05-022

# REVIEW OF THE STATE OF THE ART, REGULATORY AND TECHNICAL CHALLENGES OF DISTRIBUTED GENERATION IN EUROPEAN RURAL LOCAL ENERGY COMMUNITIES

Lozano Rivas, Alberto (1); Martinez, Lucas Rodolfo (2); Ribó Pérez, David (2); Gómez Navarro, Tomás (2)

(1) Instituto de Ingeniería Energética - Universitat Politècnica de València, (2) Universitat Politècnica de València

Spain and Europe are currently developing regulations and incentives for distributed generation, participation in the electricity market and the definition of social energy subjects. All this with the aim of empowering citizens and their social welfare. Examples are RD 15/2018 and RD 23/2020 in Spain and Directives 2018/2011 and 2019/944 in the EU, which define collective self-consumption and local energy communities (LECs). The latter are voluntary and autonomous legal entities of citizen participation that seek the environmental, economic and social benefit of their members. In order to develop a universally applicable project methodology, and given the unequal transposition times and scaling-up models in the different countries, this study responds to two research questions. A) What are the starting situation and constraints in each EU country, the most recent regulatory developments and what conclusions can be drawn about the feasibility of undertaking realistic LEC projects? B) Given the particularities of rural communities, as opposed to the predominantly urban LECs, what policies, decarbonization targets and distributed renewable generation models specific to rural LECs can be proposed to foster these projects?

Keywords: Distributed generation systems; Energy regulation; Rural local energy communities; Policy recommendations.

# ANALISIS DEL ESTADO DEL ARTE, RETOS REGULATORIOS Y TÉCNICOS DE PROYECTOS DE GENERACIÓN DISTRIBUIDA EN COMUNIDADES ENERGÉTICAS LOCALES RURALES EUROPEAS

Actualmente España y Europa desarrollan normativas e incentivos en materia de generación distribuida, participación en el mercado eléctrico y definición de sujetos energéticos sociales. Todo ello con el objetivo del empoderamiento ciudadano y su bienestar social. Son ejmeplos el RD 15/2018 y el RD 23/2020 en España y las Directivas 2018/2011 y 2019/944 en la UE, en el seno de los cuales se define el autoconsumo colectivo, y las comunidades energéticas locales (CELs). Estas últimas son entidades legales voluntarias y autónomas de participación ciudadana que buscan el beneficio ambiental, económico y social de sus miembros. Para desarrollar una metodología de proyecto universalizable, y ante los desiguales tiempos de transposición y modelos de escalado en los diferentes países, este estudio responde a dos preguntas de investigación. A) ¿cuál es la situación de partida y condicionantes en cada país comunitario, los desarrollos normativos más recientes y qué concluir sobre la viabilidad de emprender proyectos realistas de CEL?. B) Dadas las particularidades de las comunidades rurales, a diferencia de las predominantes CELs urbanas, ¿Qué políticas, objetivos de descarbonización y modelos de generación renovable distribuida específicos para este tipo de CELs se pueden proponer para incentivar estos proyectos?

Palabras clave: Sistemas de generación distribuida; Regulación energética; Comunidades energéticas locales rurales; Recomendaciones para políticas.

Correspondencia: Lucas Rodolfo Martinez. Correo: lrmartin@doctor.upv.es

Agradecimientos: This research work was funded by the Chair of Urban Energy Transition of Las Naves, the FVCiE and the UPV.

## 1. Introduction

The adoption of EU Directives included in the 'EU Winter Energy Package' of 2018, specifically, Directive (European Union, EU) 2018/2001 or RED II, aims to assist the EU's goal of enabling collective self-consumption, distributed generation, citizen participation in the electricity market and the establishment of social energy projects such as local energy communities, hereinafter referred to as LEC projects. LEC projects are novel entities participated by individuals and local authorities as well as small and medium-sized enterprises, which seek to deliver environmental, economic, and social benefit to their members. Moreover, due to their wide applicability, they can be set up in locations such as cities and towns, regardless of the social economic status of such city or town.

Although Directives are standards that must be transposed in each Member State, hereinafter MS (European Union, 2010; Navas Marqués; Juan Ignacio, 2021; Sánchez, 2016), several authors note an uneven transposition of the Directive by country (Frieden, Tuerk, Rita Antunes, et al., 2021). In Spain, Directive (EU) 2018/2001 has been transposed through Royal Decree, RD, 15/2018 and RD 244/2019 with an average progress (Dorian Frieden et al., 2020).

Therefore, to develop a universally applicable project methodology, a first research question arises: whether the legislative framework of each MS, considered as a preconditioning factor, enables the feasibility of undertaking realistic LEC projects and consequently whether the contextual conditions in place promote their development.

On the other hand, LEC projects can be developed in different settings, each one with its own features. However, based on research, urban LEC projects are predominant (Shnapp Sophie et al., 2020; Verde et al., 2020). However, there is also a limited number of LEC projects found in rural areas (Comunidades Energéticas, 2022; Energy Communities, 2022; Hive Power, 2021; IDAE, 2022; Rescoop, 2022)

In consequence, the goals of this work are, for the first research question, to analyse the existing European regulations, their transposition and technical constraints in each MS in order to identify of the feasibility of LEC projects and, for the second research question, to determine the singularities of rural LEC projects and their development opportunities. Thus, this research aims to help develop these projects efficiently and with a greater likelihood of success. For ease of reading, Table 1 lists the acronyms and abbreviations used throughout the article.

