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Published in:
Energies

DOI:
[10.3390/en14248452](https://doi.org/10.3390/en14248452)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2021

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Lupi, V., Candelise, C., Almuni Calull, M., Delvaux, S., Valkering, P., Hubert, W., Sciuillo, A., Ivask, N., van der Waal, E., Jimenez Iturriza, I., Paci, D., Della Valle, N., Koukoufikis, G., & Dunlop, T. (2021). A Characterization of European Collective Action Initiatives and their Role as Enablers of Citizens' Participation in the Energy Transition. *Energies*, 14(24), [8452]. <https://doi.org/10.3390/en14248452>

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Article

A Characterization of European Collective Action Initiatives and their Role as Enablers of Citizens' Participation in the Energy Transition

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Citation: Lupi, V.; Candelise, C.; Calull, M.A.; Valkering, P.; Delvaux, S.; Hubert, W.; Sciullo, A.; Ivask, N.; van der Waal, E.; Iturriza, I.; et al. A Characterization of European Collective Action Initiatives and their Role as Enablers of Citizens' Participation in the Energy Transition. *Energies* **2021**, *14*, 8452. <https://doi.org/10.3390/en14248452>

Academic Editors: Wen-Hsien Tsai and Ignacio Mauleón

Received: 2 July 2021

Accepted: 18 November 2021

Published: 14 December 2021

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Abstract: This paper provides novel additional evidence on the characteristics of Collective Action Initiatives (CAIs), investigating their role within the European energy sector. It analyses and presents results of a survey administered in six European countries: the Netherlands, Belgium, Italy, Poland, Estonia, and Spain. CAIs are studied in light of four key dimensions, those being their creation dynamics, the way they are organized, financed, and the activities they undertake. The results presented are also interpreted to reflect on their role as drivers of social innovation (SI) within energy transition in Europe. The analysis shows that the contribution of CAIs to the energy transition has a much wider scope than the development of energy projects and provision of energy services. CAIs are intrinsically socially innovative models of implementation as characterised by a strong level of citizen involvement and participation. Moreover, they have a potential multi-level role in the energy transition, from the technological and social perspectives. Indeed, alongside traditional energy activities, our results show that CAIs are evolving and expanding towards socially innovative activities, raising awareness on environmental issues, promoting citizens' mobilization, and fostering social inclusion.

Keywords: energy communities; community energy; energy transition; green energy; citizen participation; social innovation

1. Introduction

Citizens and local communities are increasingly playing an active role in energy transitions and delivering green energy projects. In this context, the Collective Action Initiatives (CAIs) have a prominent role (as defined in [1]). They are understood as citizen-driven initiatives that engage collective activities favoring energy transitions at a social, economic, and environmental level. The most common CAIs are community energy initiatives [2–6]. Community renewable energy initiatives were born more than a century ago in several European countries to ensure access and electricity, with communities producing and distributing renewables [4,7]. Indeed, community energy initiatives are often defined and classified as entities with a high degree of citizen ownership and control. They are also deemed to provide collective benefits through local involvement, grassroots innovation and wider community and social activities [8,9]. As such, they can be defined as a form of Social Innovation (SI) within energy systems. They bring forward a novel approach to deploying energy projects and services, which focuses on citizens' participation and wider societal benefits [10]. Following [11], Social Innovation in the energy transition can be defined as “innovation that is social in its means and which contributes to low carbon energy transition, civic empowerment and social goals pertaining to the general wellbeing of communities”

Relevant literature has emerged to understand the conditions in which these initiatives occur and thrive and their contributions towards a zero-carbon society [3,10,12–14]. Academic literature has also shown interest in how community energy interacts with energy justice, redistribution of costs, and the benefits of the transition, particularly for low-income households (see, for example, [15–18]). Similarly, the creation, scalability, and initial conditions for community energy initiatives have been researched in specific countries or theoretical approaches [19–21]. An overarching finding is that community energy is heterogeneous, both in its structures and objectives [22]. For example, [23] acknowledged that such initiatives may differ in motives, contexts, and actors involved. The need to map and characterize them across Europe has emerged in recent years [10,24]. In their survey to collective Renewable Energy Sources (R.E.S.) prosumers, [14] explored this diversity for a suite of relevant characteristics such as legal forms, use of technology, financing strategy, and various aspects of organizational structure. Moreover, perceived hindering versus facilitating factors were reported, highlighting knowledge and finance as key enablers, with current policies and infrastructure as main barriers. The authors of [25], while focusing on the community energy sector in Italy, also highlighted the heterogeneity of community energy initiatives and characterized them as adopting a multi-dimensional framework accounting for dynamics of creation, activities, and economics, organizational structure, and outcomes delivered to their members.

Despite energy communities representing the most common CAI in Europe, this paper focuses on a wider conceptualisation of CAIs, which includes, but is not limited to, grassroots associations, community energy initiatives [2], collective renewable energy prosumers [14], and renewable or citizen energy communities. This broader conceptualization was chosen to capture the full range of collective initiatives relevant to social innovation and citizen engagement in the energy transition. Besides the traditional scope of acting along the energy supply chain, CAIs can include wider objectives and activities, such as environmental awareness, and contribute to spreading knowledge and acceptability about renewable energy, clean technologies, and reducing consumption across society [24]. With their broad range of activities and high level of citizen involvement, CAIs are seen as playing an important role as drivers of citizen participation and Social Innovation (SI) in the European energy transition. Previous research stresses the need for institutional responses directed towards participatory organizational formats [26,27]. A socio-technological transition can occur if citizens participate [28], and, according to [29], if actors and collectives produce different participation models. Thus, there is a need for governance structures and community-focused organizational formats that are participatory, inclusive, and empower citizens to become stakeholders in the process [30–32]. To

participate in the low-carbon energy transition, stakeholders need access to an appropriate mix of policy tools, support mechanisms, and financing [2,33,34].

Moreover, CAIs in the renewable energy sector represent new socio-economic organization types at the community level. They fall within the operational scope of Social Innovation (SI), defined as “new ideas (products, services, and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations” [35]. In the energy domain, SI can be perceived as a process and a strategy capable of matching technological innovation with innovative social practices and relations to contribute to the low carbon energy transition [36].

