of the pure consumer, who receives one invoice from the supplier chosen and another one from the prosumer. From a prosumer side and considering the type of investment, revenues and costs are listed in Table 7.

Table 7. Revenues and costs for multi-household config. – prosumer side, France

Revenues	Costs
Sales to REC participants	CapEx
Saving from optional TURPE	OpEx
	O&M
Surplus Sales	Other costs

Sales from REC participants for the owner of the generation unit, come from billing the allocated produced electricity to the different consumers at an energy price expected to be lower than the one charged by the supplier chosen, so that joining the community represents a saving to the pure consumer (assuming there is no extra related cost). However, as it is for the condominium case, participants must be charged the network usage fees under the scheme of the optional TURPE for self-consumption, which could represent a revenue or a cost depending on the amount of electricity concerning. In addition, they receive as many invoices as producers being part of the REC, and one more from the complementary supplier. Furthermore, regarding the surplus sales, these are calculated based on the *Tarif d'Achat* defined by the CRE, for this specific nature of operation. As seen, this sales-with-full-injection configuration is not eligible for *Prime à l'Investissment*.

It is worth saying that for both condominium and household configurations, the sales from electricity surplus are subject to income taxes, being it possible to be eligible to a special tax regime called micro-BIC (*Bénéficies industriels et commerciaux*), for which a 71% reduction for the income amount to be taxable is considered [47] [48].

3 Italy

Renewable energy communities, and in general collective self-consumption configurations, were legally defined for the first time in Italy in the *Decreto Milleproroghe 2020* (in English: Decree Law of December 30, 2019, n. 162) which entered into force in February 2020, and aimed at starting the transposition journey of RED II and IEM 2019 provisions into the Italian legislations [49]. Article 42-bis of *the Decreto Milleproroghe 2020* concerning self-consumption from renewable energy sources, states the main objective of the RECs, parties allowed participating, proximity limitations, the shared energy definition, incentive scheme, among other regulations [50]. Thereafter, the *Autorità di Regolazione per Energia, Reti e Ambiente*, ARERA (in English: Italian Regulatory Authority for Energy, Networks and Environment), which is the Italian entity performing regulatory and supervision activities in the sectors of electricity, natural gas, water services, waste cycle and district heating; published on August 2020 the 318/20 Resolution [51]. This resolution determines which network tariff components are not applicable for the shared energy that has been produced within the collective self-consumption configurations, and that must be reimburse by the GSE, which is the *Gestore dei Servizi Energetici*, GSE (in English: Energy Services Operator) [52] [53]. Later, it was the *MASE* Decree in September 2020 to set the vales for the incentive tariff applicable to the energy produced for sharing inside the self-consumption operation [54]. Afterwards, on December 2020, the GSE released the *Regole tecniche per l'accesso al servizio di valorizzazione e incentivazione dell'energia elettrica condivisa* (in English: The Technical Rules of eligibility for the valorisation and incentive service of shared electricity), which lays down all the operating rules for enable collective self-consumption configurations [55]. However, the *Decreto Milleproroghe 2020* represented the pilot phase for the transposition of the REDII and IEM 2019 directives into the Italian context, and established the guidelines ARERA, MiSE and GSE entities must base their regulatory provisions on [52].

Subsequently, it was on November 2021 when the Legislative Decree 199/21 was officially approved for the transposition of the REDII and the IEM 2019 into the Italian legislation, thus setting the in-force regulatory framework for collective self-consumption [52] [56]. Afterwards, the ARERA issued the 72/2022/R/EEL Deliberation in December 2022, setting the regulations for the *autoconsumo diffuso* (in English: widespread self-consumption), including within the renewable energy communities, in accordance with the 199/21 decree [57]. At the moment the present work report is being written, and up to the extent of the information possessed, regulations setting the incentive schemes from the MASE, which is *the Ministero dell'Ambiente e della Sicurezza Energetica* (in English: Ministry of Environment and Energy Security), are still in draft phase to be publish in the short-term, so that the GSE can deliver the respective technical rules.

The provisions stated in the Legislative Decree 199/21 specifically Renewable Energy Communities are going to be the ones deepened in the following section.

3.1. Legislative Decree 199/21: Renewable Energy Communities provisions and incentive schemes

This legislation has the main objective of accelerating the deployment of energy production from renewable sources, in line with the European target of decarbonizing the energy system by 2030, through the establishment of all the necessary instruments, mechanisms, incentives and regulatory and financial frameworks.

The legislative decree 199/21 defines a Renewable Energy Community as an autonomous legal entity controlled by natural persons, small and medium-sized enterprises (for which the REC participation does not constitute the main commercial and professional activity), private associations, local authorities including municipalities, research and training institutions, tertiary sector, among others. Any consumer, even those with low-income or vulnerable can also be part of a REC configuration, provided that the community control falls on the figures previously mentioned. The REC operation must have as the main objective providing economic, social, and environmental benefits to its members and shareholders or to the areas in which it operates, rather than financial profits creation.