**Table 1. Acronyms or abbreviations used. Own elaboration.**

| Acronym or abbreviation | Meaning |
|---|---|
| LEC | Local Energy Community |
| REC | Renewable Energy Community |
| MS | Member State |
| RED II | Directive (European Union, EU) 2018/2001 |
| NUTS | Nomenclature of Territorial Units for Statistics |
| SV | Smart Village |
| WOS | Web of Science |
| SD | Science Direct |
| ENRD | European National Network for Rural Development |
| NIMBY | “Not In My Back Yard” effect |

## 2. Methodology and case study

### 2.1 Methodology

Figure 1 shows the methodology followed along this research in order to review the relevant literature with the goal of answering the two research questions set out above.

In the first place, it is analysed the number of publications per search query related to LEC projects and those in a rural context. The reviewing period has been from 2020 up to the present since the release of RED II, RD, 15/2018 and RD 244/2019 was between 2018 and 2019. The selected keywords are those corresponding to the novel legal figure of Local Energy Community and a widespread related term, Positive Energy District, as well as their rural equivalents. Additionally, Figure 2 shows that the growth of publications is exponential in recent years. Therefore, the main focus is on those years, since it was assumed that the highest proportion and the most relevant articles had been published then (see References for the main sources of information).

Secondly, a legislation and bibliographic review is performed based on grey literature (European legislation, MS legislation, papers from work groups, which accounts for 57% of the reviewed articles) and peer-reviewed sources (Scopus, Science Direct: SD and Web of Science: WOS, which represents a 43% of the reviewed articles). On the third place, a systematic review and analysis is performed by clustering research fields of interests, authors' main research, findings and unanswered questions. Lastly, obtained findings are discussed and conclusions drawn.

**Figure 1: Methodology for this research. Own elaboration based on Yadav et al., 2019.**

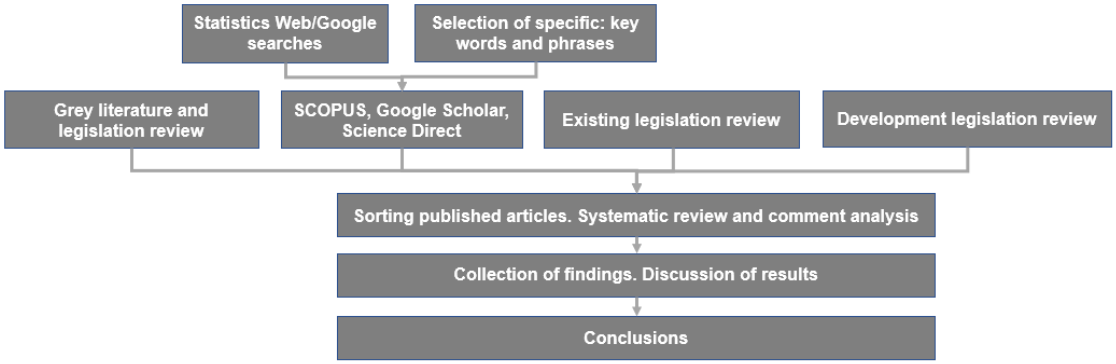
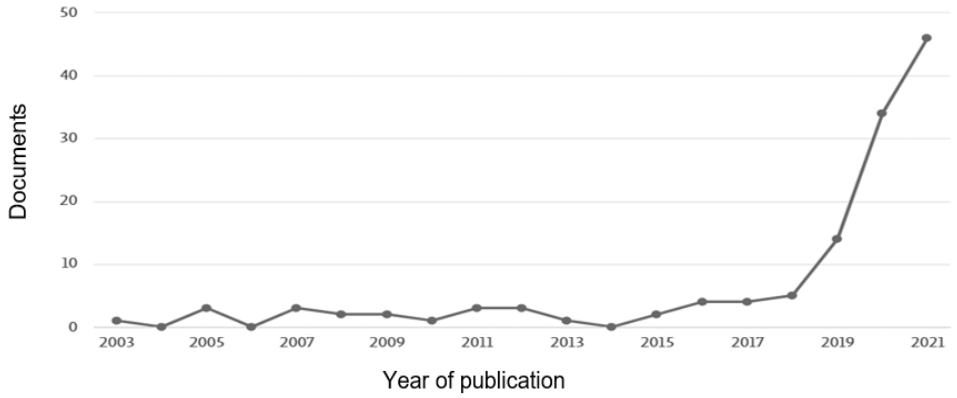



**Figure 2: Histogram of results in Scopus associated with Local Energy Community (Scopus Term Analyzer, n.d.)**




### 2.2 Case study

This case study focuses on LEC projects in the EU and, specifically, in rural settings. It analyses the definition of rurality, the RED II transposition and main regulatory entities in each MS as well as technical, economic limitations and opportunities for these projects. This case study aims to identify their potential growth, by presenting their singularities and the main clusters of research questions around them.