This paper builds on previous research on CAIs presenting and discussing the results of a survey, with 206 CAIs responses across six European countries: Belgium, The Netherlands, Italy, Poland, Estonia, and Spain. The survey results are presented in order to contribute to the ongoing debate on CAIs’ definition and characterization, by analyzing their creation dynamics, the way they are organized and financed, and the activities they undertake. It provides novel data and analysis on conditions for deployment and characteristics of a heterogeneous sector composed of multifaceted initiatives. The results presented are also interpreted to reflect and validate the definition of CAIs as drivers of social innovation (SI) in the energy transition in Europe. Following previous conceptualisations of social innovation [34–36], we assess the main contributions of CAIs to Social Innovation. These firstly include their definition of CAIs as socially innovative implementation models of energy services in the energy transition due to the implied high level of citizen participation and empowerment. Then we look at their attainment of social goals, such as inclusion, community jobs, and wealth creation or poverty reduction. We finally look at their contribution to civil society mobilisation such as social and environmental awareness-raising, enhancing the social acceptance of renewables, and strengthening social networks and social movements.

The paper proceeds as follows: Section 2 describes the methods, such as the survey design and the analysis dimensions; Section 3 presents the aggregate survey results and characterizes CAIs across Europe to identify the prevailing trends; Section 4 discusses and compares the role and the development level of CAIs in different European countries, and elaborates further on CAIs as drivers of citizen participation and social innovation.

2. Methods of Analysis

This section describes the methodology used to gather and analyze the data. First, we describe the survey design, then the dimension of analysis for CAIs used in this paper.

2.1. The Survey and Data Gathering

The survey objective is to shed light on how European CAIs mobilize to contribute to the energy transition [1]. The survey was administered in six countries (Belgium, Estonia, Italy, the Netherlands, Poland, and Spain) between May 2020 and September 2020. We collected 206 valid responses. The survey counts 49 questions, organized into eight sections. Four sections were dedicated to explaining the project, privacy, use of data, and parameters to profile the CAI. The remaining four sections explore the main aspects identified during the design process, organized by the temporality of the CAI to make it easier for respondents: initiation, present, and future (explained later in this section).

We followed the survey design methodology from the Handbook of Recommended Practices for Questionnaire Development and Testing Methods [37]. This process has five stages, as shown in Figure 1, and we will describe how they were implemented in the COMETS survey design.

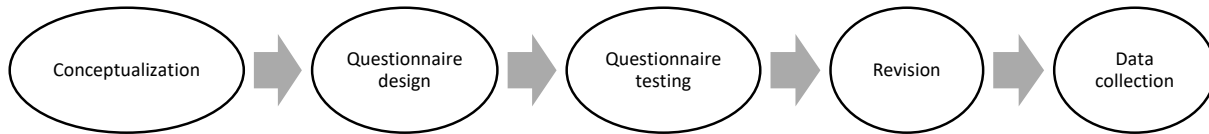


Figure 1. Methodology for survey design. Source: see [1].

The conceptualization identified four initial dimensions: interests and values; organizational process; mobilization and resource control; and opportunities and threats [38]. The second starting point was a multidisciplinary literature review. This included sociology, social theories, political science, and sustainable transitions [1,39,40]. The four initial dimensions evolved into dimensions around activities in the energy transition, environmental and social impact, including: social innovation; community participation in the decision-making process; reliance on internal and external financing sources; the environment and partnerships in which the CAI evolve; and barriers and enablers.

Based on these concepts, we developed a questionnaire design (stage two). Testing and revision (stages three and four) consisted of several phases. Initial testing was conducted with energy community experts, and their feedback was included in the revisions. Then, between two and four CAIs from each country tested the questionnaire and provided feedback. The format and content of the survey were further harmonized in the revision stage with the support of experts.

The harmonization resulted in four sections that were then established. They followed the temporality of the evolution of the initiative (past, present, and future). The core sections were: (i) how the initiative started (including financing); (ii) activities of the CAI, in the energy transition (generation, energy efficiency, mobility services), and beyond (environmental protection, social inclusion, poverty alleviation); (iii) governance, organization, and participation (including financing); (iv) support needs of the CAIs to overcome current and future barriers and to capitalize on opportunities.

The data collection was possible thanks to a robust dissemination strategy, utilizing networking activities, workshops, emails, and phone calls [41]. The countries selected were at different levels of CAI development: mature (Belgium and the Netherlands), developing (Italy and Spain), and emerging (Estonia and Poland). The final database collected 206 valid responses from a total of 664 CAIs contacted, reflecting a response rate of 31%. Country-level response figures ranged from 24 (in Poland) to 47 (in the Netherlands), with a balanced representation of responses reflecting the country's development maturity. Details on survey design (including testing), data collection, and analysis are described in [41–43].

2.2. The Key Dimensions of Analysis

In analysing and presenting the survey results, this paper identifies four key dimensions for CAIs characterization, elaborating on similar approaches taken into the literature [10,14,25].

1. Dynamics of creation describes the CAIs' origin and their objectives. We investigate the role and contribution of different stakeholders (e.g., citizens, banks, local authorities) through the process of transforming an idea into a concrete CAI. We also look at the main objectives and proponents of the initiatives and discuss the role of different stakeholders in providing the finance needed to initiate them. We assess how the stakeholders involved in the initiation and financing would reflect either a bottom-up or top-down approach.
2. Organizational structure discusses whether CAIs are informally or formally organized, which legal form, if any, prevails (e.g., cooperative, association, foundation, company), and the average dimension proxied by the number of members.

3. Financing identifies the actors and tools to support CAIs economically. It investigates the roles of citizens, public entities (municipalities, national schemes), private entities (banks, energy companies), and others (cooperatives, foundations). A focus is given to the evolution of financing actors, with a special emphasis on public actors through grants, loans, or subsidies.
4. Activities investigates energy transition-related activities along the energy supply chain (e.g., the generation, supply, or other energy services), the main technologies chosen, and other aspects such as energy efficiency and mobility. It also studies CAIs environmental and social impact activities beyond the energy systems, such as increasing environmental awareness, skills creation, political empowerment, and social inclusion. The geographical location of CAIs is crucial for social inclusion and participation: the urban and rural divide, the local and regional, or even national scope.