Among the activities the community is allowed to carry out, it can be found the production, in-site consumption, sharing consumption inside the community and surplus energy selling even through renewable power purchase agreements, directly or through aggregation. The RECs can also produce other types of energies from renewable sources besides electricity, as well as provide other commercial energy services such as energy efficiency services, electric vehicles charging services or ancillary services, among others.

In terms of production facilities, the self-consumer can be directly connected to the installation and this one can be owned and managed by a third party (not considered as a renewable self-consumer) who is subject to the instructions of the final renewable self-consumer. In this case, the shared energy represents only the produced energy from the production facilities controlled and under the disposition of the REC. Moreover, this shared energy is shared through the electricity public distribution network, that is, no private networks are allowed to be owned or managed within the community configuration.

Regarding the incentive scheme applicable to RECs, art. 2 of the present legislative decree defines the *energia condivisa* (in English: shared energy) as the minimum, in each hour measurement time span, between the self-produced energy by the renewable energy facilities within the REC configuration and injected into the grid, and the total withdrawn energy by all the participants of the configuration situated in the same market zone.

Subsequently, art. 8 sets the regulatory provisions for the incentive scheme applicable to the shared energy within a collective self-consumption configuration. It states that the installed power capacity of the installation must not exceed 1 MW and that the final consumers must be all connected to the same primary substation (HV/MV) [57]. In addition, this incentive is given along with the reimbursement of the variable parts of the distribution and transmission tariff components based on the shared energy, given that it has been self-consumed in the same network section. However, these configurations are not eligible for the incentive in case a tender application request has been submitted.

In addition to the previous incentive scheme, the facility installation can access to *Bonus Casa 50%* deduction, which consists of the reimbursement of 50% the invested amount, but up to 96.000 euro [49] [58].

Lastly, it is worth mentioning that, within Renewable Energy Communities, end consumers have the right to freely choose their electricity supplier, and to contractually determine a reference figure for the configuration, who is in charge of distributing the shared energy and managing the interactions due to payment reasons, with the GSE and suppliers.

Further detailed information regarding the Italian regulatory framework for Renewable Energy Communities can be found in the annually released Electricity Market Reports by the Energy & Strategy team, managed by the School of Management of Politecnico di Milano [59].

3.2. Establishment and Management of a REC in Italy: Investment analysis

Following the same structure as previous countries, this section has the objective to analyse the energy flows and revenues and costs associated to the establishment and management of two different REC configurations that can take place in Italy considering the related-regulatory framework in force.

In the same way, the two arrangements will be examined under a business model in which 100% of the investment comes from prosumers. The REC is assumed to be constituted by 20 participants with different consumption profiles and whose withdrawals and injection points are connected to the same HV/MV primary substation, so that it can access to the shared energy inventive. Alongside, PV facilities are assumed to be rooftop-mounted in order to be eligible for *Bonus Casa 50%* incentive, with an aggregated installed capacity assumed as 30 kW. All these general assumptions are presented in Table 8.

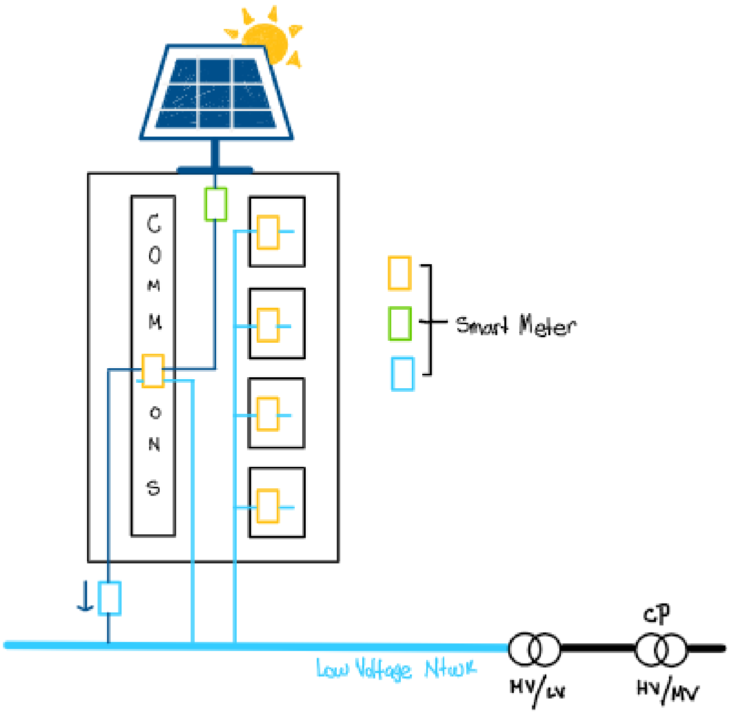
Table 8. General assumptions for the investment analysis of REC configurations, Italy

General assumptions	
Business model	100% participant's equity
Proximity	HV/MV primary substation
PV type	Rooftop-mounted
PV aggregated installed capacity	30 kW
PV lifetime	20 years

3.2.1. Condominium configuration

This configuration is composed by 20 residents in a multi-apartment building whose commons consumption is directly connected to the rooftop-mounted PV system. It enters as well within the definition of collective self-consumption and the organization of this configuration is illustrated in Figure 5.