## 3. Results

### 3.1 Statistical review of publications on LEC projects

The analysis about publishing records performed results in Table 2, which shows that search queries on LEC projects and positive energy districts are more frequent compared to similar terms for rural areas. This may indicate that rural LEC projects are an emerging research field, may be a distinctive entity, and they should be further studied.

**Table 2. Number of publications per search query.**

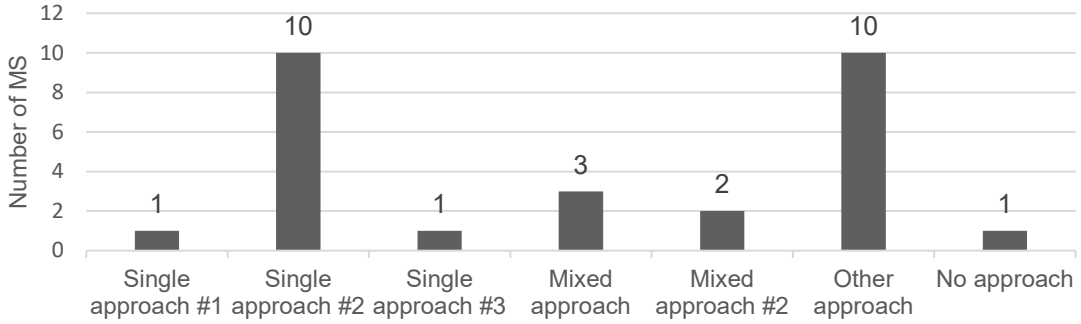
| | WOS | Scopus | SD | Google Scholar |
|---|---|---|---|---|
| "Local energy community” | 53 | 108 | 166 | 1450 |
| "Local energy community" & "rural" | 4 | 2 | 32 | 173 |
| "Positive energy district | 24 | 97 | 32 | 186 |
| "Positive energy district" & "rural” | 1 | 10 | 10 | 48 |
| "Positive energy community” | 4 | 9 | 28 | 80 |
| "Positive energy community" & "rural” | 0 | 4 | 4 | 26 |

### 3.2 Review of demographic rurality definition for each MS

The baseline for rurality definition in the EU is the Eurostat classification known as Nomenclature of Territorial Units for Statistics, NUTS. There are three hierarchical levels: NUTS 1, macroeconomic regions, NUTS 2, basic regions with regional policies and NUTS 3, small regions with local policies. However, the specific limits between the categories depend on each MS (Patarchanova et al., 2011).

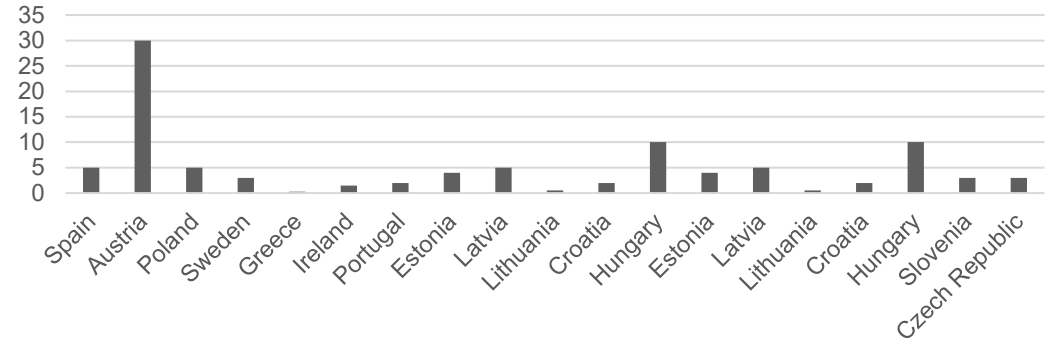
Figure 3 shows the different criteria used by MS. The two main criteria are the number of inhabitant or a historical or administrative approach. Figure 4 shows for the maximum number of inhabitants for rurality, i.e., 5.042 persons. Therefore, the definition of a rural LEC project may be currently different for each MS.

**Figure 3: Criteria for rural-urban classification and number of MS. Own elaboration.**




Note: i) Single approach #1: population density ii) Single approach #2: inhabitants iii) Single approach #3: distance to a service centre iv) Mixed approach #1: density and inhabitants v) Mixed approach #2: surface occupation or use and population vi) Other approach: historical or administrative vi) No approach.

**Figure 4: Maximum inhabitants in a rural municipality (in thousands). Own elaboration.**




Note: when several criteria are present in a MS, the most restrictive one has been chosen.

### 3.3 Review of European framework legislation

Directive (EU) 2018/2011 or RED II, defines Renewable Energy Community (REC) or Local Energy Community (LEC) as a legal figure constituted by renewable energy self-consumers acting jointly (Parlamento Italiano, 2021) which:

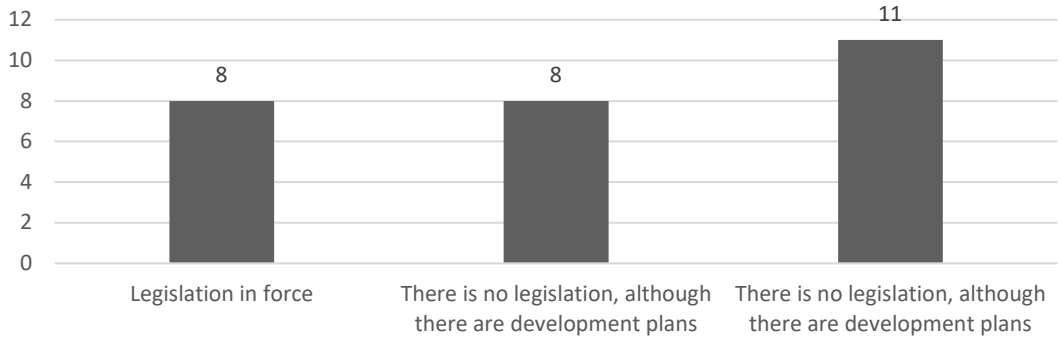
1. is based on voluntary, autonomous, open participation and controlled by its members
2. members are natural persons, small and medium-sized enterprises or local authorities
3. main objective is to provide environmental, economic or social benefits

These projects can relate to renewable energy generation, demand, efficiency, aggregation, storage and, less likely, distribution, electric mobility or other energy services (Miteco, 2020a). Transposition is mandatory by June 2021 (Gámir Meade, 1998).

### 3.4 Review of legislation and regulation bodies for MS

Figure 5 shows the degree of the transposition of the relevant LEC legal framework for each MS. The majority of MS are yet to approve any corresponding legislation or development plans. Table 3 shows the applicable regulatory body for each MS. The central ministry under the government is the majority. France is the only country with no rural policies. There are countries whose relevant entities belong to more than one category, such as Belgium. All this may result in higher complexity and unequal opportunities for LEC projects in different MS due to not uniform approval rules and procedures for these projects.

**Figure 5: Member States according to each type of transposition. Own elaboration based on Dorian Frieden et al., 2020; Frieden, Tuerk, Antunes, et al., 2021.**




Note: 1) Legislation in force: Belgium, Greece, Italy, Ireland, Lithuania, Austria, Luxembourg, Slovenia 2) Development plans: Spain, France, Sweden, Estonia, The Netherlands, Hungary, Finland, Portugal 3) No plans: Germany, Malta, Portugal, Croatia, Cyprus, Slovakia, Czech Republic, Denmark, Poland.

**Table 3. Distribution of responsibility in Rural Policy and Plans (OECD Rural Studies, 2020)**

| Entity | No. of MS (% of total) | Countries |
|---|---|---|
| Central ministry or government | 26 (96,29%) | Germany, Spain, Austria, Denmark, The Netherlands, Poland, Sweden, Greece, Italy, Ireland, Portugal, Czech Republic, Estonia, Hungary, Luxembourg, Slovak Republic, Finland, Latvia, Croatia, Lithuania, Slovenia, Malta, Romania, Bulgaria, Cyprus |

| | | |
|---|---|---|
| National agency or institution (other than government) | 11 (40,74 %) | Spain, Austria, Denmark, The Netherlands, Poland, Sweden, Italy, Slovak Republic, Croatia, Slovenia |
| Ministry or regional government | 5 (18,51 %) | Belgium, Austria, Poland, Portugal, Finland |
| Regional agency or institution | 6 (22,22 %) | Belgium, Austria, Greece, Italy, Ireland, and Finland |
| Municipality | 6 (22,22 %) | Denmark, Sweden, Ireland, Hungary, Finland and Lithuania |
| No national rural policy | 1 (3,70 %) | France |

### 3.5 Review of published literature on rural LEC projects.

The bibliographic review carried out has allowed this case study to group the research fields and regulatory interests, which show the singularities of rural LEC projects.

About the specific definition of rural LEC

NUTS is the European framework for rurality; however it depends on each MS how to define its specific criteria. Therefore, the is not a single framework for the MS in order to define rural LEC projects regardless of its location (Dorian Frieden et al., 2020; Frieden, Tuerk, Antunes, et al., 2021).

However, several authors reflect about defining rural LEC formally (Fajrillah & Novarika, 2018; OECD, 2021) and, other authors also define the related concept of Smart Village (SV). A SV is a rural local entity that brings together the efforts of its inhabitants by means of technology to benefit rural communities and meet "global means for local needs" (Fajrillah & Novarika, 2018). This concept could be taken as a basis for defining a rural LEC, since a SV must ensure minimum services, some of which are common to the RED II definition of LEC projects, such as democratic engagement (good governance, social development, strengthening of community organization), health prosperity (sanitary conditions) educational (energy awareness), responsible economic improvement (local business development) and use of renewable energies.

In addition, some authors study urban LEC projects, using other associated terms such as Positive Energy Districts and Climate Neutral Cities (Shnapp Sophie et al., 2020). This can be aligned with a formal definition to distinguish rural LEC projects.

About their technical characteristics

Several authors indicate that rural LEC projects can help reduce the load management problems associated with centralized energy production and increase grid voltage stability at the local level (Hepburn Wind - Community Energy, 2008; Hicks & Ison, 2011; Walker & Cass, 2007). This is particularly relevant, as average power consumption is often higher in rural areas, and there may be higher associated losses. Rural areas usually have a comparatively worse grid connection than other areas (Bakker, 2020; Instituto Enerxético de Galicia, 2011; Ministerio de Industria, 2022) with longer interruption times. In Spain, some rural areas have their own grids, such as in the case of the Valencian Community (Armero Martínez, 2015), Andalusia (Suministradora Eléctrica de Cádiz, 2022), Castilla la Mancha, Extremadura, Galicia, Navarra and Madrid (Comisión Nacional de los Mercados y la Competencia, 2022). Therefore, rural LEC projects can help to manage the increased complexity of the network in rural areas.

