Digital Platforms for Renewable Energy Communities Projects: An Overview

IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

International Journal of Sustainable Development and Planning
Vol. 17, No. 7, November, 2022, pp. 2007-2013
Journal homepage: http://iieta.org/journals/ijsdp

Digital Platforms for Renewable Energy Communities Projects: An Overview

Francesco Demetrio Minuto*, Andrea Lanzini, Lorenzo Giannuzzo, Romano Borchiellini

Energy Center Lab – Polytechnic of Turin, via Paolo Borsellino 38/16, Turin 10152, Italy

Corresponding Author Email: francesco.minuto@polito.it

7th int. Conf. AIGE-IIETA and 16th Conf. AIGE—SPECIAL ISSUE

https://doi.org/10.18280/ijsdp.170701

Received: 5 July 2022
Accepted: 12 October 2022

Keywords:
renewable energy sources, renewable energy communities, digital platforms, supporting tools, project development, design, creation, operation

ABSTRACT

The European Union energy policy agenda of achieving the transition to carbon neutrality has been established by an important legislative package called "Clean Energy for all Europeans". A novel approach introduced was to put the citizen at the center of the energy transition. On one side, by powering his freedom of action and, on the other side, by asking him an exceptional engagement in energy consumption reduction activities and in participating in the investments for new distributed Renewable Energy Sources (RES) power plants. The Renewable Energy Communities (REC) is the policy framework used to implement this strategy introduced by the Renewable Energy Directive Recast (RED II). In particular, RECs promote citizen's active role by encouraging energy consumption reduction and energy demand flexibility while reducing the Not In My Bachyard (NIMBY) effect towards RES. Each member state is transposing the RED II directive, adapting it to national legislation and energy transition strategy. Pioneers countries like Italy have already started the experimentation of this framework and developing the first pilot projects. The citizens' interest and their will to participate in REC projects indicate the need for supporting tools guiding them along all the project development stages: "design", "creation", and "operation". This work presents three categories of supporting digital tools and platforms required to develop REC projects: Commercial, EU Founded and Freeware. We analyzed 30 tools, evaluating the services provided in each of the different stages of REC project implementation.

1. INTRODUCTION

In 2019 the European Commission completed the approval process of the "Clean Energy for All Europeans" package, a framework of eight among regulations and directives, aiming at reshaping the European energy policy [1]. The goal of this reform is to deliver on the EU's Paris Agreement commitments for reducing greenhouse gas emissions and moving toward cleaner European energy system. The Renewable Energy Directive Recast (RED II) [2], one of the eight legal files, introduces the Renewable Energy Community (REC) as a new paradigm to empower citizens by giving them an active role in the energy transition.

The renewable energy community has been designed to support the deployment of renewable energy sources for energy production, including electricity, and to foster the acceptance of renewables among European citizens. RECs allow citizens to organize energy projects collectively, pool individual investments, and become active users of the energy market [3].

The transposition of the RED II i" to m'mber state laws and regulations is ongoing. Some EU countries such as Austria, Belgium, Czech Republic, Estonia, France, Greece, Lithuania, Luxembourg, Ireland, Italy, Portugal, Slovenia, Spain, and Sweden have already implemented fully or partially the RED II directive [4].

Among the energy policy frameworks formulated to support the development of REC projects, the "virtual meterin" is becoming the most implemented energy policy among EU countries, rather than the peer-to-peer framework that has been the main framework of the smart grid research. The "virtual meterin" policy considers different membe's points-of-delivery (POD) of an REC as part of the same "virtua" POD, even if the members are physically connected on different points of the distribution grid [5]. Therefore, the amount of energy the REC exchange with the grid is the net energy flux of different POD of demand and production (i.e. PV or WIND generation), called "shared energy". Recently Minuto et al. [6], reviewed the support schemes for REC projects put in place by the EU pioneer countries, such as Belgium, Germany, Greece, Italy, Ireland, Portugal and Spain. The energy components incentivized by different mechanisms are: the shared energy, the energy fed into grid, and the reduction of network charges on the shared energy. The most commonly used incentives mechanism are [6, 8]: The virtual net-metering (Belgium, Grece, Portugal, Spain) or the virtual self-consumption (Germany, Italy) on the shared energy quota; the feed-in-tariff (Germany), net purchase and sale (Italy, Spain), feed-in-premium (Ireland) or bilateral contract (Portugal) on the energy feed in to the grid quota; the exemption (Germany, Portugal) or a rembourse (Italy) on the network charges quota.

