MASTERPIECE -

Multidisciplinary Approaches and Software Technologies for Engagement, Recruitment and Participation in Innovative Energy Communities in Europe

Deliverable 2.1

BUSINESS REQUIREMENTS, BARRIERS AND REGULATORY ANALYSIS FOR ENERGY COMMUNITIES (FIRST VERSION)

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Disclaimer:

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1 INTRODUCTION AND DELIVERABLE GOALS

- MASTERPIECE aim starting from D1.4 definition

MASTERPIECE aims at creating a digital coordination and cooperation arena that will facilitate the creation and operation of energy communities throughout Europe. The project's objectives are: i) to develop technical and social innovations to empower traditional energy consumers and to make them active agents of collaborative energy communities, paving the way towards a new energy market paradigm; ii) to create user-centric solutions that are based on participatory approaches such as co-creation and naturally accelerate citizens' involvement; iii) to propose new business strategies and incentive mechanisms that activate the reactions of market participants craving for business opportunities that imply energy use and cost reduction; iv) to configure a standardised and sound cyber-security infrastructure so the active citizens are protected against cyberattacks, at the same time that privacy is defended in accordance with the revised EPBD and the GDPR law; and v) to demonstrate the applicability and replicability of methodological, technical and business innovations in a variety of real life pilots in different geographical locations, with heterogeneous social and economic environments and different regulatory/administrative frameworks. MASTERPIECE will follow a staged implementation approach, utilizing use cases with different maturity and TRLs. To demonstrate and evaluate the proposed innovations, it will leverage 4 pilot cases in different geographical areas and within different operational/policy frameworks (France, Italy, Sweden and Turkey).

- Aim of the deliverable: Provide a complete state-of-art of policy frameworks, existing financial instruments and related EC barriers
    - Identify policy frameworks linked to ECs setup and implementation considering EU, National and Local policy levels (4 pilot cases). Both policies setting rules for EC setup and implementation and policies indirectly affecting EC are considered (e.g., digitalization)
    - Understand how ECs work under a business model prospective
    - Identify and analyse existing financing mechanisms (relevance and efficacy)
    - Identify ECs barriers considering financial and economic barriers, institutional (legal and administrative) barriers, technological barriers, social and behavioral barriers
- Deliverable structure:
    - We perform 2 parallel analyses (policy framework and EC business models with a focus on financial mechanisms)
    - We conduct our analysis on 3 contextual levels: EU level, National level, Local levels. For National and Local levels (either regional or municipal levels) we consider only pilot cases involved in the project

2 ENERGY COMMUNITIES: A PARADIGM SHIFT (1-2 PAGES + COMPARATIVE TABLES)

The first section aims at defining energy community within the border of this work. Starting from energy transition goals and the evolution of energy systems we would like to describe the core elements driving the energy paradigm shift (theoretical background) towards the rise in relevance of active energy citizenship. We describe and compare the existing active energy citizenship initiatives to clarify what we intend as an energy community since mismatching definitions emerge in the literature.

- International and EU goals/targets driving the energy transition (e.g., Paris agreement, Green deal, RePowerEU, Fit for 55)
- From centralised to decentralised energy systems
- The energy system unbundling process
- New actors emerge
- From Passive energy citizens to Active energy citizenship
- The role of prosumers
- Different active energy citizenship initiatives exist: Energy self-consumption; Collective self-consumption; P2P; Virtual energy community; Energy community (REC and CEC)
- A definitions clarification is necessary to well recognise EC initiatives from other forms of active energy citizenship
- Comparative assessment among active energy citizenship experiences looking at 4 features: initiative scope, services, legal form, fiscal aspects, membership, technical aspects, and financial aspects
- The most relevant factors to discern EC from other active energy citizenship initiatives are the initiative's scope and the legal form
- EC definition for the purpose of this deliverable

3.1 Multi-dimensions of Energy communities: the triangle concept (1/2 page with contribution from UMU (also the graphical representation) and EXP)

After defining and clarifying the border of our analysis (what we consider as an EC), we explain the triangle concept considering the 3 pillars shaping and affecting ECs:

- Participation and inclusion dimension (EXP)
- Technological dimension (UMU)
- Regulatory and business dimension (UB)

INTRODUCTION FOR THE FIGURE OF THE TRIANGLE

In our journey to better understand and evaluate Energy Communities (ECs), we have created the preliminary triangle concept. The triangle is formed by three key dimensions of ECs, each representing a side of a triangle. In addition, each regulatory framework and policy affects each of these dimensions, this aspect is a common thread linking the three sides of the triangle.