Figure 5. Condominium configuration, Italy



The energy flows considered for generation and consumption for this configuration are the following:

1. The electricity is generated by the PV facility to meet as much commons-load as possible and then, fed into the grid.
2. The shared energy among the REC, as stated in the legislative decree, will be the minimum between the electricity injected into the grid and the total withdrawn energy by all the participants at the given timespan. This shared electricity is allocated to each participant by the refence party.
3. The remaining consumption load f
4. or the commons and parties is met by the complementary supplier.

The revenues and costs associated to this configuration and considering the type of investment are presented in Table 9.

Table 9. Revenues and costs for condominium configuration, Italy

Revenues	Costs
Savings from commons in-site self-consumption	CapEx
Energy fed into the grid	OpEx
Incentive on shared energy	O&M
Reimbursement of charges for shared energy	Other costs
Reimbursement of avoided energy losses for shared energy	
Bonus casa 50%	

Savings from commons in-site self-consumption consider the total electricity price, PUN (in Italian: *Prezzo Unico Nazionale*). The energy fed into the grid is remunerated by the GSE at the *Prezzo Zonale Orario*, PO (in English would be the electricity market value) which fluctuates depending on the time and market zone at which the energy is injected into the grid [60].

For the given amount of shared energy, there is a fixed feed-in-premium incentive which, as far as the available information concerns, is going to be modified shortly to a scheme that depends on the electricity market value at each measuring timespan. In addition, the variable part of the distribution and transmission tariff components are reimbursed given that the shared energy is intended to be self-consumed within the same distribution network portion, connected to the same primary substation [49] [61]. In the same way, there is a reimbursement for the avoided energy losses since the self-consumption can be equated to an in-site one.

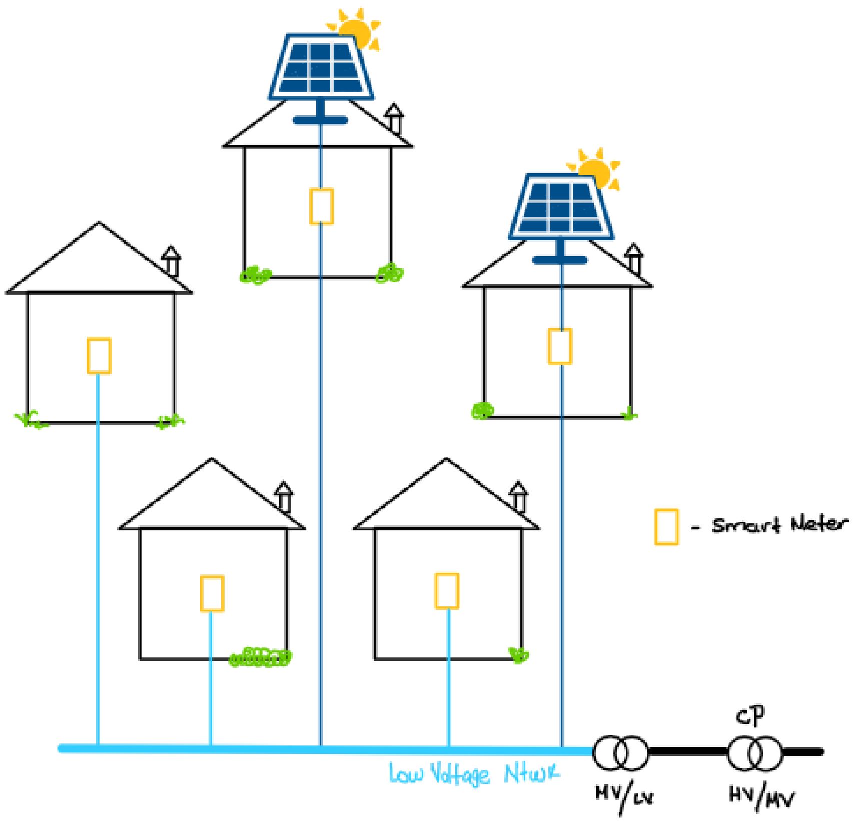
Lastly, the rooftop-mounted PV facility is subject to the Bonus Casa 50% incentive, considering the total invested amount, as explained in prior sections.