Against this background, the lesson learned from the first renewable energy communities born in Italy from 2019 onwards [9] is that there are three typical phases for the development of a REC project: “design”, “creation”, and “operation”.

The main objective of the "design" step is to originate the REC project and develop a feasibility study [10]. In this stage are analyzed different renewable generation technologies, energy conversion and storage assets, and business models in order to find the configuration and sizes that fit the project energetic and economic goals.

Moving forward to the process of development of RECs, the main objective of the "Creation" step is to find the means, procedures and resources to implement the setup of the REC [11]. This phase is the most complex of the three because it depends strongly on the RES project business model and comprehends a sequence of interconnected and interdependent sub-steps that require many competencies to be accomplished, e.g. legal, administrative, technical, financial, and social engagement.

The main objective of the "Operation" step is to operate and maintain the Renewable Energy Community [12]. It involves day-to-day activities to monitor, organize, and optimize the resources to guarantee the design performances and meet the project's goals.

Each of the three REC project steps involves regulated activities such as law, technical rules, legal, tax, and financial aspects to be covered. Many of the tasks are highly technical and require specific professional competencies that are not common knowledge to any citizen. On the other side, some tasks require all REC members' high level of understanding and agreement. Moreover, across Europe, each country has its own set of regulations limiting the standardization and spreading of best practices of successful pioneers REC projects. The complexity of these processes might result in a barrier to the citizen’s grass-root energy community projects [13]. In this regard, digital platforms might develop transparent, automatic/semi-automatic procedures guiding and assisting the REC management through the whole project life-cycle. In this case, the objective of the digital platform is to reduce the gap between the opportunity, the creation of the EC, and the practical possibilities of an aggregate of citizens that are not energy managers or energy market experts.

On the other side, the increase in the citizens' interest and their will to participate in REC projects is raising the demand for expert help and support. For this reason, several digital supporting tools and platforms are emerging, commercial, freeware or developed by EU founded projects.

This work presents aims to identify how the digital platforms and tools available today can be used by citizens to develop REC projects, analyzing their capability of covering the different activities required in each of the three stages of REC project implementation: “design”, “creation”, and “operation”.

2. MATERIALS AND METHODS

This work aims to provide an overview of the types of services offered by 30 different digital platforms and tools.

We differentiate three categories of tools depending on the type of context pushed their development, distinguishing between commercial purpose (16 tools), EU funded projects (9 tools), Freeware or open-source (5 tools). Therefore, the tools and platforms analyzed have been identified using a mixed approach of literature review, scouting of websites, and survey.

The full results are reported in the Appendix. Since this paper does not intend to promote or expose any specific company, the name of the commercial tools has been anonymized, and their order is randomized.

2.1 Data sources

Since 2019, the Energy Center Lab (EC-L) of Polytechnic of Turin has provided support to associations, municipalities, and companies accompanying them in all the development steps of renewable energy community projects in Italy. The data on the commercial tools provided in this paper comes from the activities of EC-L of administrating surveys on several private companies that manifested their interest in offering tools and platforms for renewable energy community projects and also provided datasheets, and documentation of their products. The type of information used to analyzed the company tools are reported in Table 1, where the companies name has been anonymized.

The digital platform and tools developed by projects funded by the European Horizon 2020 (EH2020) programs have been identified by performing a search on the Community Research and Development Information Service (CORDIS).

Table 1. List of private companies involved in this review and source used to analyze their product

Company name	Online website	Datasheets	Documentation
Company 1	•	•	
Company 2	•		•
Company 3		•	•
Company 4	•		
Company 5			•
Company 6		•	
Company 7			•
Company 8		•	•
Company 9		•	•
Company 10	•		•
Company 11	•	•	•
Company 12	•	•	
Company 13		•	
Company 14			•
Company 15		•	•
Company 16	•	•	

The search query included the following keywords: 'renewable energy community', 'energy community', 'tool', 'platform'. The results are filtered by selecting "Energy" from the field "Domain of application" and "project" from the field "Collection". The full search query performed is:

(contenttype='project') AND applicationDomain/code='ener' AND ('renewable energy community' OR 'renewable energy communities' OR 'energy community' OR 'energy communities') AND ('tool' OR 'tools' OR 'platform'). The query gave 51 results. The results of the projects and related tools have been summarized in Table 2.