An example of how the multi-dimensional concept could be applied is illustrated in Figure 1. An EC may be technologically advanced, but if it lacks inclusiveness and for example does not offer compelling end-user incentives, it falls short of being a balanced community. In such cases, measures must be implemented to harmonise the three dimensions. The triangle serves as an supportive framework, facilitating the analysis, classification and assessment of ECs

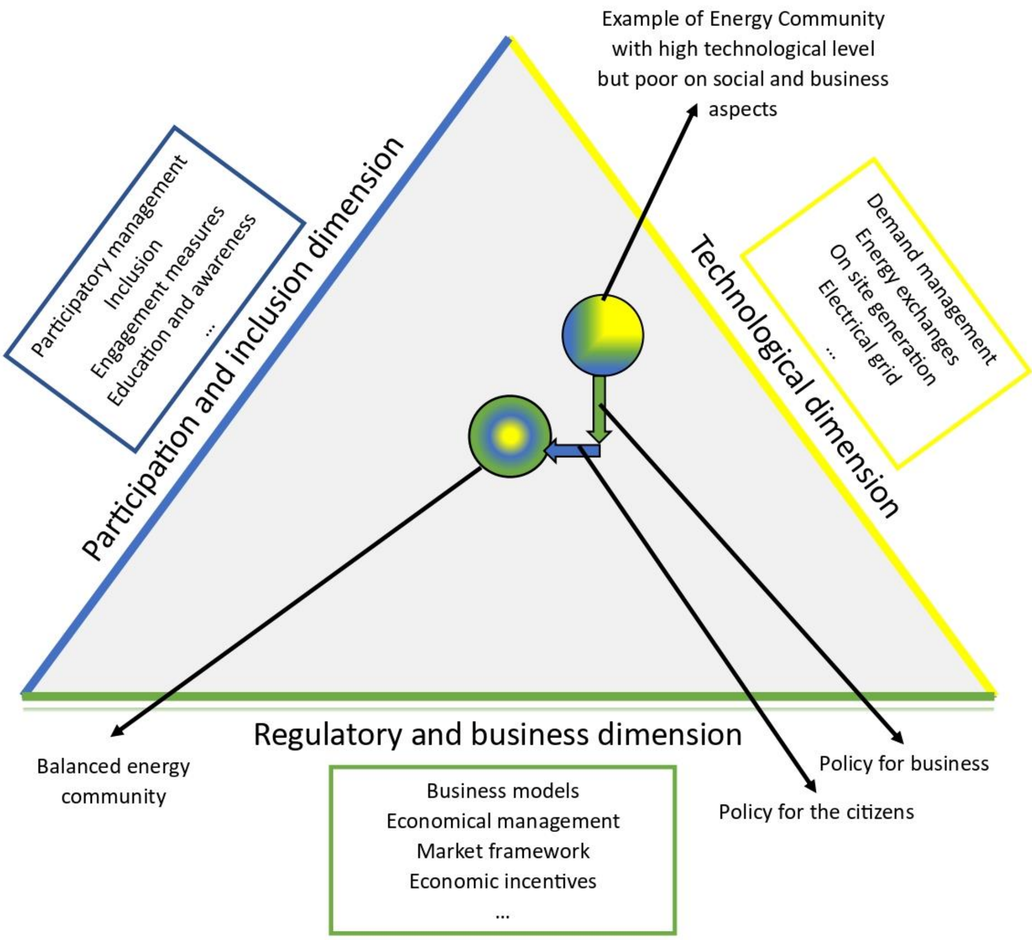

Figure 1: Triangle concept representation for the multi-dimensions of Energy Communities

TECHNOLOGICAL DIMENSION

The technology dimension of energy communities extends beyond just the use of physical devices. It involves harnessing technologies and digital tools that play a key role in their functioning. The Internet of Things (IoT), smart solutions, digital platforms, and management and monitoring tools are central elements in this dimension, contributing significantly to the technical development of ECs.

The initial step present in this deliverable has been to undertake an exploration of the technological dimension of ECs from an approach based on identifying potential enabling technologies in the literature. Enabling technologies are understood as those technologies, tools or digital solutions that contribute to the development, implementation, and operation within the mentioned dimension of ECs. These facilitating technologies are closely related to digitisation, connectivity, monitoring, and energy systems management.