3. Profiling CAIs

3.1. Dynamics of Creation

Overall, the survey highlights that the CAIs' main objectives are energy democracy and citizen participation, creating profits for citizens, and promoting community development. These findings are in line with the observations in [10], that energy community development—after 2008—started focusing on the democratization of energy and citizens empowerment.

Table 1 below presents an overview of the main aims declared by the surveyed CAIs. These include energy democracy, profits for citizens, and wider community-level development. Table 1, which expresses CAIs' answers in percentages and by country, highlights a certain degree of similarity between Belgium and the Netherlands. For example, the CAIs in both such countries aimed to pursue increasing citizens' profit, giving importance to local communities, and improving energy democracy. Estonian CAIs mostly fostered alternative energy models, profits for citizens, and energy efficiency. These objectives were shared by Polish CAIs, where access to renewable energy and offering fair energy prices were also relevant objectives. Spanish CAIs paid particular attention to community development and energy democracy, while community development, energy democracy, and accessing renewables were the main concerns in Italy.

Thus, CAIs' main objectives were mainly directed towards increasing citizens' well-being from an economic and social point of view, with a particular focus on making renewable energy fair and accessible at the local level.

Table 1. CAIs' main objectives.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia
Profit for citizens	17%	25%	8%	2%	9%	17%
Making energy local	17%	22%	8%	8%	12%	10%
Energy democracy	19%	11%	13%	17%	2%	2%
Accessing renewables	11%	8%	12%	11%	19%	8%
Alternative energy models	10%	4%	7%	11%	18%	18%
Sustainable behaviors	5%	15%	9%	11%	5%	11%
Community development	7%	6%	14%	17%	7%	2%
Energy efficiency	2%	5%	7%	6%	7%	14%
Fair energy prices	3%	0%	10%	7%	12%	11%

As for the actors at the origin of the initiatives in Table 2, citizens and municipalities were typically the first. The prominent role of citizens was self-evident in every country except Poland, where municipalities led. The citizens' role was crucial in Belgium, the Netherlands, Italy, and Spain due to a long-lasting tradition in CAI development. CAIs are a recent phenomenon in Poland and Estonia, and local communities' initiatives in

those countries are not well understood yet. Thus, municipalities have an essential role in guiding, guaranteeing, and initiating or facilitating CAIs' development to enlarge citizens' participation. The survey results also show other types of actors at the origin of CAI formation. For example, the role of energy cooperatives was relevant in Belgium and the Netherlands, while private energy utilities supported CAI formation in Italy and Poland.

Table 2. The main actors at the origin of CAIs.

	Belgium	Netherland	Italy	Spain	Poland	Estonia	Total
Citizens	38	40	23	21	2	10	134
Municipality	15	20	9	9	14	6	73
Energy cooperatives	13	15	7	8	1	3	47
Private energy utility	4	0	8	4	11	1	28
NGO—energy related	5	5	5	2	6	0	23
Total answers	75	80	52	44	34	20	305
Total CAIs	44	47	39	25	24	27	206

Table 3 qualifies CAIs as initiatives that rely on the investment of different types of actors. The data collected show that citizens and public authorities (through public grants) were the main actors in financing CAIs in every country, together with private and cooperative banks (see also [14]). Moreover, the survey also highlighted that few CAIs were collecting funds through crowdfunding, especially in Belgium and the Netherlands.

Table 3. The main initial investors.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Citizens	34	26	24	14	2	14	114
Public Grant	15	33	4	10	15	10	87
Private Bank	7	3	7	3	3	9	32
Cooperative Banks	2	4	9	2	2	0	19
Crowdfunding	4	6	2	1	0	3	16
Total answers	62	72	46	30	22	36	268
Total CAIs	44	47	38	25	23	26	203

We looked jointly at evidence emerging on both promoters and initial investors in the initiatives (Tables 2 and 3), to assess if CAIs tended to adopt a top-down or a bottom-up approach in their initiation and development. In this context, we refer to bottom-up CAIs being those where citizens are substantially involved in the project's initiation and financing. In contrast, initiatives are top-down when an institution (i.e., a local authority or a private company) leads the process and facilitates citizens' involvement [43]. The results show that when citizens were involved at the origin of the initiatives, they were also the primary investors in more than half of the cases surveyed, displaying a 'pure' bottom-up approach. When public administration was at the origin of CAIs' development, both citizens and banks were identified as leading investors.

To summarize, we observe that citizens are the prominent supporters and play a relevant role in funding CAIs. Thus, most of the surveyed CAIs can be characterized as participative initiatives that directly involve citizens (i.e., as members) since the first stage of development. However, our results also show a key role of public authorities and banks as initial investors in CAIs, leading to a mixed bottom-up and top-down approach regarding CAIs' financing.

3.2. Organization and Size

Concerning the size of the CAIs surveyed, our sample shows that more than half of the initiatives were small (i.e., less than 100 members), as reported in Table 4. The medium-sized CAIs (i.e., 100 to 999 members) accounted for 28% of the research sample. Only 10% were large organizations with more than 1000 members.

Table 4. CAIs' Size.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
SMALL (<100 members)	36%	45%	33%	56%	71%	85%	50%
MEDIUM (100–999 members)	39%	45%	28%	32%	4%	0%	28%
LARGE (>1000 members)	20%	4%	18%	8%	4%	0%	10%

Large CAIs were most strongly represented in Belgium and Italy, accounting for 20% and 18%, respectively, of the sample. Medium-sized CAIs dominated in the Netherlands and Belgium, with 45% and 39% of initiatives falling in the medium range. The majority of Polish and Estonian respondents belonged to small organizations. Table 5 analyzes the legal form of the CAIs. It shows that about 47% of the organizations were cooperatives across the sample.