Participants received an invoice with the shared energy already considered, and incentives and reimbursements.

3.2.2. Multi-household configuration

This configuration is composed by 20 distanced households connected to the same primary substation. Some of them are equipped by rooftop-mounted PV installations and share the excess of energy within the renewable energy community after an in-site self-consumption. The organization for this configuration is illustrated in Figure 6.

Figure 6. Multi-household configuration, Italy



The energy production and consumption sequences are the following:

1. The generation units supply as much the owner's consumption load as possible and the rest is fed into the grid.
2. The shared energy for the REC, as it is laid down in the regulatory decree, is the minimum between the energy injected into the grid and the total withdrawn energy by all the parties composing the REC, for the given measuring timespan. The reference party must declare the distribution of the shared energy among the participants.
3. The remaining consumption of the participants is fed by the complementary supplier.

Revenues and costs can be analysed from a PV-owner's perspective or from the side of a pure consumer, but for the latter, joining a REC represents mainly a revenue, assuming there are no related-costs. For PV owners, revenues and costs are the ones listed in Table 10.

Table 10. Revenues and costs for multi-household config. – prosumer side, Italy

Revenues	**Costs**
Savings from commons in-site self-consumption	CapEx
Energy fed into the grid	OpEx
Incentive on shared energy	O&M
Reimbursement of charges for shared energy	Other costs
Bonus casa 50%	

For this configuration, revenues and costs work the same way as for the condominium case, except from the reimbursement of avoided energy losses related to the shared energy. Due to the distance between withdrawal and injection points, the self-consumption does happen in the same distribution network portion but cannot be equated to an in-site self-consumption, which is the case for the condominium configuration [49].

4 Cross-country Comparison

This chapter aims at summarizing, further explaining and comparing the enabling frameworks for renewable energy communities in Austria, France, and Italy, relying on dedicated literature and research. Moreover, a cross-country discussion about the investment analysis and the support schemes is going to be addressed.

4.1. Regulatory Framework

To conveniently compare the legal and enabling framework adopted by each country, a summary of the main points was conducted, as shown in Table 11. The following subsections deepen on the comparison of each matter.

4.1.1. Definition, participation, and legal organization

In terms of REC definition, main purpose, and participation, the three countries comply with the EU guidelines. However, even though REDII specifies RECs are not intended to be financially attractive new businesses for stakeholders, but rather to provide social, environmental, and specifically, economic benefits; a minimum economic sustainability should exist in order to attract all income-levels citizens and ensure their deployment [22].

Austria, France and Italy broadly identify the same members and shareholders that can participate in a REC, considering as well that for private companies the involvement within the community does not constitute their main professional and commercial activity. Despite EU guidelines lay down the importance of member states to ensure the REC accessibility to all consumers, regarding including low-income and vulnerable households, it is only Italy the one emphasizing this matter within their REC provisions. However, dedicated policy measures to facilitate the participation of these groups, as well as the finance and information accessibility is still lacking for the three countries [62].

Regarding the legal personality the organization may constitute, all the concerning countries have quite similar figures, expect for corporations, which are not stated in the Italian provisions [63]. In fact, cooperatives are a type of social and economic enterprises that allow participants to own and manage renewable energy projects, and they are the most common organizational legal figures used in citizen-driven initiatives [64].

Table 11. Cross-country comparison of the regulatory and enabling frameworks

	Austria	France	Italy
Definition	Autonomous legal entity	Autonomous legal entity (PMO)	Autonomous legal entity
Main purpose	Not-for-profit, but economic, social, and environmental benefits to members and operating areas	Not-for-profit, but economic, social, and environmental benefits to members and operating areas	Not-for-profit, but economic, social, and environmental benefits to members and operating areas
Participation	Open and voluntary	Open and voluntary	Open and voluntary
Members and shareholders	Two or more: natural persons, municipalities, legal entities, SMEs. Not the main professional and commercial activity for private companies	Two or more: natural persons (if only, at least 20), local authorities or their groupings, joint-stock companies, SMEs. Not the main professional and commercial activity for private companies	Two or more: natural persons, private associations, local authorities and related, SMEs and even low-income or vulnerable consumers. Not the main professional and commercial activity for private companies
Legal personality organization	Association, cooperative, partnership, corporation or similar, with legal personality	Public limited company, simplified joint-stock company, cooperative society of collective interest or an association	Associations, third sector entity, cooperatives, consortium, partnership, non-profit organization

