

Doctoral Dissertation  
Doctoral Program in Urban and Regional Development (37<sup>th</sup> Cycle)

# **Renewable Energy Communities: A Preference Learning Approach to Evaluate Differential Participation in Cities**

By

**Giulio Cavana**

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**Supervisors:**

Prof. Marta Bottero, Supervisor  
Prof. Cristina Becchio, Co-Supervisor  
Prof. Giovanna Fancello, Co-Supervisor

**Doctoral Examination Committee:**

Prof. Ivan Blečić, Referee, University of Cagliari  
Prof. Matteo Brunelli, Referee, University of Trento  
Prof. Irene Pluchinotta, Referee, University College of London  
Prof. Eleftherios Siskos, Referee, Technical University of Crete  
Prof. Andrea Lanzini, Referee, Polytechnic of Turin

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## Summary

Urban areas are of particular significance in addressing the environmental impacts of human activity, particularly with regard to energy consumption and greenhouse gas emissions. As they account for over 70% of global energy-related CO<sub>2</sub> emissions, cities are central to climate and energy strategies. Within the European Union (EU), the pivotal function of urban areas in fostering decarbonisation is exemplified by initiatives such as the "EU Mission: 100 Climate-Neutral and Smart Cities by 2030," which underscores inclusivity and citizen participation. This mission-oriented approach underscores the imperative for sustainability transitions to be socially inclusive, economically feasible, and environmentally ambitious.

Among urban sectors, the building sector is of particular significance due to its substantial decarbonisation potential. Within the European Union, the construction sector accounts for approximately 40% of final energy consumption and 36% of energy-related carbon dioxide emissions. However, the adoption of clean energy at the urban scale continues to progress at a gradual pace, with regulatory, economic and behavioural factors acting as impediments to this process.

There is an emergent paradigm shift towards citizen-centred energy systems, in which individuals assume active roles in the generation and management of energy. This phenomenon is exemplified by the emergence of Renewable Energy Communities, as delineated in the EU Renewable Energy Directive (RED II). Renewable Energy Communities facilitate the joint production, distribution, and governance of renewable energy by citizens, local governments, and small enterprises with an emphasis of the environmental, economic and social benefits that they could bring.

This research project explores the socio-demographic and performance-related factors influencing citizen participation in Renewable Energy Communities. In addition, it investigates the potential for their urban-scale diffusion based on preference models, spatial variations in participation, and financial mechanisms to align private actions with public sustainability goals.

To answer the above, a survey was conducted to collect data on citizens' willingness to participate in different Renewable Energy Community configurations and their preference rankings among these alternatives. In accordance with the respondents' stated preferences, two models were developed: a moderated logistic regression model and an additive model using value functions estimated through the UTA method. These models were then subjected to a process of generalisation through the utilisation of supervised classification algorithms, and subsequently linked to respondent profiles defined by socio-demographic vectors. A synthetic population was generated for a selected case study area using statistical data. Finally, the share of the population likely to accept participation in a Renewable Energy Communities, as well as preferences for specific alternatives, was estimated.

The findings of the study indicate that six socio-demographic factors significantly affect individuals' propensity to participate in Renewable Energy Communities and their preferences regarding different Renewable Energy Communities performance attributes. The utilisation of these variables determined the categorisation of 144 distinct types of individuals, with each type being associated with the two distinct models: the logistic model for the estimation of participation likelihood and the additive model for the ranking of alternative options. The analysis estimated the acceptability levels of various Renewable Energy Communities configurations, revealing that the most environmentally effective option corresponded to the lowest potential acceptance rate. In order to enhance its acceptability and elevate its standing in relation to competing alternatives, it was estimated that a comprehensive financial support package amounting to €3.9 billion would be required at the urban scale. Finally, the applied methodology focused on estimating the acceptability of Renewable Energy Communities but demonstrated promising potential for application to other urban transformation challenges.