Those tools that belong to open source or Freeware software have been searched in the literature and by monitoring the offer of the Italian stakeholder involved in energy community activities. The literature research has been conducted in Scopus using the following search keywords' renewable energy community', 'energy community', 'tool', 'platform'. The results are filtered selecting the article published starting from 2018 which is the date of approval of the RED II directive; "Energy" as subject area; "journal" as source type. The full search query performed is:

(TITLE-ABS-KEY ("energy communit*") OR TITLE-ABS-KEY ("renewable energy communit*") AND TITLE-ABS-KEY (tool*) OR TITLE-ABS-KEY (platform*) AND NOT TITLE-ABS-KEY (peer-2-peer OR peer-to-peer OR pap OR p-2-p)) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (SUBJAREA, "ENER")) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018)).

The query gave 48 results. From this long-list of articles, we selected only those papers that present the usage or the design of tools or platforms for REC projects, as reported in Table 3.

Table 2. List of European projects and their related tools

Project name	Tools name	DOI / CORDIS ID
Renaissance	MAMCA, Renaissance	10.3030/824342
City ExChange	+CITYXCHANGE	10.3030/824260
Compile	Homerule, Gridrule, Compilot, Coolkit	10.3030/824424
localRES	Multi-Energy Virtual Power Plant (MEVPP), LocalRES Planning Tool	10.3030/957819
EC2	EC2	10.3030/101022565
BECoop	BECoop toolkit	10.3030/952930
eCrew	eCrew, Energy Cockpit	890362
UP-STAIRS	Uplifting Energy Communities	10.3030/892037
eNeuron	eNeuron	10.3030/957779

Table 3. Tools and platforms identified in SCOPUS

Article title	Tool name	Article DOI
Web-based platform for the management of citizen energy communities and their members [14]	Pereira et al.	10.1186/s42162-021-00155-7
Developing a scenario calculator for smart energy communities in Norway: Identifying a gaps between vision and practice [15]	PI-SEC	10.1016/j.scs.2019.01.003

The list in Table 3 has been extended adding three tools developed and managed by the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and the GSE (Gestore dei servizi energetici). GSE is the company appointed to promote sustainable development in Italy, managing the incentive scheme in Italy. The tools are available online for everyone's usage, and reported in Table 4.

Table 4. Open source or freeware software developed and currently available in Italy

Tool name	Agency	Website
GSE simulator	GSE	www.autoconsumo.gse.it
DHOMUS	ENEA	www.smarthome.enea.it
RECON	ENEA	recon.smartenergycommunity.enea.it

2.2 Development step of a REC project

The objective of the current analysis is to identify what services are provided by the different tools and platforms to support citizens along with all three development steps of a renewable energy community project: "design", "creation" and "operation". The three steps are typically deployed in sequence in a reasonable timeframe. Each of them is constituted by multiple sub-task, depending on the specific country's laws and regulations. In the following, we want to give an overview of the activities and sub-task a group of citizens might face in the process of developing a REC project in each project phase.

In the "design" step, the grassroots initiative starts with a group of enthusiastic citizens who aggregate the interest and willingness of other members to join forces. They identify the initial core of the project number by identifying other potential members, verify their geograpycal proxymity, get data on their energy demand, identify available RES plant or potential for new installation. Then with the gathered data develop a feasibility study to simulate the energy flux, optimize the REC design, and develop a preliminary business plan. Then it comes the call to action for all other citizens, investors, and other stakeholders to approve the project design, investments, and move toward the "creation" phase of the project.

The "creation" step begins with the formalization of the REC legal entity, the definition of stakeholder roles, and the REC governance. This is followed by obtaining the necessary funds and permits for the installation of the new generation facilities. This phase ends with the setup of the generation plant, devices, and technologies to manage and control the REC and obtaining the permits to operate the REC.