Table 5. CAIs' legal form.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Cooperatives	68%	83%	46%	36%	0%	0%	47%
Not formally organized	14%	6%	5%	44%	42%	33%	20%
Not cooperatives	14%	9%	31%	16%	46%	48%	24%

The remaining registered organizations, which were not cooperatives and made up 24% of the total sample, were usually foundations, limited liability companies, or associations. The respondents also indicated other forms of organization, e.g., housing communities or energy clusters. Finally, 9% of CAIs did not provide information about the form of the organization. Apartment associations dominated the sample in Estonia, while several initiatives were not formally organized (33%). A similar situation was found in Poland, where 42% of CAIs defined themselves as informally organized. Among those registered, the dominant legal form of organization was energy clusters and there was also quite a large representation of housing organizations. Besides Estonia and Poland, cooperatives tended to be the dominant legal form across the sample. In the Netherlands, 83% of CAIs were organized as cooperatives, and those that had different legal forms were mostly foundations. In Belgium, 68% of CAIs were cooperatives. In Italy, 46% of surveyed CAIs were cooperatives, while 31% were other organizations (associations, limited liability companies). In Spain, 36% of surveyed CAIs were cooperatives, and 16% were not cooperative (mostly limited liability companies). The CAIs that operated without a legal form (44%) were most likely to get a legal form or intended to have one soon. However, it should be stressed that the results may be biased by the CAI definition adopted in different countries, the method of research dissemination, and the sampling strategy.

To summarize the main findings on the dimension of organization and size, we observed that countries such as the Netherlands and Belgium had mainly medium and large CAIs. Countries such as Italy and Spain were more heterogeneous. Finally, Poland and Estonia were populated primarily by initiatives of a small size. Regarding the legal form, if any, the cooperative was the preferred one in Belgium, the Netherlands, Spain, and Italy, while Poland and Estonia reported other organizational structures. However, several CAIs in our sample did not have a legal form at the time of the survey.

3.3. Financing

As shown in Table 3, citizens, public grants, and banks were the CAIs' main sources of financing their first activities. The role of citizens was essential in all countries, except for Poland, where public grants were the main source of financial support. Thus, it is essential to understand who the main actors financing CAIs after the initial phases were. Table 6 shows the main investors in surveyed CAIs. In particular, members (i.e., citizens) were the main investors in Belgium, Italy, the Netherlands, and Spain, together with Estonia, where private banks had a leading role too. In Poland, public authorities were the main financing source for CAIs. The CAIs surveyed listed other financing sources, such as private corporations, non-member citizens, and cooperative banks.

Table 6. Today main investors in CAIs.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Members	34	33	23	11	0	20	121
Public authorities	3	5	4	1	10	3	26
Private banks	1	3	2	1	0	13	20
Private corporations	1	1	7	1	0	0	10
Non-member citizens	2	1	0	3	2	1	9
Cooperative banks	1	4	2	1	0	0	8
Total answers	42	47	38	18	12	37	194
Total CAIs	37	40	27	17	15	22	158

Table 7 reports other types of financing sources. For example, self-financing, emphasizing again the role of members (citizens) as the main investors for CAIs and confirming the bottom-up approach that characterized several CAIs in our sample. Moreover, Table 7 shows that collecting funds from the private sector through loans was especially relevant for the Italian CAIs, as funding from public grants is limited in their case. The use of loans was also crucial for Belgian, Dutch, and Spanish CAIs to complement members' contributions and public funding, whereas loans were largely lacking in Poland. Besides the financing obtained from their members, Estonian CAIs benefited from public funding through support measures and, in some cases, from bank loans. Again, crowdfunding emerged as a viable funding source for CAIs.

Table 7 also shows that public grants were quite relevant in the Netherlands. The reason for this is that the provinces and municipalities there have supported local renewable energy projects, such as CAIs. Also in Poland, local authorities are promoting the creation of CAIs through public grants, which is reflected in the survey results.

Table 7. Other relevant sources of financing for CAIs.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Self-financing	15	11	14	13	6	7	66
Public grant	12	25	2	9	7	4	59
Loans	12	7	9	7	0	5	40
Crowdfunding	2	4	1	2	0	6	15
Total answers	41	47	26	31	13	22	180
Total CAIs	40	46	29	21	19	22	177

To conclude, in Italy and Spain, the support of the members was the main source of financing for CAIs, both at the initial and later stages. Belgian and Dutch CAIs were also strongly supported by public funding. In Poland and Estonia, the support of public grants emerged as relevant. In particular, the surveyed CAIs in these countries declared that European funds were also essential in supporting the creation and development of CAIs.

3.4. Activities

This section gives some insights into the geographical location of CAIs and their activities along the energy supply chain, as well as their efforts in providing wider social and environmental services and community benefits. As shown in Figure 2, our sample indicates that, overall, CAIs are mainly local, in a single region, and equally distributed in urban and rural areas. Notice that several Belgian CAIs were located inside one region, while in Poland the urban and rural dimensions were equally represented. The urban category was relevant for Belgium, Estonia, the Netherlands, and Poland. Several CAIs are in rural areas, especially in Italy, the Netherlands, and Spain.

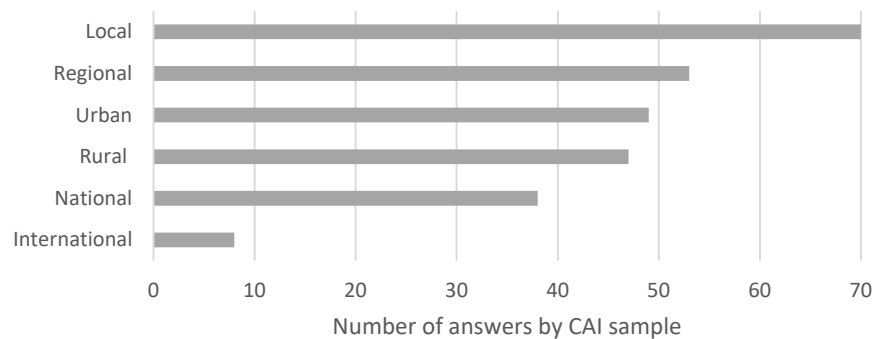


Figure 2. Overall geographical scope.

3.4.1. Energy Supply Chain Activities

In order to characterize the CAIs' activities along the energy supply chain, the survey looked at their role in generating renewable energy, selling renewable energy to consumers, operating an energy grid, and energy-sharing activities. As reported in Table 8, renewable energy generation was indicated as the most common activity among the CAIs in the sample. This was particularly true for Belgium, the Netherlands and Italy. However, several CAIs in Spain, Poland and Estonia performed such kind of energy activities too.