Withdrawal and injection points - proximity criteria	Local area: same MV/LV substation and LV network Regional area: same HV/MV substation and MV network	CSC provisions apply: Same building/residential building Extended CSC: LV network, 2 km (20 km exception), 0.5 MW or 3 MW	For shared energy incentive: Same HV/MV substation 1 MW
Market activities	Production, consumption, storage and selling of self-generated energy, and providing other energy services Access to all energy markets directly or through aggregation	Production, consumption, storage and selling of self-generated energy (including PPA), and providing other energy services Provisions for shared electricity production given by self-consumption Access to all energy markets directly or through aggregation	Production, in-site consumption, shared consumption inside the REC and surplus energy selling (PPA included), directly or through aggregation. Provide other commercial energy services: energy efficiency services, electric vehicles charging services or ancillary services, etc
Complementary supplier	Freely chosen	Freely chosen	Freely chosen
Technology	RES	RES	RES
Assets ownership	3rd party allowed	3rd party allowed	3rd party allowed
Shared energy allocation (distribution key)	Statically or dynamically	Statically or dynamically	Statically or dynamically

Network ownership and operation	Not anymore	No	No
Network charges considerations for RECs	For the allocated self-produced energy: percentage discount on the energy-related part of the grid usage fee (situation specific), no Renewable subsidy and some levies	Optional network tariff scheme for self-consumption: autoproduced and *alloproduced* distinctions for the energy-related part of the withdrawal component. Taxes and levies still applicable	For the shared energy: Reimbursement of the variable parts of the transmission and distribution network tariff components and/or the avoided energy losses
Default measuring timespan	15 min	30 min	1 hour
Specific support schemes for RECs and/or shared energy	No	No	Shared energy incentive
Applicable financial incentives	Investment subsidy Market Premium	Depending on the config.: *Tarif d'Achat* (and) *La Prime à l'Investissement*	Subject to eligibility: *Ritiro dedicato* Investment bonuses
Surplus sales	Allowed	Allowed	Not allowed
Selling among REC participants	Allowed	Allowed	Not allowed

4.1.2. Proximity criteria

The proximity criterion is one of the main left-open parameters by the REDII to be addressed by member states considering their domestic general context. As it is required by the REDII that RECs must be *"effectively controlled by shareholders or members located in the proximity of the renewable energy projects"*, some EU countries refer to this concept whether as a pure-physical requirement or as a governance-related requirement [65]. For instance, some countries such as Lithuania and Greece, limit the proximity relying on a percentage of members being residents of the specific municipality in which the production facilities are located; while other countries rely purely on spatial limitations given whether by specific perimeters or by network connection or substation connection limitations. Austria narrows spatially RECs in local and regional areas depending on the substation and downstream network connection of injection and withdrawal points. For the French case, besides REC members must be located close to the renewable energy projects, they are required to comply with the provisions of self-consumption operations, for which the limitations are given by both spatial, network connection and capacity limitations, considering classical or extended collective self-consumption configurations. Similarly, Italy does not explicitly specify neither a spatial nor a governance-related proximity criterion, but rather limitations in terms of the grid connection of production and consumption points, and the generation facility capacity for the eligibility to shared energy incentives.

4.1.3. Activities and system ownership and operation

When it comes to the main activities RECs are allowed to carry out, the three countries lay down quite the same possibilities, including renewable energy power purchase agreements.

All the nations concerned enable the asset ownership whether by tenants, prosumers or any other third party [66]. In terms of technologies, they all specify the use of renewable energy sources, further than only electricity. The allocation of the produced energy within the REC members can be done both statically or dynamically for the three cases, taking into account that for Austria depending on the case, it can also be done both statically and dynamically, and for France the default allocation by the DSO is the dynamically one based on consumption loads, when no indication has been provided by the reference figure (PMO).

France and Italy have never permitted the ownership and operation of distribution grids, while Austria has. Austria intended to allow energy communities to operate and own network for distribution in such a way that it encourages grid operator to collaborate with the communities to avoid competition to arise [67]. However, the last enacted law has removed this possibility, thus enabling smoother procedures.

4.1.4. Cost-reflective network charges

As stipulated in the concerning EU directive, member states must ensure in their enabling frameworks for RECs, the cooperation of the relevant grid DSOs with the communities, as well as cost-reflective network charges so that the RECs still contribute in a balanced, fair, and adequate manner to the overall cost sharing of the system. Therefore, Austrian RECs are subject to network usage charges discounts depending on the location category (local or regional area), and the removal of the mandatory renewable subsidy and the exclusion from some levies, such as the electricity levy. France, instead, has chosen to enable RECs to select between the classical scheme or the self-consumption scheme for the calculation, mainly, of the withdrawal component of the network usage fee, considering a distinction of the self-produced and *alloproduced* electricity. In some way, French regulation aims at incentivizing the deployment of RECs through this optional scheme, but some studies have identified that not always this option correspond to a revenue, but rather a cost, and depends a lot on the installed capacity of the facilities [68]. Although the incentivizing aims are reported on the CRE deliberation, it is not so clear yet how the optional scheme is providing cost-reflective charges to RECs, given that the withdrawal component value for the *alloproduced* electricity is higher compared to the classical scheme, and even compared to the value the autoproduced electricity within this optional scheme. On the other hand, it can be said that Italy has taken a more convenient path for ensuring cost-reflective network charges, since it specifies that the reimbursements of avoided energy losses, and transmission and distribution components consider the fact that the shared energy is self-consumed within the same network portion it has been produced.