In the field of energy exchange, several technologies related to blockchain technology, smart contracts, peer-to-peer transactions, and other types of exchanges have been identified. Cases of microgrid energy markets based on blockchain have been identified [1], as well as systems for decentralized energy trading found in [2]. Alongside smart contract formats that allow shared control of energy transfer among different parties [3], and integrated platforms for blockchain-based energy management [4]. Additionally, there are technologies where the collaboration of artificial intelligence with IoT for the analysis of large amounts of data is shown [5], or proposals of virtual currencies to trade renewable energy within smart networks [6]. Also, there is the application of P2P in the residential area with energy storage systems [7]. All of them must cover security and data privacy aspects [2],[8].

There are systems more focused on the aspect of energy management through cloud based IoT platforms that support companies in monitoring both produced and consumed energy [9], or in energy management systems but based on edge computing that allow faster data processing closer to the generation source [10]. In addition, the literature proposes an approach for Energy Communities where energy exchange optimisation models consider the energy community as a single prosumer [11]. To this is added the availability of replicated virtual models of houses appliances as digital twins [12].

Regarding more specific technologies such as storage or renewable generation, it was found systems for the evaluation and monitoring of the state of charge and life of the battery, whether fixed or mobile, using digital twins of battery systems [13] or IoT-based systems for battery management in microgrids [14]. In addition, there are tools focused on prediction for the management and planning of charging electric vehicles [15]. Similarly, the implementation of IoT in the combination of electric vehicle charging stations with photovoltaic renewable generation has been explored [16].

Other enabling technologies focus on citizen participation. For this, tools for monitoring and evaluating this participation have been identified [17] which can foster the creation of relationships between the end user and governments. By means of dynamic pricing models based on renewable energies, the aim is to encourage citizens to use these energies as in [18]. Along with the above, incentives are included in P2P architectures for energy markets including smart contracts [19], [20]. As well as existing platforms focused on financing projects as an investment by the citizen himself [21].

From this preliminary identification of enabling technologies, some of them and their main technical characteristics are shown in the Table 1.

Table 1: Main technical components of several enabling technologies

Category	Activity	Enabling technologies

Energy exchange	Energy trading [2]	- Security: Blockchain and user validation identity. - Combined Optimal Power Flow (OPF) problem with a bilateral trading mechanism. - Energy allocation designed: Discrete-time double auction. - Energy system implementation with Hyperledger Fabric (HF).
	Blockchain-based energy management and trading platform [4]	- Input data: User consumption data, configuration of the community, solar installation details and EV profiles data. - Data storage and security: Blockchain Network. - Energy trading with smart contracts.
	AI, blockchain and IoT [5]	- Objective: converging of AI and Blockchain for IoT application. - Architecture: device, edge, fog, and cloud layers: o Data collection from IoT devices using AI tools. o Data analysis and integration with AI tools and a distributed edge network blockchain. o Data security with blockchain.
	Virtual currencies [6]	- Objective: Decentralized protocol and renewable energy-based currency generation. - Virtual currency: NRGcoin rewards from local substations based on renewable injection into the grid. The value of NRGcoins determined by open exchange market. DSO's role is only for the collection and distribution of payments.
	Energy exchange optimisation models [11]	- Input Data: Energy and tariffs data; Predicted energy production. - Optimization problem: Mixed integer linear programming. - Data information visualized: Energy exchanges between users and day scheduling for different loads.
Energy management	Cloud based IoT platform [9]	- Input data: Energy and bills/investments data of users. - Data collection by Verbund IoT devices using MQTT. - Data storage: POSTGERSQL CitiSim Database. - Data integration: MQTT protocol and Central MQTT Broker. - Data visualization: Grafana, ChartJS and SemanticUI.