On the other hand, there are studies on objective methods of assessing renewable energy potential by region that may be more cost-effective than urban LEC projects because they may have more immediate access to it (Benedek et al., 2018). In addition,

domestic properties in rural areas have a poorer energy efficiency index and insulation ratings than those in urban areas (Skerratt et al., 2012).

In relation to per capita $CO_2$ emissions in the rural domestic sector, several authors report they are higher than in urban areas and gas consumption per capita may be also higher (Scottish Goverment, 2011; Skerratt et al., 2012). This trend is also found in studies conducted worldwide, including the nordic countries (Rauhala et al., 2004), the United States of America (Glaeser & Kahn, 2009), Canada (Norman et al., 2006), China (Auffhammer & Carson, 2008), other EU countries such as Spain, Germany, France, Italy, the Netherlands and Belgium and in Scotland (Carney, 2009). Current $CO_2$ costs have increased from approximately EU ETS 26 €/Tm on 1st January 2020 to 95 €/Tm on 1st February 2022 (Trading Economics, 2022). As a result, rural LEC projects may count on good economic viability of projects (Clausen & Rudolph, 2020; European Court of Auditors, n.d.; Irena, 2016) compared to urban or hypercarbon projects

About its contribution to EU development, equal opportunities and decarbonisation goals

The European National Network for Rural Development, ENRD, defines as one of its legislative priorities the development of rural SVs, i.e. socially and economically developed villages based on sustainability and economic sustainability. Rural Development Programmes are established in MS to support their deployment.

Besides, its alignment with rural RECs is identified. This is done by defining smart local strategies for sustainable rural energy communities based on renewable energies with special focus on isolated areas such as small islands or mountainous areas in the EU.

Currently the decarbonisation targets do not distinguish the specific contribution of LEC (Comisión Europea, 2020; Comunicación de La Comisión Sobre El Pacto Verde Europeo, 2019; Ministerio para la Transición Ecológica y el Reto Demográfico, 2020b). However, several studies have identified its potential to reduce emissions in sectors with a higher specific weight than in urban areas, such as agriculture, forestry, and livestock, which can account for around 20% of $CO_2$ emissions in rural communities (Jackson et al., 2006). These initiatives can generate opportunities through renewable energy generation, contributing to the EU decarbonisation and energy independence objectives.

About the behaviour of its members

Some authors indicate that remote rural areas in the EU, have a higher proportion of households in the lower income brackets, even though the average income is higher than in urban areas (Skerratt et al., 2012). Therefore, they may benefit socially more from LEC projects, as there is a higher percentage of people with the lowest income sites (L. W. Li et al., 2013; Verde et al., 2020). Besides, the engagement of residents may be related to a successful start of small-scale energy projects (L. W. Li et al., 2013). All this may imply a higher probability of success of LEC projects and a greater project-community symbiosis effect.

Several studies show that rural LEC projects may even have different objectives and relational patterns among their members than urban ones (L. W. Li et al., 2013; Verde et al., 2020). Some of these distinguishing characteristics may be:

1. Larger size of projects and potential number of members and greater capacity to scale up by raising new funds and greater (L. W. Li et al., 2013; Mah, 2019; Skerratt et al., 2012; Verde et al., 2020)
2. Greater capacity to influence different stakeholders, such as local authorities, businesses and other neighbours (L. W. Li et al., 2013; Markantoni & Woolvin, 2014; Verde et al., 2020).

3. Increased resilience in terms of long-term commitment to the project (X. Li et al., 2013; Skerratt et al., 2012)
4. Greater distribution of human and financial resources than in urban projects (Verde et al., 2020).
5. Greater commitment with the project and closer degree of relationship between members (Cabarcos et al., 2020; L. W. Li et al., 2013; X. Li et al., 2013; Mah, 2019)
6. Greater willingness to accept members with low income (Cabarcos et al., 2020)
7. Greater environmental awareness due to nearby resource (Verde et al., 2020)
8. Less rejection to the implementation of nearby projects, also known as NIMBY (Dmochowska-Dudek & Bednarek-Szczepańska, 2017).

### 3.5 Review of technical limitations

Some authors point out that the morphology of rural business and industry in the EU differs from those urban areas (Skerratt et al., 2012). Therefore, demand load curves may be different. In addition, the renewable resources near rural LEC projects may be more abundant and diverse. This may increase complexity in the match of demand and supply curves (Benedek et al., 2018) and also limit the deployment of rural LEC projects, as well as the development of local markets due to rural electricity grids facing more technical and saturation issues (Skerratt et al., 2012).

Furthermore, RED II states that effective control of LEC projects should be in the hands of its nearby members. However, these control criteria may be different for each MS, e.g. in terms of proximity or maximum power. Different criteria currently coexist in the EU (División de Asuntos Reglamentarios. Gobierno de Grecia., 2019; Frieden, Tuerk, Antunes, et al., 2021), among others, based on:

1. Belonging to the same administrative reference (e.g. the Netherlands, Greece, and France)
2. Maximum distance between production and consumers (e.g. Spain)
3. Belonging to the same physical location (e.g. Austria, Denmark and Germany)
4. Belonging to the same grid voltage downstream (e.g. France and Slovenia).