Table 8. Energy-Supply Chain Activities.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Generation of renewable energy	32	36	24	10	10	20	132
Selling of renewable energy	11	13	13	5	5	2	49
Energy sharing	11	7	6	12	2	3	41
Operating an energy grid	4	2	8	2	1	0	17
Total answers	58	58	51	29	18	25	239
Total CAIs	44	47	36	24	22	25	198

The survey further highlights that several CAIs sold the renewable energy produced to consumers, especially members. If we consider the combinations of multiple answers

by CAIs (see Appendix A, Figure A1.), 36% of CAIs generated renewable energy in Belgium. In Estonia, 52% of CAIs generated renewable energy plus other activities, while 8% of the sample was involved in both renewable energy generation and selling energy to customers. In Italy, 20% of respondents declared that they did not perform any of the energy supply chain activities mentioned. Overall, 17% of CAIs were active in the generation of renewable energy, and 8% of the sample pursued renewable energy generation and sold the energy to customers.

Almost 80% of CAIs in the Netherlands performed renewable generation, with 8% of the sample engaged in both renewable generation and selling the energy to customers. In Poland, 40% of respondents declared that they did not perform any of the energy supply chain activities mentioned, and 14% of the sample pursued both generation and selling of renewable energy to customers. There was no clear focus activity reported in Spain, even though renewable energy generation and energy sharing activities were the main answers. The overarching result emerging from Table 8 is a strong prevalence of energy generation among the activities performed by CAIs across the energy supply chain.

Table 9 provides further evidence on this point, by zooming in renewable energy generation technologies installed by CAIs, and showing a prevalence of photovoltaic (PV), with a strong focus on rooftop PV installations.

Table 9. Renewable Energy generation.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Photovoltaic (rooftop)	30	41	21	13	9	25	139
Wind	24	22	3	3	3	0	55
Photovoltaic (other)	5	18	8	3	6	2	42
Biomass/Biofuels/Bio-gas	8	2	5	3	5	0	23
Cogeneration	8	0	4	0	7	1	20
Total answers	75	83	41	22	30	28	279
Total CAIs	43	47	36	23	22	26	197

This result is in line with evidence presented in the literature [6,25], which links the emergence of CAIs (energy communities) since the late 2000s with the generous Feed-in Tariff support scheme for PV deployed in several European countries (Germany and Italy in particular). Considering the combinations of answers (see Appendix A), we can extrapolate that 23% of Belgian CAIs exclusively performed PV activities, while 9% performed only wind-on shore activities. The prevalence of PV is even more evident in Estonia, where 88% of the CAIs surveyed operated with PV plants on rooftops. In Italy and the Netherlands, almost 40% of CAIs' activities were related to PV, while 30% of CAIs were connected to PV installations in Spain. Finally, 27% of CAIs in Poland performed PV activities.

Despite the strong prevalence of energy generation, the survey also highlights differentiation in CAIs activities along the supply chain, including providing energy efficiency services and introducing e-mobility services. Figure 3 reports E-mobility activities, such as e-mobility sharing, bike-sharing, charging facilities, and e-mobility purchase (see Figure A3 in Appendix A for details). Overall, 71% of CAIs did not perform any of such activities. From the survey results, e-mobility appears to be a relatively recent and upcoming sector for CAIs.

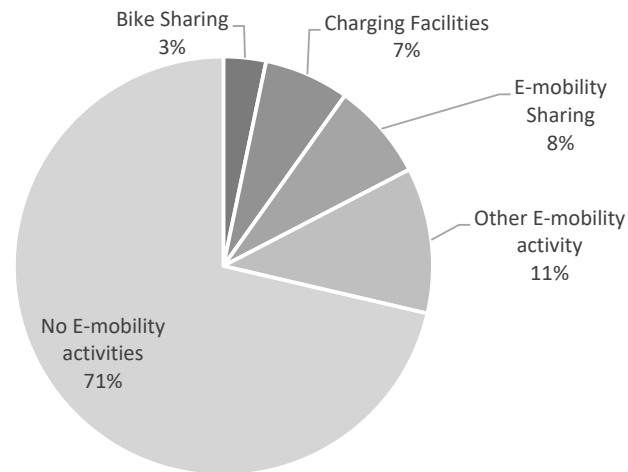


Figure 3. E-mobility.

To conclude, 60% of CAIs in our sample perform energy efficiency-related activities. In particular, these CAIs offer energy consumption advice, confirming the educational role of CAIs in increasing environmental awareness. The next section focuses on the potential social impacts of CAIs, highlighting the multi-level perspective of such initiatives.

3.4.2. Socially and Environmentally Oriented Activities

Several surveyed CAIs undertook not only energy-related activities, but also contributed to environmental care, and strove for social aims. In particular, the CAIs in our sample declared themselves to be politically active in mobilizing citizens towards a green-energy and equal society.

Table 10 focuses on environmental care activities undertaken by CAIs. In Estonia, such activities were not performed by the surveyed CAIs, and only a few Polish CAIs organized environmental activities, such as sustainable practices, waste management, and reforestation. Conversely, Spanish initiatives engaged quite actively in such activities. Several CAIs performed sustainable practices and improvements in waste management. In Italy, CAIs promoted sustainable practices and works on waste management and regeneration of ecosystems. In Belgium, a few respondents undertook environmental care activities, primarily promoting sustainable practices in general. In the Netherlands, sustainable practices were encouraged, and there were contributions mainly to sustainable waste management.

Table 10. Environmental Care.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Sustainable practices	6	4	7	10	2	0	29
Waste management	2	3	3	7	7	0	22
Ecosystems	3	2	3	5	1	0	14
Reforestation	2	2	1	3	1	0	9
Total answers	13	11	14	25	11	0	74
Total CAIs	43	46	34	23	21	25	192

Table 11 looks into the social objectives of CAIs. We find that CAIs also support social goals not directly related to energy provision. High priority objectives include: financially promoting local projects [3]; empowering youth; social inclusion of all genders in the initiative; and proposals for support groups. Interestingly, Spanish CAIs were remarkably

focused on social objectives, such as empowering women and gender inclusion. Estonian CAIs, on the other hand, had relatively little attention for social scopes, with a minority of CAIs striving to support local projects.