	Edge computing based on Deep Reinforcement Learning (DRL) [10]	- Input data: Energy supply and demand data. - Data collection and analysis: Energy edge servers. - Data storage: Cloud server. - Data integration: Communications technologies. - Cognition layer: DRL for intelligent decision-making and optimization. - Data visualization: Web and device applications.
	Digital twins of households appliances [12]	Cognitive Household Digital Twins formed by the cognitive, the Decision, the Control, and the Influence blocks. Input data: from IoT sensors connected to households appliances (physical twin), the user and communication.
RES management	IoT based system battery management [14]	- Input data: Battery measurements, parameters, intelligent electronic device data and photovoltaic monitoring system data. - Data collection by the embedded IoT systems and digital communication (TCP/IP with JSON format). - Data storage: Cloud-based database with SQL format. - Data integration: Internet gateways and ADSL. - Data visualization: Human Machine Interface (HMI) using ExtJS/HTML5 framework.
	Optimal scheduling of EVs recharging [15]	- Input data: Charging station data and user requests. - Data collection: sensors, BMS and by GPS. - Data storage / security: Cloud SQL and Local host database / SSL protocol or AES-256 bit encryption algorithm. - Data integration via API. - Data analytics techniques: Descriptive (data collection), predictive (charging demand forecasting) and prescriptive (optimizing charging station allocation). - Data visualization: Dashboard and an application.
	EV substations charging with PV installations [15]	- Input data: Battery measurement and solar installation parameters. - Data collection and acquisition: IoT as an internet gateway; TCP/IP-based digital connection. - Data storage: Cloud database. - Data integration: GSM modem interface. - Data visualization: HMI using ExtJS/HTML5 framework.

Citizen-centred	Monitoring and evaluating participation [17]	- Input and processing data from the decision-maker, interface toolkit (participation encouragement tool and debate control tool). - Data analysis from e-participation platforms, social media and IoT and risk management component. - Data visualization: Displaying information in e-participation platforms and social media.
	Dynamic incentives [18]	- Input data: Real-time electrical parameter data, energy consumption data, operating parameters of home devices. - Data collection: Meters. - Data storage: Cloud-integrated database (with real and historical data). - Data integration: IoT controller based on an ARM processor using the Modbus protocol. - Data visualization: Application web (PHP, JS and HTML).
	Financing projects by citizens [21]	Models based on crowdfunding and crowdlending.

Therefore, it can be concluded that the technological dimension of energy communities offers a broad spectrum of opportunities to stimulate their progress and integration with the other dimensions effectively. As observed, enabling technologies are not limited to energy aspects, but also impact economic issues and empower the citizen as an active player in the Energy Community and the energy sector.

3 POLICY FRAMEWORKS ON ENERGY COMMUNITIES

Aim: assessing policy frameworks considering both direct and indirect policies affecting EC setup and implementation at the EU Level and National Level. For the National Level (if relevant also the sub-national level) we consider only pilot cases' countries, namely: Italy, France, Sweden, Turkey.

4.1 Methodology

- Where information come from (scientific and grey literature, survey)
- How we conduct literature review (Keywords, snowball approach)
- Description of surveys design
- Description of methods used to assess surveys results

4.2 EU Policy framework directly affecting energy communities

This section is dedicated to the EU policy framework on energy communities.

- Directive (EU) 2018/2001 (RED II): Recast on renewable energy-REC
    - Definition of REC
- Directive (EU) 2019/942: Common rules for the internal market for electricity-CEC
    - Definition of CEC
- Comparative analysis of REC and CEC

Main features	Renewable energy community	Citizen energy community
Status	**Legal entity**	**Legal entity**
Membership	Open and voluntary participation; the shareholders or members are natural persons, micro, small or medium sized enterprises (SMEs) or local authorities, including municipalities	Voluntary and open participation; members or shareholders are natural persons, local authorities, including municipalities, or small enterprises
Management	Autonomous; effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by renewable energy community (CEC)	Effectively controlled by members or shareholders; the decision making powers should be limited to those members or shareholders that are not engaged in large-scale commercial activity and for which the energy sector does not constitute a primary area of economic activity
Primary purpose	To provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits	To provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits
Other	Produce, consume, store and sell renewable energy, including through renewables power purchase agreements as well as share, within the renewable energy community, self-produced renewable energy	May engage in production of electricity, including from renewable sources, distribution of electricity, supply (the sale, including the resale, of electricity to customers), electricity consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles, or may provide other

		energy services to its members or shareholders

EMD			RED II	
Energy sector	Electricity market (technology-neutral)		Renewable energy market (heat and electricity based on renewable energy)	
Legal form	Any		Any	
Participation	Structure	Actors	Structure	Actors
	Open and voluntary	Any	Open and voluntary	Natural persons, local authorities and SMEs whose participation does not constitute their primary economic activity
Control	Structure	Actors	Structure	Actors
	Effective control	Natural persons, local authorities and small and micro-sized enterprises	Effective control	Natural persons, local authorities and SMEs whose participation does not constitute their primary economic activity
Autonomy	Large energy companies cannot exercise any decision-making power		Explicitly mentioned	
Geographical limitation	No		Those in control need to be located proximity of projects owned and developed by the community	
Activities	Generation, distribution, supply, consumption, sharing, aggregation and storage of electricity Energy-efficiency services, EV charging-services, other energy-related services (commercial)		Generation, distribution, consumption, storage, sale, aggregation, supply and sharing of renewable energy Energy-related services (commercial)	
Purpose	Social, economic and environmental benefits for members/shareholders or the local area in which it operates		Social, economic and environmental benefits for members/shareholders or the local area where it operates	