The "operation" step encompasses the REC's daily management activities. These include the monitoring of the energy flows and performance of the REC, the maintenance of plants and devices, the management of costs and revenues, member engagement, customer service, and the sharing of profit among members.

In order to better picture this process, we provided a non-exhaustive list of the activities for each development step in Table 5.

2.3 Evaluation criteria and KPI

Among all the activities listed in Table 5, only some of them can be translated into a digital automatic or semi-automatic service provided through digital platforms. Nevertheless, a digital platform can provide transparent and guided procedures assisting the REC management through the whole REC project life-cycle.

The digital tools analyzed in this work are evaluated by defining first a list of services for each STEP of a REC project, which constitutes the reference set of Key Performance Indicators (KPI). Each KPI is associated with a list of possible functions or features. Then all analyzed tools are scrutinized regarding each KPI to evaluate if they are compliant or not with the KPI functions. This evaluation does not assign any merit grade but only verify if such service is provided or not. For each KPI the score can be "negative" or "positive" (marked as a black dot in Table A1). Therefore, a "positive" evaluation of a KPI it is sufficient that the analyzed tool demonstrates or declares to offer one of the specific functions and characteristics associated those KPI in the "Function or Features" column of Table 6. Sixteen KPIs have been chosen, 7 for the "design" step (KPIs 1.x), 4 for the "creation" step (KPIs 2.x) and 5 for the "operation" (KPIs 3.x). Table 6 provides the full KPI list and their associated function.

Table 5. List of the activities for each development step

Phases	Activites
design	Engagement citizens interested in becoming REC members; Identify the potential of renewable generation assets supplying the REC; Identify users aggregated demand and flexibility potential; Verify geographical limits of the REC (e.g. users connection to as specific transformation shaft); Define the roles of engaged members; Simulate the energy flux within the REC; Estimate new generation/storage assets and auxiliary capital, operating, and maintenance costs; Estimate costs for final uses energy savings, energy efficiency, and fuel switching; Identify the energy services providing revenue to the REC; Simulate the economic flux of a REC; Simulate the distribution of revenues among members using different strategies; Optimize the REC technology size respect to the REC users energy demand; Development of the REC business plan.
creation	Define the REC governance; Identify the most suitable REC legal entity needed to achieve project goal; Establish the legal entities according to the requirements set by the current law about REC; Obtain the financing instrument to build the REC project; Obtain the permissions required to install the new generation/storage and auxiliary assets; and eventual demand-side refurbishment; Set up the REC technology infrastructure; Obtain the license to operate the REC; Set up the REC energy service contract; Set up the REC operating tools; Set up the administrative management of the REC and its members.
operation	Monitoring the energy fluxes; Monitoring REC economic fluxes; Maintenance of the REC technological infrastructure; Operate and engage members in participating in the REC energy services through internal mechanisms like "gamification"; Set up members assistance services; Manage subscription and termination of members and technology assets; Distribute revenues among members.

Table 6. List of KPI and their associated function

KPI	Service	Function or features
1.1	Identify potential REC members	Database of real final user demand, GIS location, estimation of final user demand
1.2	Identify potential of renewable generation assets	Simulate potential renewable plants, databases of energy production, estimate energy production,
1.3	Identify physical perimeter of REC project	Georeferencing of the REC perimeter (e.g. distribution network below the same transformation shaft)
1.4	Identify energy services suited for REC project	Provide and simulate energy services based on REC requirements
1.5	Presets of REC businesss models to test	Possibility to simulate different financial structures
1.6	Simulate business plans	Economic analysis and visualization, customization of economic parameters
1.7	Simulate energy services	Estimate energy services impact of REC project, customization of energy services
2.1	Process status development	Graphical visualization of REC development status
2.2	Online support	Real time assistance during non operative steps
2.3	Resources and finance control	Finance, funding, tax and investment management
2.4	Normative and operative guideline	Legal support on REC project, guidelines
3.1	Metering	Integration with other systems, integration with other meters, usage of company's meters
3.2	EC management	Auto consumption evaluation, automatic billing, energy storage evaluation and remote FER control
3.3	User Management	User's access and control of raw energy data, notifications of target/threshold events (e.g demand response)
3.4	Management Dashboard	Web management interface, control of members status, and access and control of raw energy data, notifications of target/threshold events, remote control.
3.5	User Dashboard	Graphical data visualization, knowledge-based services (tutorial, guides etc.), collaborative tools (gamification etc.)