Table 11. Main Social Objectives.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Support local projects	23	30	17	14	7	5	96
Social inclusion genders	8	2	4	10	1	0	25
Empower youth	4	4	7	7	3	0	25
Support groups	6	4	3	2	2	0	17
Empower women	0	1	3	11	0	0	15
Social inclusion elderly	4	2	2	5	1	0	14
Multiculturalism	3	1	2	5	2	0	13
Reduce unemployment	1	2	1	2	1	0	7
Total Answers	49	46	39	57	17	5	212
Total CAIs	43	46	32	23	20	25	189

Table 12 shows that CAIs also undertook Civil Society Mobilization (CSM) activities. Providing political recommendations, lobbying, and participation in campaigns were the most popular activities on this spectrum. Estonian CAIs stand out with no CSM activities reported. In Italy, only a few CAIs participating in CSM activities. Belgium, the Netherlands and Spain are the most politically active country, with several CAIs providing political recommendations and undertaking other CSM activities. In the Netherlands, CAIs are also partially involved in lobbying and making political recommendations, while Poland had a few CAIs providing political suggestions and lobbying.

Table 12. Civil Society Mobilization.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Political recommendations	13	12	5	10	5	0	45
Lobbying	11	12	5	4	4	0	36
Participating in mobilizations	11	5	6	4	1	0	27
Organizing mobilizations	7	0	3	3	0	0	13
Total answers	42	29	19	21	10	0	121
Total CAIs	41	46	33	23	21	25	189

Several surveyed CAIs performed knowledge and skill creation activities (Table 13). The most prevalent activities were raising awareness, developing technical knowledge related to renewables, and participation in research projects. Renewable awareness-raising was the top-ranked activity in all countries. It ranged from more than half of the CAIs surveyed in Belgium and the Netherlands to less involvement in Estonia and Italy. Participation in research projects was quite common in Belgium, the Netherlands, Italy, and Spain. Polish CAIs were mainly active in raising awareness and developing technical knowledge on renewables.

Table 13. Knowledge and skill development.

	Belgium	Netherlands	Italy	Spain	Poland	Estonia	Total
Raising awareness on renewables	35	37	16	17	13	5	123

Technical knowledge on re- newables	17	13	7	11	12	2	62
Research projects on renewa- bles	14	15	11	12	7	2	61
Energy digitalization	8	0	4	5	5	0	22
Total answers	74	65	38	45	37	9	268
Total CAIs	44	47	34	24	22	25	196

This section highlights that the CAIs had strong ties with local contexts and had an active role in society. Social objectives such as inclusion, diminishing gender imbalances, and promoting local projects were supported by CAIs. However, new realities, such as Poland, showed CAIs interested in increasing their social impact too. Estonian CAIs still need to increase their effort in this area. Our results also show the performance of CAIs in terms of social mobilization. Such experiences are blooming, even though they were more present in Belgium, the Netherlands, Spain, and Italy. In Estonia, where CAIs have established themselves as new entities in the territorial and political context, social activities were not prominent among the CAIs surveyed, but are expected to develop in the near future.

4. Discussion and Conclusions

This paper contributes to the literature investigating the role of CAIs in the energy transition and provides novel evidence on their characteristics and activities across Europe. It relies on a recent survey covering several European countries, including the Netherlands, Belgium, Italy, Estonia, Poland, and Spain. This work provides insights into assessing CAI activities at the economic, environmental, and social levels in Europe, and their current and potential relevance to supporting a citizen-led transition to renewable energy. A heterogeneity of results was found in the surveyed countries, but certain highlights can be derived from this study. These concern, for example, their size, a predominantly local focus, legal forms often (but not only) based on a cooperative model, and photovoltaic or wind-based renewable energy generation as a common activity. Importantly, it confirms the key role of citizens in the initial stages of CAI formation (from the origin of the idea to the investment phase), and the relevant role of municipalities as either promoters or facilitators for funding.

In particular, the results suggest that Belgium and the Netherlands, which we define as “*mature*” countries due to their long history in CAIs development, share common characteristics. The prominent role of citizen participation in CAIs is self-evident from the results. Moreover, CAIs are recognized as key entities in such countries and public administration supports them through public grants, again, as highlighted by the results. Some CAIs in Belgium and the Netherlands were founded several years ago and are still active. They are of medium–large dimensions (even though small CAIs are still present) and are formally organized as cooperatives. CAIs, in these mature contexts, perform several activities. The focus is still on renewable energy generation from wind and photovoltaic plants, with some CAIs exploring other activities such as sustainable mobility. As previously discussed, CAIs in such countries are also committed to social impact, support local projects, promote social inclusion, and are active at the political level.

Italy and Spain can be defined as developing countries in terms of CAIs. Citizens are the engine of CAI promotion. CAIs here are mainly of small and medium dimensions. Most of the Italian and Spanish CAIs in the sample are cooperatives, even though Spain presented several CAIs without any formal organization, confirming the evolving nature of such contexts. In terms of activities, these CAIs are mainly involved in renewable energy production and electricity supply. It is interesting to highlight that a consistent number of Italian CAIs are operating an energy grid due to the historic cooperatives in the sample, established in remote areas of Italy (mainly the Alps), at the beginning of last

century. From the social point of view, Italian and Spanish CAIs support local projects and raise environmental awareness. Moreover, the results show that Spanish CAIs are particularly interested in being politically active and in gender inclusion.

Finally, Estonian and Polish CAIs can be defined as *new* initiatives. CAIs here are a recent phenomenon and citizens' influence is less marked. In particular, our results highlight that these CAIs mainly rely on European funding (i.e., external funding) to promote their activities. In both countries, CAIs are mainly of small dimensions, are not formally organized, or are organized in forms other than the cooperatives. Regarding their activities, Estonian and Polish CAIs mainly rely on renewable generation from photovoltaic. The CAIs in these two countries are still building their social impacts on society. However, there are few exceptions focused on promoting and supporting local projects and rising environmental awareness.

Our work further shows that the contribution of CAIs to energy transitions has a much wider scope than energy supply and efficiency alone. They can be considered as vehicles of social innovation, contributing to citizen participation and a range of social goals. Reflecting on our results, three key features of social innovation stand out.