4.1.5. Support and financing schemes

It is well noted that Italy is the only country among the three studied ones that has a dedicated support scheme for the shared energy within the REC framework. It encourages sharing self-produced electricity among the participants of the REC by paying extra money, which is not intended to cover avoided costs or to reflect actual charges borne by the configuration, but rather to promote an accelerate the deployment of self-consumption communities. In addition to the shared energy incentive, many support schemes for RES are covering REC configuration or at least, not excluding them (*Ritiro dedicato* and investment bonuses).

Instead, Austria and France have only adopted support measures for REC by enabling them to access to existing RES support schemes. The investment subsidy and Market Premium in Austria already existed for RES and REC configuration has been included in them, while no dedicated inventive to shared energy exists. *Tarif d'Achat* and *Prime à l'Investissement* in France are intended to rooftop-mounted photovoltaic installations below 500 kWp within specified natures of operation, for which REC configurations have also been considered. Above the installed capacity thresholds, tendering procedures for injecting electricity have been defined.

Surplus sales to third parties and the selling of self-produced electricity within REC participants is only permitted in Austria and France. In Italy, on the other hand, all the electricity self-produced (after in-site self-consumption) is injected into the grid and purchased by a third party (GSE), to afterwards being allocated among the REC consumers as shared energy, which is the minimum between the electricity fed into the grid by the community and the aggregated consumption load. In this way, there is no distinction for energy surplus and instead consumers identify in their electricity bills the amount of allocated shared energy and the total to be paid due to complementary supply. For Austria and France, the energy is initially allocated among the consumers and then sold to the grid. These are different accountability and billing procedures for the self-produced and self-consumed electricity within a REC configuration. Moreover, Austria and France, when it is the case, allow billing and selling produced electricity within the REC among the participants, while Italy decides to manage it all through the regulator figure.

The billing activity among the REC participants might complicate the administrative and management procedures for RECs, for which France, for example, has been considering the possibility to aggregate the invoices of purchasing energy, so that participants receive only one.

4.2. Investment Analysis

The analysis of an investment in each country for two different REC configurations with quite the same assumptions of network connections, consumption loads and production facility capacities; intended to identify the main revenues and costs to be considered when evaluating the establishment of a REC.

Even though each country manages the REC operation in its own way, it can be said that Austria and France have quite similar methodologies, while Italy differs more from them, since, for instance, surplus sales and billing between REC participants is not permitted. However, in terms of proximity criteria the three countries are pretty much on the same page in the different cases evaluated.

Broadly speaking, renewable energy communities are benefited by revenues coming from:

- In-site self-consumption (if it is case) bearing no cost at all.
- Savings related to the energy cost due to self-production of the allocated electricity within REC participants, compared to the conventional supplier's energy costs.

- Savings regarding the regulations of network costs for RECs, in comparison to the supplier's conventional scheme; managed in different manners, depending on the concerned country.
- Savings regarding the regulations for taxes and levies for RECs compared to the no-REC base-case, varying according to the country under consideration.
- Sales related to the non-allocated self-produced electricity of the REC.
- Financial support for the not-allocated electricity of the REC, injected into the grid (such as Feed-in tariffs)
- Incentives schemes for the shared electricity within the REC.
- Investment support for RES installations, applying to REC configuration as well.

In terms of costs borne, it can be found:

- Capital expenditures related to the facility initial investment. Here, it can be also included the public distribution network-related costs.
- Operational expenditures throughout the useful life of the asset.
- Operations and maintenance of the asset over the lifetime of the facility systems.
- Other costs related to administration, consolidation, legal and management costs.

Both revenues and costs sources might vary according to the country-based context. Furthermore, more in-depth analysis, specifically, economic valuations can be caried out for RECs, to endorse quantitatively future legislation modifications. This matter will be further elaborated in the following section.

4.2.1. Recommendations for future studies

There exist few techno-economic valuations for renewable energy communities that properly backup the financial suitability of the investments considering the in-effect regulatory frameworks, and that could also help increase the availability and accessibility of information about RECs for the average citizen. Although, it must be considered that these types of evaluations are very country specific.

The main challenges that can emerge when running these techno-economic valuation might be:

- Proper consumption load depending on the type of consumer and information available by each country for the needed measuring timespan.
- The consideration about the space availability of the production facilities to properly define the configuration of the REC, which might imply, if it is the case, a rooftop-mounted or a ground-based PV system.
- The accessibility to production profile information, for the case of photovoltaic installations.
- The proper forecasting of the electricity market prices for households during the future lifetime of the project, given the current prices volatility. The same

applies for financing and incentive values that might vary over the years depending on the regulatory framework changes.