3. RESULTS AND DISCUSSION

Figure 1 reports the total score achieved by each analyzed tool. The total score is calculated by summing the scores of the KPI in each category and normalizing it to 33,3%. Thus, a tool fulfilling all the KPIs in all development stages reaches a total coverage score of 100%.

The first insight from Figure 1 is that no tool achieves 100% score. The top scores are performed by the EU project tools, in particular the RENAISSANCE, eNeuron and CITYxChange projects. Among the commercial tools, only one achieves a score higher than 60%, while the Freeware tools lie below 30%.

Figure 2 shows a more detailed analysis of the number of tools and platforms that provide services or features compliant with the KPIs identified in each development step. The majority of the KPIs of the "design" phase are covered, especially by EU projects and Freeware tools. In fact, less than 20% of the commercial tools provide services for this development stage. Among all, the KPI 1.3, accounting for the service "Identify physical perimeter of REC project", is not covered by any tool or platform. This result might be due to the lack of public information about the distribution network. For example, in Italy, the distribution network lying below a common transformation shaft defines the REC's perimeter. The information about the network topology is possessed by the distributor system operator (DSO) and is not publicly available. The Creation step, among all, is the one where the offer of services is less covered. Only the tools and platforms developed by the EU project offer a range of options on this stage.

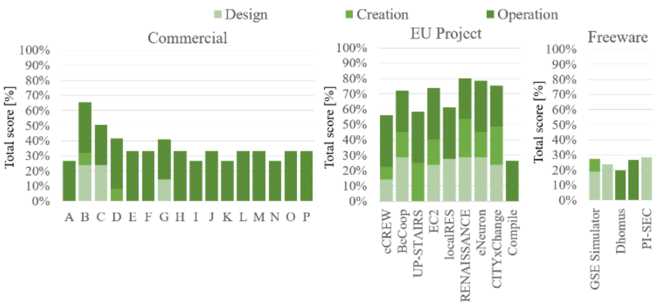

Figure 1. Total score of the analyzed tools and platforms, broken down for each REC phases: "design" (light green), "creation" (green) and "operation" (dark green)

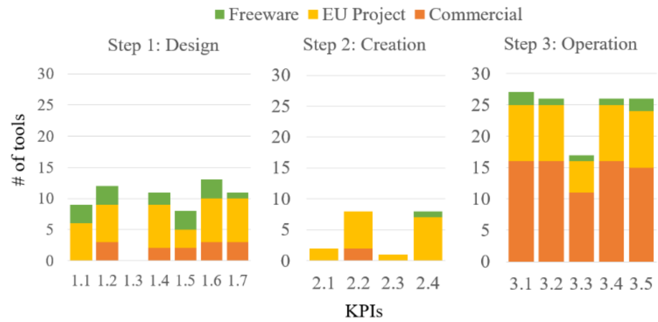

Figure 2. Number of tools and platforms providing service compliant with each KPI

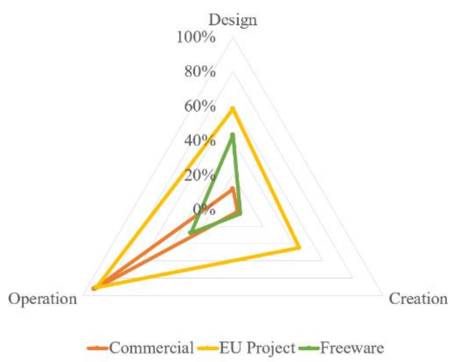

Figure 3. Mean score in each development stage by category of tool

The "operation" step is where the majority of the tools offer services and features. Only the 3.3 KPI "User's access and control of raw energy data, notifications of target/threshold events (e.g demand response)" registered a lower offer of services by the commercial platforms. This result might be related to the commercial interest in the ownership and management of the user's energy data. Both commercial and EU project tools achieve in almost all KPIs the maximum score, while the coverage of the Freeware software for this stage is limited.