## 4. Discussion

In relation to the regulation, as reviewed in section 3.3 to 3.5, the relatively recent and progressive definition of socially participatory collective self-consumption projects, until the formal definition of LEC in RED II, as well as the uneven transposition between the different MS, may be related to the lack of specific and ambitious decarbonisation objectives for this type of projects, neither in urban nor in rural areas. There may be a clear risk of further alienation between MS in relation to the development of these projects (Verde et al., 2020).There is also a lack of a common definition of rurality for all MS, which could help to define which LEC projects are located in rural areas.

Moreover, as reviewed in section 3.3, the current definition of LEC projects does not contain elements adapted to their deployment area, which would allow to distinguish between rural and urban LEC projects. Therefore, as reviewed in section 3.5, MS do not have an unambiguous differentiation which, they could transpose into their regulations. However, there is a concern expressed by several authors that focuses on the singularities and needs associated with rural LEC projects. Furthermore, the ENRD, promoted by the European Commission, promotes the definition of SV in contrast to

Smart Cities and it has found a response in several MS, and specifically in the field of energy, in Spain, Ireland and Greece, as reviewed in section 3.5.

In relation to social impact, several authors note that there are some characteristics of rural LEC projects that may make them more successful than their urban counterparts such as available renewable resource and access or sense of ownership. There may be greater commitment and resilience on the part of project participants due to factors such as distance between project members, closer social relations, or a greater sense of integration into a community. In relation to the economic level, there may be a higher percentage of people with the lowest income brackets. Therefore, as reviewed in section 3.5., rural LEC projects may also have a greater impact associated with the potential reduction of energy poverty and greater willingness to participate. In relation to environment, higher per capita emissions ratio may make rural LEC projects more successful.

Regarding differing installation criteria for LEC projects, restrictions on the distance between energy generators and consumers as well as maximum power of the installation are relevant. In addition, a more complex match between generation and demand can lead to more often technical problems specific to rural LEC projects at the local level.

Based on these findings, the following policy recommendations are proposed:

Firstly, to standarize the definition of LEC for all MS, as it can help the development of this type of project. Secondly to homogenize the definition of rurality and establish specific limits.

Besides, to define a universal methodology for this type of rural LEC projects. The development of resource potential assessment methods, economic models of savings and emission reductions can help to promote this type of project and obtain financing more easily.

Furthermore, to research more deeply on the singularities associated with rural LEC projects and to promote specific technical management models for these facilities. This can include the measurement of preconditioning positive characteristics, such as a lower NIMBY effect, a greater resilience and community benefit, better eradication of energy poverty and greater commitment to the project.

Then, to set specific plans to highlight and communicate to citizens and potential public-private investors the likelihood of success of rural LEC projects.

Consequently, to define specific targets for rural LEC projects that can foster their development. LEC projects can contribute to strategic goals such as demographic challenge, decarbonisation, energy transition or energy independence.

Therefore, encouraging specific taxation that considers the social and environmental impact of these projects, as well as the vulnerability of some participants, their specific contribution to rural development plans and the deployment of SV.

Lastly, defining common technical requirements for all MS, e.g. in relation to the distance between generation and consumers as well as maximum power, in order to achieve homogeneous favourable conditions in all MS.

## 5. Conclusions and further steps

There is a growing interest in LEC projects due to recent EU legislative changes and projects are being developed. However, the findings of this case study show that their feasibility may depend on the MS in which they are developed, due to uneven transposition and technical conditions, among others. Besides, the present study shows that the focus is on urban LEC projects. The reason may be that the definition of rurality

differs among MS and, in addition, there is no regulatory framework to categorise LEC projects according to their location.

The case study assessed has identified the singularities of rural LEC projects and their development potential. The limited preceding studies made it more difficult to identify clusters of research questions and opportunities associated with them. Some of these opportunities for rural LEC projects may be a greater access to renewable resource, greater engagement, participation and resilience of their members and greater potential for reducing per capita emissions and energy poverty. Based on these results, some policy recommendations are proposed to facilitate the development of these types of projects, such as reducing technical constraints, establishing specific taxation policies and establishing communication plans about their potential to facilitate public-private investment.

This study is mainly based on the legislative, bibliographical, and contextual analysis of rural LEC projects. Nevertheless, it includes some further steps in order to establish more robust models for analysing the technical and economic potential of this type of projects, and specific measures to facilitate their successful development.

## 6. References

Armero Martínez, A. (2015). El proceso de electrificación inicial en la provincia de Valencia (1882-1907).