- Possible legal structures for energy communities (JRC)

Legal structure	Description

Energy cooperatives	This is the most common and fast growing form of energy communities. This type of ownership primarily benefits its members. It is popular in countries where renewables and community energy are relatively advanced.
Limited partnerships	A partnership may allow individuals to distribute responsibilities and generate profits by participating in community energy. Governance is usually based on the value of each partner's share, meaning they do not always provide for a one member - one vote.
Community trusts and foundations	Their objective is to generate social value and local development rather than benefits for individual members. Profits are used for the community as a whole, even when citizens do not have the means to invest in projects (for-the-public-good companies).
Housing associations	Non-profit associations that can offer benefits to tenants in social housing, although they may not be directly involved in decision-making. These forms are ideal for addressing energy poverty.
Non-profit customer-owned enterprises	Legal structures used by communities that deal with the management of independent grid networks. Ideal for community district heating networks common in countries like Denmark.
Public-private partnerships	Local authorities can decide to enter into agreements with citizen groups and businesses in order to ensure energy provision and other benefits for a community.
Public utility company	Public utility companies are run by municipalities, who invest in and manage the utility on behalf of taxpayers and citizens. These forms are less common, but are particularly suited for rural or isolated areas.

- Regulation (EU) 2018/1999 (Governance Regulation): Governance of the Energy Union-REC
- Regulation (EU) 2019/942 (ACER Regulation): Agency for the Cooperation of Energy Regulators (ACES)-CEC
- REGULATION (EU) 2019/941 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC
- Future initiatives of EC by EU (to achieve different targets or goals)
  - Energy Communities Repository
    Rural Energy Community Advisory Hub
  - Citizen-Led Renovation. 'Citizen-Led Renovation' is a new EU initiative aiming to empower energy communities and put citizens in the driver's seat for energy-saving renovation projects. (Launch of the Citizen-Led Renovation Project and Open Call for Participation, n.d.)

4.3 EU Policy framework indirectly affecting energy communities

4.3.1 EU policy framework on digitalization

- COM (2020) 767 final [Data Governance Act]

- Digitalising the energy system - EU action plan [Strasbourg, 18.10.2022 COM (2022) 552 final]

4.3.2 EU behavioural policy framework

We are not funding many sources in this regard. Can EXP support us?

4.4 National policy frameworks

- Overview and stage of EU directive transposition in EU member states
  - RED II deadline was set for 30 June 2021, though the deadline is already approached not all member states are properly transposed the RED II
  - Similarly, IEMD was not transposed by all member states appropriately which deadline was set for December 2020
  - Bad Transposition: Bulgaria, Czech Republic, Poland, Sweden
  - Substantial deficiencies – Transposition: Austria, Croatia, Estonia, Finland, Hungary, Luxembourg, Malta, Portugal, Romania, Slovakia
  - Average progress – Transposition: Cyprus, Greece, Latvia, Lithuania, Netherlands, Slovenia, Spain
  - Good Practice - Transposition: Belgium, Denmark, France, Germany, Ireland, Italy (REC and CEC Definitions - REScoop, n.d.)

In the following sections we focus on pilot cases national and sub-national policy frameworks collecting information from literature, reports and survey answers.

4.4.1 Italy National policy framework

- Short Evolution of Italian National policy framework regarding EC
- Transposition of EU directives regarding REC and CEC (Current Situation)
- Best Practices of EC national level or regional level
- Crucial Obstacles of transposition

4.4.2 France National policy framework

- Short Evolution of French National policy framework regarding EC
- Transposition of EU directives regarding REC and CEC (Current Situation)
- Best Practices of EC national level or regional level
- Crucial Obstacles of transposition

4.4.3 Sweden National policy framework

- Short Evolution of Swedish National policy framework regarding EC
- Transposition of EU directives regarding REC and CEC (Current Situation)
- Best Practices of EC national level or regional level
- Crucial Obstacles of transposition

4.4.4 Turkey National policy framework

- Short Evolution of Turkish National policy framework regarding EC
- Best Practices of EC national level or regional level
- Crucial Obstacles of transposition

4 ENERGY COMMUNITY BUSINESS MODELS

Here we start defining what is a business model, with a focus on sustainable business model and how we can analyse and assess it by looking at which factors/elements should be considered based on literature review. This section aims to identify which key factors/elements may drive a business model definition for EC. The final goal is to provide a new business model canvas (analysis framework) for designing innovative business models for EC which will be used in WP3 (Task 3.2).

