Objective and contribution of the paper

A rising interest for energy communities (ECs) is been perceived among citizens, institutions and the academic community in the recent years. Such trend is no surprise, taking into account the potential these entities hold when facing some of the greatest challenges of current times; namely, climate change, the growing disparities and energy security.

Although increasing attention is paid to them, especially after the adoption of the RED II[1] and IMED[2] European Union Directives, ECs are not a novel concept, but have been among us for a long time. In fact, the networks that were used in the early XX century for distributing energy contained the community spirit that these initiatives entail. However, it is not until the last decades of the century that ECs develop in the way we currently understand them, as an option for clean energy consumption (Roberts, 2020).

ECs entail great potential for environmental protection, which has been pointed out by institutions as one of the reasons for promoting their development. In fact, the European legislator included the purpose of providing environmental benefits, among others, in the definition of energy communities (see RED II; art. 16.c).

According to a study carried out in 2015 (Romero-Rubio & de Andrés Díaz, 2015) a greater tendency towards EC creation is observed in Germany than in Spain. This is only an example of how the development of these initiatives is not homogeneous in Europe, and the reasons behind this fact are varied. Moreover, differences are not only found between countries, but also within them. For this reason, the present paper takes a regional approach.

[1] Directive 2018/2001 on the promotion of the use of energy from renewable sources.
[2] Directive 2019/944 on common rules for the internal market for electricity.

The main objective of the paper consists of gaining a deeper understanding of the figure of the EC and more specifically of the reasons for its uneven development across European regions.

The European legislator advocates for the promotion of ECs, but no specific measures are included in the Directives. This, together with the lack of clarity and understanding surrounding the figure of the ECs, calls for an in-depth of what conditions can effectively contribute to boosting their expansion.

The growing research that is being conducted on this figure, mainly through case studies, has provided important insights on the factors that can affect its greater or lesser development in several European countries or regions. However, no quantitative study has yet been carried out that studies these relationships.

In order to contribute to filling this gap, a quantitative analysis is proposed, based on data on community energy initiatives for European regions and several variables that are extracted from an academic literature review on the matter. Through analysis of the relationships between several variables and the development of this figure across the European regions, insight is provided on the main drivers of ECs. This is expected to contribute in developing the most efficient policies for the promotion of this figure so that the existing gap between regions can be reduced.

Methods and data used

In order to gain an in-depth understanding on the ECs, first an academic literature review and a study of the regulation on the matter is conducted. This, on the one hand, provides insight on the conceptualization of the ECs, which is still a matter that arises some questions due to its amplitude. On the other hand, it also contributes to the subsequent analysis, by providing some ideas on the variables that may be affecting the degree of development of the figure.

Once this first analysis is carried out, the main methodology used for the study consists on a multiple linear regression analysis. The dependent variable to be explained is the density of EC, which is calculated using spatial information on community energy initiatives provided by Wierling et al (2022) and applying the analysis tools available in QGIS software.

As for the explanatory variables, these are drawn from the previously conducted review of the academic literature. The variables considered for the analysis are the following. GDP per capita is repeatedly mentioned in the literature as a contributing factor to the development of ECs (Romero-Rubio & de Andrés Díaz, 2015). This is considered one of the most interesting variables to analyse, since it is strongly connected to the potential that is attributed to energy communities in the fight against energy poverty. Due to that, an eventual relationship between GDP per capita and higher density of ECs would reveal the existence of a vicious circle that would need to be urgently tackled.

Another variable considered for the analysis is population density, which is also mentioned by Romero-Rubio and de Andrés Díaz (2015), among others. This is also an interesting aspect to study due to the effect of rural depopulation on poverty in general and on energy poverty in particular.

On the other hand, favourable regulation is also analysed, which is mentioned in several studies (Sokołowski, 2020; Palm, 2021) and brings insight to the possible effect of the recent European directives on the development of ECs.

Climate conditions are also considered an important factor since it affects both energy consumption needs (Horstink et al., 2019) and the potential for generating renewable energy (Inês et al., 2020).

The final two dimensions relate to social dimensions that can affect the proliferation of ECs, which are the education, which is expected to boost the participation on these kind of initiatives (Caramizaru & Uihlein, 2020; Conradie et al., 2021; Steadman et al, 2023), and the left-wing ideology, related to an environmental awareness, which is also mentioned as an important factor for EC creation (Conradie et al., 2021; Romero-Rubio & de Andrés Díaz, 2015).

Data is retrieved from several sources for measuring each of the dimensions at the NUTS2 level, so that it can be compared to the EC density data. A linear multiple regression model is defined including each of the dimensions mentioned above.

Tentative results

The results of the multiple regression analysis show that 54,4% of the variation of EC density is explained by model. Attending to the coefficients and p-values of the variables, the results show the following relationships.

First, GDP per capita, population density and left-wing ideology affect positively to the density of EC, as expected from the literature review. However, FV energy potential shows a negative effect on the dependent variable, which requires for further research on the matter to further elaborate on the reasons behind this outcome.

In the case of the education dimension, unexpected results are observed, because the coefficient on the regression analysis shows a negative sign with high significance level. However, the correlation coefficient shows a positive sign, as expected based on the literature review. The results call for further analysis, although it is noted that the relationship between education and GDP per capita may be conditioning this result.

Finally, as for the effect of regulation, carrying out an adequate transposition of the European Directives shows a positive effect on the density of EC, but only after certain level of transposition.

Conclusions

From the results obtained from the analysis, the following conclusions have been reached. First, four main factors have been identified as drivers of ECs. GDP per capita, the ideology of citizens, demographic density, and an adequate transposition of the Energy Directives on EC.

The most outstanding conclusion reached from the analysis is based on the relationship between higher income and higher population density with the development of energy communities. This poses a demanding challenge for the years to come, which is the development of policies that contribute to weakening this relationship. Only this way the potential of energy communities to reduce energy poverty will be exploited, and steps will be taken towards a truly just and equitable energy transition.

The results on the transposition of the Directives also provide useful insight since it can be concluded that efforts should be made for an adequate transposition, but until certain progress is made, no significant results are expected on the development of ECs.

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