Auffhammer, M., & Carson, R. T. (2008). Forecasting the path of China's $CO_2$ emissions using province-level information. *Journal of Environmental Economics and Management*, 55(3), 229–247. https://doi.org/10.1016/J.JEEM.2007.10.002

Bakker, F. (2020). La despoblación y la electricidad: el caso de España. *El Periodico de La Energía*. https://elperiodicodelaenergia.com/la-despoblacion-y-la-electricidad-el-caso-de-espana/

Benedek, J., Sebestyén, T. T., & Bartók, B. (2018). Evaluation of renewable energy sources in peripheral areas and renewable energy-based rural development. *Renewable and Sustainable Energy Reviews*, 90, 516–535. https://doi.org/10.1016/J.RSER.2018.03.020

Cabarcos, M. Á. L., Castro, N. R., & Viña, V. M. (2020). Analysis of the predisposition to participate in renewable energy communities. Revista Galega de Economía, 29(2), 1–25. https://doi.org/10.15304/rge.29.2.6914

Carney, S. (2009). Greenhouse gas emissions inventories for 18 European Regions. http://hummedia.manchester.ac.uk/institutes/mui/cure/downloads/GRIP_Brosch ure_low_res.pdf

Clausen, L. T., & Rudolph, D. (2020). Renewable energy for sustainable rural development: Synergies and mismatches. *Energy Policy*, 138, 111289. https://doi.org/10.1016/J.ENPOL.2020.111289

Comunicación de la Comisión sobre el Pacto Verde Europeo, (2019). https://sustainabledevelopment.un.org/post2015/transformingourworld

Comisión Europea. (2020). Marco energía y clima 2030. https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

Comisión Nacional de los Mercados y la Competencia. (2022). Listado de Distribuidoras de electricidad CNMC. https://sede.cnmc.gob.es/listado/censo/1

Comunidades Energéticas. (2022). Comunidades Energéticas, casos de éxito. https://comunidadesenergeticas.org/

División de Asuntos Reglamentarios. Gobierno de Grecia. (2019). Implantación de la medición neta virtual de los autoproductores.

Dmochowska-Dudek, K., & Bednarek-Szczepańska, M. (2017). The NIMBY Syndrome in Rural Areas. The Case of Poland. A Research Report. *ISR-Forschungsberichte*, 43, 99–120. https://doi.org/10.1553/ISR_FB043S99

Dorian Frieden, Andreas Tuerk, Stanislas d'Herbemont, & Josh Roberts. (2020). Collective self-consumption and energy communities: Trends and challenges in the transposition of the EU framework.

Energy Communities. (2022). Case Studies - Energy Communities in Europe. https://enercommunities.eu/case-studies/page/2/

European Court of Auditors. (n.d.). Special Report Renewable energy for sustainable rural development: significant potential synergies, but mostly unrealised.

Fajrillah, Z. M., & Novarika, W. (2018). Smart city vs smart village. *Jurnal Mantik Penusa*. http://webcache.googleusercontent.com/search?q=cache:O9D5-XstEh8J:e-jurnal.pelitanusantara.ac.id/index.php/mantik/article/download/338/221+&cd=1&hl=es&ct=clnk&gl=es

Frieden, D., Tuerk, A., Antunes, A. R., Athanasios, V., Chronis, A. G., D'herbemont, S., Kirac, M., Marouço, R., Neumann, C., Catalayud, E. P., Primo, N., & Gubina, A. F. (2021). Are We on the Right Track? Collective Self-Consumption and Energy Communities in the European Union. *Sustainability 2021*, Vol. 13, Page 12494, 13(22), 12494. https://doi.org/10.3390/SU132212494

Gámir Meade, R. (1998). Un enfoque práctico desde la óptica de técnica normativa de las operaciones de transposición de directivas comunitarias. *Revista del Poder Judicial*, ISSN 1139-2819, No 49, 1998, Págs. 199-270.

Glaeser, E. L., & Kahn, M. E. (2009). The greenness of cities: Carbon dioxide emissions and urban development. *Journal of Urban Economics*. https://doi.org/10.1016/j.jue.2009.11.006

Hepburn Wind - Community Energy. (2008). https://www.hepburnwind.com.au/

Hicks, J., & Ison, N. (2011). Community-owned renewable energy (CRE): Opportunities for rural Australia. Rural Society, 20(3), 244–255. https://doi.org/10.5172/RSJ.20.3.244

Hive Power. (2021). Top Five Energy Community Projects in Europe. 2021. https://hivepower.tech/top-five-community-energy-projects-in-europe/

IDAE. (2022). Proyectos con participación ciudadana, de PYMES y entidades locales o que proporcionen apoyo a las mismas. https://www.idae.es/ayudas-y-financiacion/comunidades-energeticas/comunidades-energeticas-vigentes-en-las-distintas-comunidades-autonomas

Instituto Enerxético de Galicia. (2011). Informe sobre el Tiempo de Interrupción equivalente a la potencia instalada en Galicia.