5.1 Methodology

- Literature review regarding business models and business model factors/elements
- Literature review regarding business model analysis frameworks

5.2 Definition of Business model

- What is a business model?
    - There is no universal definition of business model and there is confusion between business model and business strategy
    - Table comparing different definitions of BM
- How to analysis and assess business models
    - There are different ways for analysing and assessing business models by considering different factors/elements (i.e., Business models Canvas, lean canvas framework etc)
    - Table comparing different BM analysis frameworks, with a focus on elements/factors considered
    - Result: Although there is no single analytical model or widely agreed definition of a business model, everyone agreed that there are four macro-elements: Value proposition, Value creation, Value delivery, and Value Capture
- The concept of value is the cornerstone of any business model analysis
    - The Business-as-usual models focusing on economic value
    - The concept of "blended value" or "shared value" emerge in the content of sustainable business model such as energy community
- What is a sustainable business model and which innovations it brings
    - There is an increasing literature that seeks to define what is a sustainable business model, or what are the factors/elements of analysis to consider
    - In addition to the shift in the value, sustainable business model "innovation involves changes in the way you do business', rather than 'what you do' and hence

must go beyond process and products" – This is relevant when we consider the EC business model where the innovation lies in a process innovation

- ECs can be considered as innovative sustainable business models (since they change the value delivered and the way to deliver it) ---- Richter (2013) claims that BMI is related to the "development of new organizational forms for the creation, delivery, and capture of value" (Richter, 2013, p.1228)
    - What is organization form and why is do crucial when we speak about EC business models?
- Energy communities are an innovative business model that redefines both the organizational form and the concept of value, aiming to cover hitherto unmet needs, both social and environmental, by giving an active role to citizens and turning them into prosumers.

5.3 Key factors affecting energy community business model

From the results of the literature review on business models we want to identify the key factors affecting and shaping the EC BMs.

- The key factors that differentiate the EC from business-as-usual are:
    - Its aim related to socio-environmental factors rather than profit
    - The variety of actors that can participate in an EC, Private, individual, state, public and its combinations
    - Incorporation of various technologies into one entity which create co-benefits
    - EC can operate as multisided platforms
    - The governance
    - Financial mechanisms

Further work: rethinking Business Model Canvas for energy communities (WP3 – Task 3.2)

5 FINANCING MECHANISMS

According to the results of the ECs business models' literature review and key factors, this section focuses on financial mechanisms for ECs setup and management. Here we focus on public and private financing mechanisms considering those targeting the whole EC and the energy assets finance (microgrids, generation plants (e.g. Solar, wind, hydro), energy storage systems, smart metering and devices for controlling the energy flow, etc.).

- We define financing mechanisms "as the ways in which financial resources are made available by a supplier to the organizations that need them, which can have very different implications in terms of recovery of capital, expected returns, ownership rights, and so forth"
- There are different ways in which an EC can raise capital

- A first categorisation considers actors that can finance an EC (public sector, citizens, financial institutes, other communities, foundations etc.), break down into two groups: public and private actors
    - Public financing mechanisms include public grants, incentives and city/public bonds
    - Private financing mechanisms include equity financing, dept financing, crowdfunding, P2P investments, EPC, etc.
- A second categorisation considers the target of financing mechanisms separating those targeting the EC (as a whole new entity), and the energy assets (rent, lease, Energy Performance Contracting (EPC), Services exchange among EC and third parties)
- Generally, an EC is financed by a combination of those public and private financing mechanisms
- Those affect various aspects of the EC such as legal aspects, profits and revenues, share of risks, accessibility of capital, scalability of projects, governance and ownership structure
- Also, national policy on pricing mechanisms and availability of public financing have an impact on EC financing opportunities
- In the following chapter we analyse different financial mechanism, namely, public financing mechanisms, private financing mechanisms existing in the EU and beyond

Private financing mechanisms

- By private parties we mean any kind of company, bank or institution that wants either to buy a share of the community (equity) in exchange for the right to the community or to lend money with loans (debt capital).
- Here we consider also bottom-up financing initiatives when individuals buy shares in the community and become members or fund a community through a platform such as crowd-funding or crowd-investment platforms.