- Data reflecting the thermosensitivity for the electricity sector to properly make a comparison among the countries (not all countries resort in the same way to electricity for space heating, cooking, etc [69]).
- Further assumptions such as inflation rate variations, billing escalations and degradation rates for the PV systems

Particularly, fluctuations in electricity market prices and financing and incentive values over the years, on which many crucial calculations depend, is an important point that can be tackle with proper available forecasting. In the same way, a simulation using a program that can process huge amount of data would be convenient. For these reasons, it is recommended that future studies close a bit more the gap for renewable energy communities in terms of more accurate economic valuations that are also up to date with the current legislative framework, which might contribute to the information availability for citizens, that can be also translated into more reasons and facilitations to create and to join RECs.

5 Discussion: key issues and gaps

This chapter has the objective to identify and elaborate more in the main issues and gaps to be addressed in the near future, in order to better and faster transpose and implement the regulatory framework for renewable energy communities in European Member States, based on the afore-explained analysis for Austria, France and Italy, but also on state-of-the-art.

5.1. Low-income and vulnerable consumers

As it has been previously mentioned, countries are not particularly addressing within the regulation provisions for RECs low-income and vulnerable consumers, as it is stated in the REDII. The drivers enabling the deployment and effectiveness of RECs cover the socio-economic, political and cultural context in which the community operates, and studies has revealed that countries with high-level income participants are more likely to establish a REC, since there is a purchasing power to cover the financial investment and capital the project will entail [64]. This is why energy communities are more prevalent in high-income northern European countries in comparison to southern ones. Countries must work on enabling schemes for low-income and vulnerable participants to be able to establish and manage RECs and have access to clear energy in a non-discriminatory manner. RECs should generate enough profits for self-sustainment so that joining does not represent a huge investment only high-income level citizens are able to afford.

5.2. Legislation modifications and limitations of regulations

Another aspect that hinders the implementation of RECs is the continuous changes in the regulations and procedural steps for the establishment, as it has been seen in the Italian case, in which accessing to electricity markets and changes in REC provisions creates uncertainty and difficulty in for future consumers and small participants [70]. Countries should enable participants to access to simple information and provide uncomplicated procedures for accessing electricity markets, so that the development is rapid and smooth for citizens.

Limitations set by regulatory provisions impede the potential innovation, emergence, and deployment of RECs, including spatial restrictions, member typology and addressing regulations with a single approach for multi-size communities [70]. Proximity criteria, as explained in prior chapters, whether physical or governance-related, narrows the extent RECs can reach and the type of consumers that can be part of them. Relatedly, plant installed capacity and the member typology are linked to the proximity restriction, relying ones on the others. For instance, larger generation units will enable the joining of more and larger consumer types, such as medium-sized enterprises, but the installed capacity limitation and the perimeter-related or MV/LV network connection-related restriction impede the REC field of action. Said so, approaches addressing regulatory provisions for RECs should consider multi-size communities given aspects such as the relation between the proximity criteria, member types and plant installed capacity, in order to create a flexible enough legal basis for various REC solutions to emerge.

5.3. REC support schemes and cooperation with DSOs

As it has been for the Austrian and French cases, many EU Member States include renewable energy communities in their support, incentive, and financial schemes for RES. However, these kinds of schemes and the necessary operational frameworks must directly tackle RECs and their complexities and opportunities, so that the gap of confusion and uncertainty in terms of regulatory provisions can be shortened [70]. Specific incentive schemes that encourage the shared energy and REC deployment, as it is the Italian case, would be more compliant with the REDII guidelines in promoting and facilitating their deployment, by the Member States' transpositions.

Another crucial consideration relates the RECs cooperations with DSOs. Laws must provide an enabling framework for REC in coupling to the overall energy system, through the electricity public distribution network. As stated in REDII, cost-reflective network charges are needed to promote the RECs implementation, considering the possible network overload, or which could also be the case, network flexibilities as well, which might offer and advantage for DSOs [71]. Within the same matter, the accountability, allocation, and billing of the produced and shared energy inside the REC should be better addressed, to simplify the complexity of the procedures and requirements, and considering all-size RECs.

5.4. Transposition approach of the countries and eventual friction

As researchers have noticed, many EU countries have followed a copy-paste approach when transposing the REDII provisions into national laws, instead of following a more country specific and context specific evaluation [62]. Country implementations are intended to reflect EU laws into national ones, according to the socio-economic, political, cultural and energy system-related contexts, that is why criteria such as proximity and support schemes have been left open to be clearly defined by Member States.