Irena. (2016). Renewable energy benefits: measuring the economics. www.irena.org

Jackson, J., Li, Y., Glen, T., & Cardenas, T. (2006). Greenhouse Gas Inventories for England, Scotland, Wales and Northern Ireland: 1990 - 2006 . https://uk-air.defra.gov.uk/assets/documents/reports/cat07/0809291432_DA_GHGI_report_2006_main_text_Issue_1r.pdf

Li, L. W., Birmele, J., Schaich, H., & Konold, W. (2013). Transitioning to Community-owned Renewable Energy: Lessons from Germany. *Procedia Environmental Sciences*, 17, 719–728. https://doi.org/10.1016/J.PROENV.2013.02.089

Li, X., Li, H., & Wang, X. (2013). Farmers' willingness to convert traditional houses to solar houses in rural areas: A survey of 465 households in Chongqing, China. *Energy Policy*, 63, 882–886. https://doi.org/10.1016/J.ENPOL.2013.09.004

Mah, D. N. yin. (2019). Community solar energy initiatives in urban energy transitions: A comparative study of Foshan, China and Seoul, South Korea. *Energy Research & Social Scienc*e, 50, 129–142. https://doi.org/10.1016/J.ERSS.2018.11.011

Markantoni, M., & Woolvin, M. (2014). The role of rural communities in the transition to a low-carbon Scotland: a review. https://doi.org/10.1080/13549839.2013.834880, 20(2), 202–219.

Ministerio de Industria, E. y T. (2022). Calidad de continuidad en el suministro eléctrico (2010 a 2020). https://sedeaplicaciones.minetur.gob.es/eee/indiceCalidad/total.aspx

Ministerio para la Transición Ecológica y el Reto Demográfico. (2020a). Consulta pública previa comunidades energéticas locales. 20. https://energia.gob.es/es-es/Participacion/Paginas/DetalleParticipacionPublica.aspx?k=358

Ministerio para la Transición Ecológica y el Reto Demográfico. (2020b). Estrategia de descarbonización a largo plazo 2050. Marco Estratégico de Energía y Clima.

Navas Marqués; Juan Ignacio. (2021). ¿Puede un juzgado u órgano jurisdiccional nacional declarar incorrecta la transposición de una Directiva de la Unión Europea?. *Law and Trends*. https://www.lawandtrends.com/noticias/ue-internacional/puede-un-juzgado-u-organo-jurisdiccional-nacional-declarar-incorrecta-la-transposicion-de-una-directiva-de-la-union-1.html

Norman, J., MacLean, H. L., & Kennedy, C. A. (2006). Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. *Journal of Urban Planning and Development*, 132(1), 10–21. https://doi.org/10.1061/(ASCE)0733-9488(2006)132:1(10)

OECD. (2021). Linking Renewable Energy to Rural Development Executive Summary Brief for Policy Makers.

OECD Rural Studies. (2020). *Rural Well-being*. Geography of Opportunities. https://doi.org/10.1787/D25CEF80-EN

Parlamento Italiano. (2021). Promozione dell'uso dell'energia da fonti rinnovabili atto di governo. Movimento Consumatori.

Patarchanova, E., Kastreva, P., & Kuleva, G. (2011). Classifications of the Rural Areas in Bulgaria. *Journal of Settlement and Spatial Planning*. https://www.researchgate.net/publication/281437952_Classifications_of_the_Rural_Areas_in_Bulgaria

Rauhala, K. ;, LastNameMäkelä, K. ;, Estlander, K. ;, Tolsa, H., Martamo, R. ;, Lahti, P., & LastNamePerälä, M. (2004). Urban form, transportation and greenhouse gas emissions Experiences in the Nordic countries. *Nordic Environmental Labelling*.

Rescoop. (2022). REScoop network map. https://www.rescoop.eu/network/map/

Sánchez, L. J. (2016). La falta de transposición de una Directiva puede hacer incurrir al Estado en responsabilidad patrimonial frente a terceros. https://confilegal.com/20161114-pascual-sala-la-falta-de-transposicion-de-una-directiva-puede-hacer-incurrir-al-estado-en-responsabilidad-patrimonial-frente-a-terceros/

Scopus Term Analyzer. https://www.scopus.com/term/analyzer (accessed Feb. 24, 2022).

Scottish Goverment. (2011). Low carbon Scotland: meeting the emissions reduction targets 2010-2022.

Shnapp Sophie, Paci Daniele, & Bertoldi Paolo. (2020). Enabling Positive Energy Districts across Europe: energy efficiency couples renewable energy. https://publications.jrc.ec.europa.eu/repository/handle/JRC121405

Skerratt, S. , Atterton, J. ;, Hall, C. , Mccracken, D. I., Renwick, A. ;, Revoredo-Giha, C. ;, Steinerowski, A. , Thomson, S. G., Woolvin, M. R., Farrington, J. H., & Heeson, F. (2012). *Rural Scotland in Focus-2012*. Scotland's Rural College.

Suministradora Eléctrica de Cádiz. (2022). https://distribuidora.electricadecadiz.es/historia

Trading Economics. (2022). EU Carbon Permits - 2005-2021 Historical Price. Trading Economics. https://tradingeconomics.com/commodity/carbon

Verde, S. F., Rossetto, N., Ferrari, A., & Fonteneau, T. (2020). The Future of Renewable Energy Communities in the EU: an investigation at the time of the Clean Energy Package.

Walker, G., & Cass, N. (2007). Carbon Reduction, "The Public" and Renewable Energy: *Engaging with Socio-Technical Configurations*. https://www.jstor.org/stable/40346067

Yadav, P., Davies, P. J., & Palit, D. (2019). Distributed solar photovoltaics landscape in Uttar Pradesh, India. *Energy Strategy Reviews*, 26, 100392. https://doi.org/10.1016/J.ESR.2019.100392

**Communication aligned with the Sustainable Development Objectives**