Equity finance

- Description
- Impacts/effects

Dept Capital

- Leasing
- Bank loans
- Ethical loans
- Green loans
- Sustainability loans
- Social loans
- Soft loans
- Green bonds

- Impacts/effects

Bottom-up financing initiatives

- Crowdfunding
- Crowd investment
- Peer to peer investment platforms
- Green trade finance
- Impacts/effects

Public financing mechanisms

Public bodies refer to any regional, national or international public authority such as a municipality or regions that can provide money to the community either in the form of equity, debt or grant.

- Grant
- Public bonds
- Incentives
- Bonus
- Impacts/effects

Pilot cases financial mechanisms

This section reports the survey results (if any)

6 BARRIERS

This section collects and reports all EC barriers emerging from the analysis. We group barriers into three main categories: 1) financial and economic, 2) institutional, 3) technological, and 4) social and behavioural (including cultural and educational).

- Definition of barrier: it is "a mechanism that inhibits a decision or behaviour"
- Results comes from the work conducted on literature and survey results

If any WP2 partners identify further barriers can add them here.

Financial and economic barriers

Financial and economic barriers refer to difficulties in accessing credit, insufficient and unstable available funding, and high risk for investors and financial institutions. Institutional barriers are related to political obstruction, conflicting guidelines and rules, and lack of policy clarification, coherence and coordination.

Institutional (legal and administrative) barriers

Institutional (legal and administrative) barriers are related to political obstruction, conflicting guidelines and rules, and lack of policy clarification, coherence and coordination.

- Definitions of CECs and RED II are blurring and give huge space to further redefinition by national laws. For example, the EU has left a relatively large degree of freedom for Member States to determine the organisational forms (National company laws may diverge in the treatment of legal entities in terms of decision-making, liability, tax advantages, start-up costs or administrative burdens) (Arnould, and Quiroz, 2022; De Almeida et al, 2021). National company laws may diverge in the treatment of legal entities in terms of decision-making, liability, tax advantages, start-up costs or administrative burdens (De Almeida et al, 2021).
- In many countries, directives have not been adequately transposed as of yet, or have not been considered in national law at all, despite the transposition deadline of June 2021. The exceptions are Belgium (except the region of Wallonia), France, Denmark, Ireland, Italy and Sweden.
- By transposing the EU directives issues arise concerning if and to what extent existing initiatives should be recognised and treated as ECs (Comeres Project (2021) from a regulatory perspective (Legal requirement for the ECs governance: eligibility, effective control, voluntary and open access, distribution of costs and benefits).
- "Proximity" requirements (RECs). This requirement is not well described in RED II. National governments have to fix specific requirements. Some decided to interpret it as network-based restrictions based on the type of electric networks and voltage levels. For example, community member injections/withdrawals of electricity must be downstream of one or several medium/low voltage transformers. Others decide on restrictions based on the distance between members of the community. Finally, some implementations base restrictions on a fixed geographic perimeter that allows an optimal scale to promote local collective self-consumption (De Almeida et al, 2021)
- National regulatory authorities must define charges, tariffs and levies for energy communities when connect to the main grid. At which extent the energy community should cover grid management costs.
- Local building codes (aesthetic requirements) or other Local regulations on preserving the landscape value or the ecosystem hinder property owners and communities from installing solar PV or other power generation plants (wind turbine, biomass-plants, etc.).

Technological barriers

Technological barriers refer to insufficient data, low diffusion of innovative technologies, and old or inefficient energy infrastructures.

- Limitation of generation capacities.

- The spread of smart meters is still low. Moreover, some citizens refuse to use smart meters due to fears of electronic poisoning or data leakage. However, smart meters are a technical prerequisite for the successful operation of energy communities.

Social/behavioural barriers

Social and behavioural barriers refer to social group interactions, inertia, lack of awareness, lack of access to trusted information and knowledge, lack of expertise (skills & training), habits and relevant behavioural aspects, undervaluing benefits, and mistrust/negative perception of new technologies, fear.

- In countries with a long history and culture in supporting community ownership there are higher changes to develop energy communities. RECs are more prevalent in higher-income Northern European countries and are currently less developed in Central and Eastern Europe (Caramizaru et al, 2020).