Firstly, the results support the definition of CAIs as socially innovative implementation models of energy services, in relation to their active role as vehicles and facilitators of a high level of citizen involvement and participation in the energy transition. The analysis of the dynamics of creation shows that most of the CAIs surveyed can be characterized as participative, involving citizens (i.e., members) since the first stage of development. Citizens also emerge as crucial actors in the financing of CAIs initiatives, both at the initial stages and along the lifetime of the initiatives. It is, however, interesting to note that among the other forms of financing used by CAIs, beside member contributions, more traditional forms of finance such as bank loans and public funding prevail over more innovative and, mostly, strongly bottom-up and participative tools such as crowdfunding. This is probably due to the still very innovative nature of the crowdfunding instrument, and its role and the potential future evolution as an additional or alternative financing source for CAIs might deserve further attention in the coming years. Moreover, as the organizational structure highlights, the cooperative, generally deemed to be the best institutional framework for citizen-owned and participatory approaches, is the mostly used legal form across the sample. Cooperatives are characterized by a 'one head one vote' decision-making process and generally encompass members participation in CAIs at the operational level, for example participating in the annual assembly and using their vote when considering new projects.

Second, the activities dimension shows that, besides the traditional energy activities, CAIs aim to contribute to social goals, support local projects, promote social inclusion, and diminish gender imbalances, even though there is still a wide heterogeneity among countries in these aspects. Third, several CAIs are active in civil society mobilisation, i.e., increasing social and environmental awareness, the acceptance of renewables, strengthening social networks and social movements.

Thus, as shown in this work, CAIs and their conceptualisation are evolving in the European context, and their role is not only linked to renewable energy generation. The survey offers novel results on European CAIs and investigates such territories, confirming and re-marking the central role of citizens, being aware of environmental problems and directly participating in the energy transition. On the other hand, CAIs are new socio-economic organization types at the community level, active in several social aspects, falling in the context of social innovation. The survey offers novel results in this sense and explores these social aspects. Indeed, this work depicts an evolving framework, where CAIs focus on social inclusion and local involvement; thus, the results suggest that CAIs are vehicles to promote and increase citizen participation in energy transitions and encourage social changes, setting the stage for social innovation within our society. This last point deserves particular attention, and further discussion should be devoted to exploring the social impacts of CAIs within and between countries.

Author Contributions: Conceptualization, all; methodology, all; validation, all; formal analysis, V.L., C.C., M.A.C., S.D., P.V.; investigation, V.L., C.C., M.A.C., S.D., P.V.; resources, all; data curation, V.L., S.D.; C.C., A.S.; writing—original draft preparation, V.L., C.C., M.A.C., S.D., P.V.; writing—review and editing, all; visualization, S.D., V.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the European Union’s Horizon 2020 research and innovation programme under grant agreement No 837722, project COMETS (Collective action Models for Energy Transition and Social Innovation).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in: the design of the study; the collection, analyses, or interpretation of data; the writing of the manuscript; or in the decision to publish the results.

Appendix A

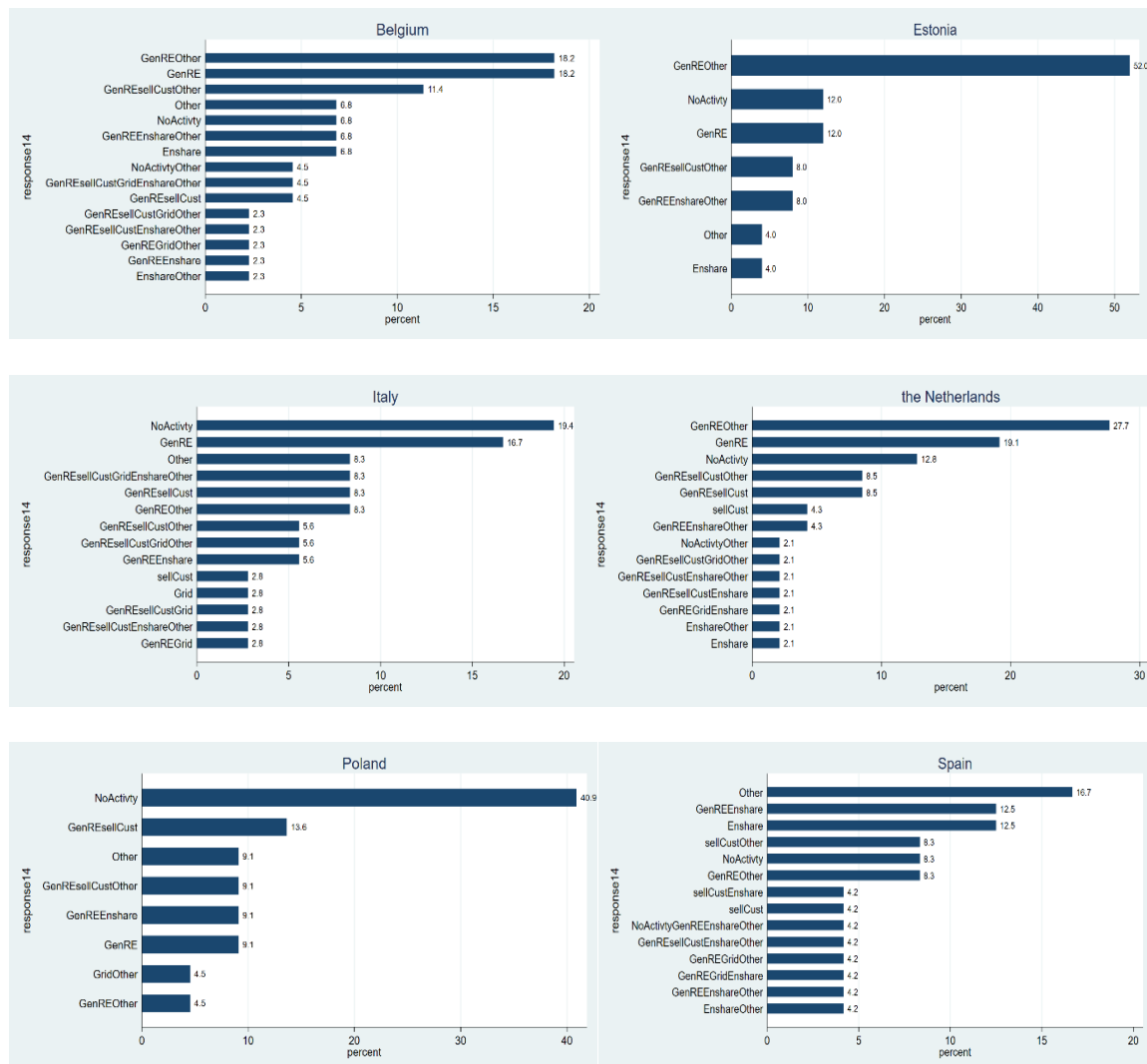


Figure A1. Energy Supply Chain Combinations. Results in percentages.