Finally, some friction could arise as RECs get to be more coupled, through convenient regulatory frameworks, in the overall EU energy system. The latter has been prevalently dependant and centralized the past decades, by the European willingness to decentralize and decarbonize it might lead to some significant changes in the structure itself. Some roles and relationships along the supply chain might be redefined, such as the DSO and energy producer ones, and some competition could take place between RECs and large utilities if it is not well regulated by the national laws and European directives. Therefore, the EU rules must address the decentralization objectives, concerning the RECs as well, in such a way that all energy system players involved are affected the least possible by the transition.

6 Conclusions

European Member States are required to transpose the provisions for renewable energy communities laid down in the REDII, according to their socio-economic, political, cultural and energy system-related context. Even though the REDII was released in 2018, countries are still modifying their regulations for a final enacted law, given the dynamism of the matter.

The present work focused on examining the existing regulatory provisions until now Austria, France and Italy are adopting to respond to the EU requirements. The main left-open aspects to be addressed by the different countries have been the following: members and shareholders, the organization of the legal personality, the proximity criteria, the allowed market activities, the network charges considerations, and the existing support and financial schemes. Afterwards, an investment analysis for each country was conducted, considered two different assumed configurations to implement the already-mention regulatory framework and incentive scheme for each case, to identify the existing revenues and costs sources and further considerations.

A comparison of the analyzed regulatory framework for the three different countries revealed that Italy is the only country referring within its provisions the low-income and vulnerable consumers, but it does not have a specific regulatory scheme for these groupings, as it is the case of Austria and France. Moreover, all the three correspond to the same legal personality with which members and shareholders of the REC can be organized; except for Italy, for which corporations are not permitted and based on research, the most spread configuration from a European perspective is the energy cooperative.

In terms of proximity criteria, even though France and Italy do not specify it for REC operations, France covers RECs within the collective self-consumption framework, while Italy gives only a restriction when it comes to the incentive scheme for the shared energy. The three countries rely on the substation network connection for the withdrawal and injection points, and France and Italy on the plant installed capacity as well, to narrow the extent of the REC.

Cost reflective network charges for the shared energy within the REC is another critical point addressed by the different countries, since they implement quite diverse methodologies. While Austria and Italy keep the same network tariff structure for REC configurations, but doing a percentage discount or reimbursing some charges, respectively; Francia decided to implement an optional network tariff structure for self-consumption that might imply and extra cost for the community but is intended to actually be an incentive.

In terms of incentive and support schemes, it is worth noticing that only Italy has a dedicated remuneration for the shared energy within the REC but is the only one as well not permitting surplus sales, due to the accounting and allocating methodology (*ritiro dedicato*), and not permitting the selling of REC produced electricity within participants. Furthermore, the three countries have covered REC configurations within RES deployment support schemes and investment bonuses, depending on the case. Overall, countries must consider shared energy incentives such as the one of Italy to explicitly incentivize the electricity exchange within the community, promote their establishment and facilitate their deployment.

Subsequently, considering the previous analysis and comparisons, it was able to be identified from a general perspective that the main revenues sources for any REC configuration (depending on the case), night come from: in-site self-consumption, savings on energy costs, savings on network charges, savings on taxes or levies, savings on surplus sales, savings on specific shared energy incentive schemes and revenues coming from investment bonuses. Costs, instead, are quite the same for all the cases considered, being prevalent CapEx, OpEx and O&M costs. In addition, it is quite recommended to further implement the regulatory frameworks in a deepened techno-economical assessment which is lacking most of the state-of-the-art, and which surely contribute to the availability of information for citizens to join RECs. Within this matter, it is worth saying the importance of the profitability of such projects, even though it is not their main objective, a minimum financial suitability is necessary for all-income level citizens to be able to join.

Finally, based on this three-country analysis and the reference studies, in general, European Member States must put the attention of their transpositions in the main following matters:

- Regulatory framework schemes must include within their provisions low-income and vulnerable citizens considerations that allow these grouping to access in a non-discriminatory manner information and support schemes for joining RECs.
- Contemplate proximity criteria, facility installation capacity and all-size allowed members and shareholders (such as medium-sized enterprises) as a whole, to set enough legal support basis for further socio-economic regulations for RECs, but being flexible enough to keep the innovative potential needed for different REC solutions to emerge.
- Develop specific incentive schemes for RECs, instead of overing then within the RES deployment framework.
- Deepen in the accountability, allocation, and billing of the shared energy within the REC configuration, do that costs are reflective enough.
- Contemplate a regulatory framework in with REC cooperation with DSOs is able to give rise, so that network overload and flexibility can be handled properly.
- Take into consideration the domestic context for the transposition of the EU rules, instead of following a copy-paste approach.
- Find a way to manage properly an eventual wide coupling of RECs in the overall European energy system for reaching the decentralization objectives, which could imply some friction between the communities and DSOs and large utility producers, so that all players involved are affected the least possible by the transition.

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List of Figures

List of Tables

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Let a new chapter begins :)