Figure 3 shows the overall coverage that each tool category has over the three stages of REC project development. Theis results show that the commercial tools are mostly focused on offering services for the "operation" stage while having limited offers of services for the "design" and "creation" stages. The Freeware software cover the "design" and "operation" stage with no support for the Creation stage; on the other hand, the EU Project tools provide a more comprehensive range of services covering all stages of REC project development. We can assert that these results depend on the financing scheme behind the development of each tool and platform. Commercial tools are typically paid to assure the optimization, management and operation of already established REC projects with a defined business model and goals. Freeware tools are mostly research-based and their development aims to provide energy scenario and develop feasibility studies. While the EU project tools are mainly developed to support demonstration project facing all stages and aspects of the REC project. On the other side, we noticed that some of the EU project tools are used for the specific project only and not publicly available, or their perimeter of competencies is limited only to those EU member states involved in the project as a demonstrator.

4. CONCLUSION

This paper analyse 30 digital tools and platforms developed to support renewable energy community (REC) projects. Three categories of tools have been identified: Commercial (16 tools), EU Project (9 tools), Freeware (5 tools). The tools have been analyzed with respect to their offer of services along the three stages of a REC project: Design, "creation" and Operation. The results show that the "design" and "operation" stages have more tools providing services, while the "creation" stage is covered by EU projects only. The reason for this result could be due to a not well-defined national regulatory framework, unconsolidated procedures, and fragmented steps that depend on different subjects, which makes it difficult to create an automatic software procedure.

From this analysis emerge that, at the moment, there are no available digital tools or platforms able to fully support the self-organized citizens to develop REC project under the RED II directive and guide them along all stages of the project development. The lack of such supporting tool represents a barrier to the spread of REC projects and the achievement of the RED II ambition of increasing the citizens' prosumership and, in turn, the renewable generated and self-consumed energy.

Therefore, the policy recommendation arising from this analysis is the need for an intervention of the national regulatory body to clarify, standardize and simplify the procedures for creating the REC, reducing also the number of interlocutors involved in the authorization process.

ACKNOWLEDGMENT

This work was supported by the Energy Center Lab of Politecnico di Torino.