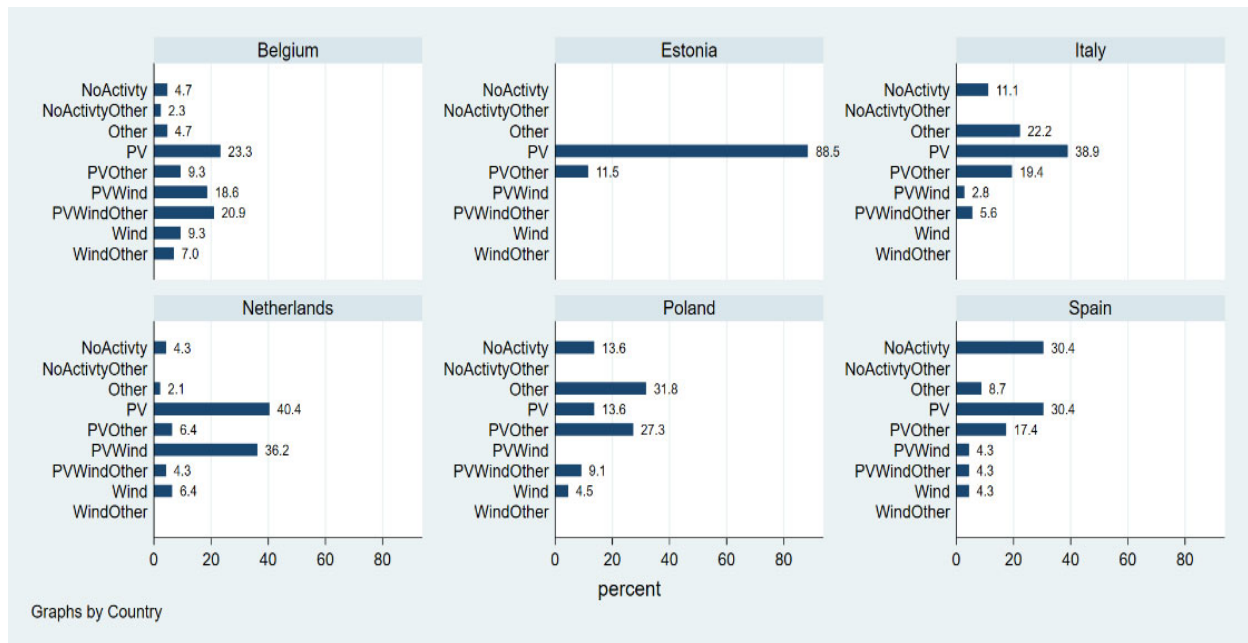


Figure A2. Renewable Energy Generation Combinations. Results in percentages.

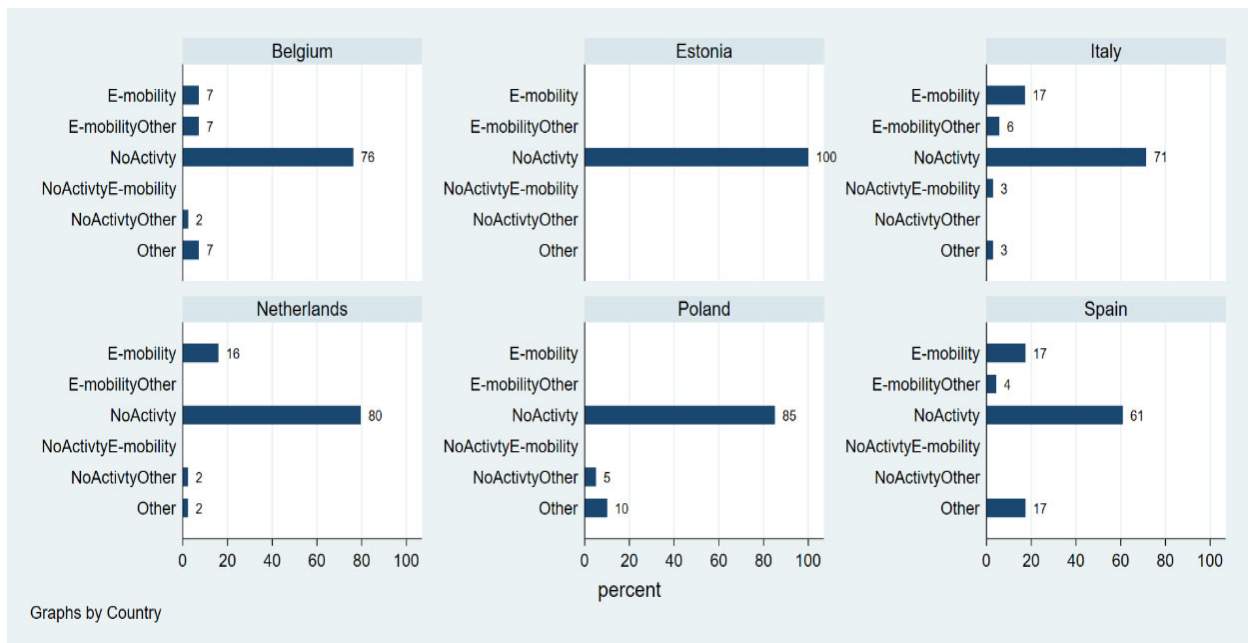


Figure A3. E-mobility Combinations, by country. Results in percentages.

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