REFERENCES

[1] Caramizaru, A., Uihlein, A. (2019). Energy communities: an overview of energy and social innovation. Joint Research Centre (European Commission). https://doi.org/10.2760/180576
[2] European Union. (2018). DIRECTIVES DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). http://data.europa.eu/eli/dir/2018/2001/oj, accessed on June 5, 2022.
[3] Surmann, A., Chantrel, S.P.M., Utz, M., Kohrs, R., Strüker, J. (2022). Empowering consumers within energy communities to acquire PV assets through self-consumption. Electricity, 3(1): 108-130. https://doi.org/10.3390/ELECTRICITY3010007
[4] Lowitzsch, J., Hoicka, C.E., van Tulder, F.J. (2020). Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? Renewable and Sustainable Energy Reviews, 122: 109489. https://doi.org/10.1016/j.rser.2019.109489
[5] Inês, C., Guilherme, P.L., Esther, M.G., Swantje, G., Stephen, H., Lars, H. (2020). Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. Energy Policy, 138: 111212. https://doi.org/10.1016/j.enpol.2019.111212
[6] de La Hoz, J., Alonso, À., Coronas, S., Martín, H., Matas, J. (2020). Impact of different regulatory structures on the management of energy communities. Energies, 13(11): 2892. https://doi.org/10.3390/en13112892
[7] Minuto, F.D., Lanzini, A. (2022). Energy-sharing mechanisms for energy community members under different asset ownership schemes and user demand profiles. Renewable and Sustainable Energy Reviews, 168: 112859. https://doi.org/10.1016/j.rser.2022.112859
[8] Yamamoto, Y. (2012). Pricing electricity from residential photovoltaic systems: A comparison of feed-in tariffs, net metering, and net purchase and sale. Solar Energy, 86(9): 2678-2685. https://doi.org/10.1016/j.solener.2012.06.001
[9] Boulanger, S.O.M., Massari, M., Longo, D., Turillazzi, B., Nucci, C.A. (2021). Designing collaborative energy communities: A European overview. Energies, 14(24): 8226. https://doi.org/10.3390/EN14248226
[10] Todeschi, V., Marocco, P., Mutani, G., Lanzini, A., Santarelli, M. (2021). Towards energy self-consumption and self-sufficiency in urban energy communities. International Journal of Heat and Technology, 39(1): 1-11. https://doi.org/10.18280/IJHT.390101
[11] Reis, I.F.G., Gonçalves, I., Lopes, M.A.R., Antunes, C.H. (2021). Business models for energy communities: A review of key issues and trends. Renewable and Sustainable Energy Reviews, 144: 111013. https://doi.org/10.1016/j.rser.2021.111013
[12] El Geneidy, R., Howard, B. (2020). Contracted energy flexibility characteristics of communities: Analysis of a control strategy for demand response. Applied Energy, 263: 114600. https://doi.org/10.1016/j.apenergy.2020.114600
[13] Vallecha, H., Bhattacharjee, D., Osiri, J.K., Bhola, P. (2021). Evaluation of barriers and enablers through integrative multicriteria decision mapping: Developing sustainable community energy in Indian context. Renewable and Sustainable Energy Reviews, 138: 110565. https://doi.org/10.1016/j.rser.2020.110565
[14] Pereira, H., Gomes, L., Faria, P., Vale, Z., Coelho, C. (2021). Web-based platform for the management of citizen energy communities and their members. Energy Informatics, 4: 43. https://doi.org/10.1186/s42162-021-00155-7
[15] Walnum, H.T., Hauge, Å.L., Lindberg, K.B., Mysen, M., Nielsen, B.F., Sørnes, K. (2019). Developing a scenario calculator for smart energy communities in Norway: Identifying gaps between vision and practice. Sustainable Cities and Society, 46: 101418. https://doi.org/10.1016/j.scs.2019.01.003

NOMENCLATURE

RES	Renewable Energy Sources
REC	Renewable Energy Communities
RED II	Renewable Energy Directive Recast
EU	European Union
POD	points-of-delivery
PV	Photovoltaic
KPI	Key Performance Indicator
DSO	distributor system operator

APPENDIX

Table A1. Scores of the analyzed commercial tools and platforms for each KPI

Category	Commercial															
KPI	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1.1																
1.2		•	•				•									
1.3																
1.4		•	•													
1.5		•	•													
1.6		•	•				•									
1.7		•	•				•									
2.1																
2.2		•		•												
2.3																

Category	Commercial															
KPI	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
2.4																
3.1	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3.2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3.3		•		•	•	•		•		•		•	•	•	•	•
3.4	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
3.5	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•

Table A2. Scores of the analyzed EU Project tools and platforms for each KPI

Category	EU Project								
KPI	**eCREW**	**BeCoop**	**UPSTAIRS**	**EC2**	**localRES**	**RENAISSANCE**	**eNeuron**	**CITY•Change**	**Compile**
1.1		•		•	•	•	•	•	
1.2		•		•	•	•	•	•	
1.3									
1.4	•	•		•	•	•	•	•	
1.5		•				•	•		
1.6	•	•		•	•	•	•	•	
1.7	•	•		•	•	•	•	•	
2.1			•			•			
2.2		•	•	•		•	•	•	
2.3								•	
2.4	•	•	•	•		•	•	•	
3.1	•	•	•	•	•	•	•	•	•
3.2	•	•	•	•	•	•	•	•	•
3.3	•		•	•	•		•		
3.4	•	•	•	•	•	•	•	•	•
3.5	•	•	•	•	•	•	•	•	•

Table A3. Scores of the analyzed Freeware tools and platforms for each KPI

Category	Freeware				
KPI	**GSE Simulator**	**RECON**	**Dhomus**	**Pereira et al.**	**PISEC**
1.1	•	•			•
1.2	•	•			•
1.3					
1.4		•			•
1.5	•	•			•
1.6	•	•			•
1.7					•
2.1					
2.2					
2.3					
2.4	•				
3.1			•	•	
3.2				•	
3.3			•		
3.4				•	
3.5			•	•	