7 References

Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal*, *22*(6–7), 493–520. https://doi.org/10.1002/smj.187

Arnould, J. and D. Quiroz (2022). Energy Communities in the EU: Fulfilling consumer rights and protections, Amsterdam, The Netherlands: Profundo.

Ballon, P. (2007). Business modelling revisited: The configuration of control and value. *Info*, *9*(5), 6 19. https://doi.org/10.1108/14636690710816417

Bellman, R., Clark, C. E., Malcolm, D. G., Craft, C. J., & Ricciardi, F. M. (1957). On the Construction of a Multi-Stage, Multi-Person Business Game. In *Source: Operations Research* (Vol. 5, Issue 4). https://about.jstor.org/terms

Campos, I., Marín-González, E., (2020). People in transitions: Energy citizenship, prosumerism and social movements in Europe, Energy Research & Social Science, Volume 69, 101718, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101718

Caramizaru, E. and Uihlein, A., (2020). Energy communities: an overview of energy and social innovation, EUR 30083 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-10713-2, doi:10.2760/180576, JRC119433.

Casalicchio, V., Manzolini, G., Prina, M.G. and Moser, D. (2022), Optimal Allocation Method for a Fair Distribution of the Benefits in an Energy Community. Sol. RRL, 6: 2100473. https://doi.org/10.1002/solr.202100473

Comeres Project (2021). Deliverable 4.1. Report on organizational and legal forms and business models for RECs.

De Almeida, L., Cappelli, V., Klausmann, N., van Soest, H. (2021). Peer-to-Peer Trading and Energy Community in the Electricity Market - Analysing the Literature on Law and Regulation and Looking Ahead to Future Challenges. EUI Working Paper RSC 2021/35. European University Institute, Robert Schuman Centre for Advanced Studies, Florence School of Regulation.

Directive 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). PE/48/2018/REV/1. HTTP://DATA.EUROPA.EU/ELI/DIR/2018/2001/OJ

Directive 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast). PE/10/2019/REV/1. HTTP://DATA.EUROPA.EU/ELI/DIR/2019/944/OJ

Energy Communities in the EU Task Force Energy Communities. (2019).

European Commission, Directorate-General for Energy (2019). Clean energy for all Europeans, Publications Office, HTTPS://DATA.EUROPA.EU/DOI/10.2833/9937

Frieden, d., Tuerk, A., Neumann, C., et al. (2020). Compile project. Collective self-consumption and energy communities: Trends and challenges in the transposition of the EU framework.

Gruber, L., Bachhiesl, U., Wogrin, S. (2021). The current state of research on energy communities. Elektrotech. Inftech. 138, 515–524. HTTPS://DOI.ORG/10.1007/S00502-021-00943-9

Hanke, F., Guyet, R., Feenstra, M. (2021). Do renewable energy communities deliver energy justice? Exploring insights from 71 European cases. Energy Res Social Sci, 80, 102244, 10.1016/j.erss.2021.102244.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing Your Business Model. *Harvard Business Review* , *86*, 50–59. WWW.HBR.ORG

Khalilpour, K.R, (2019). The Nexus Era: Toward an Integrated, Interconnected, Decentralized, and Prosumer Future, in Polygeneration with Polystorage for Chemical and Energy Hubs, Chapter 2, Energy and Chemicals, pages 27-52. HTTPS://DOI.ORG/10.1016/B978-0-12-813306-4.00002-1

Lode, M.L., te Boveldt, G., Coosemans, T., Ramirez Camargo. L. (2022). A transition perspective on Energy Communities: A systematic literature review and research agenda, Renewable and Sustainable Energy Reviews, Volume 163, 112479, ISSN 1364-0321, HTTPS://DOI.ORG/10.1016/J.RSER.2022.112479.

Longo, D., Boulanger, S.O.M., Massari, M., Turci, G. (2022). Energy Citizenship. Tools and Technologies to enable Transition in Districts / Cittadinanza energetica. Strumenti e tecnologie per abilitare la transizione nei distretti. Techne. Journal of Technology for Architecture and Environment. Doi: 10.36253/techne-13721

Magretta, J. (2002). Why Business Models Matter. *Harvard Business Review*, *80*, 3–8.

Morrison, E.J. (2022). Unbundling, Markets, and Regulation. In: Hafner, M., Luciani, G. (eds) The Palgrave Handbook of International Energy Economics. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-86884-0_24

Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems*, *16*. HTTPS://DOI.ORG/10.17705/1CAIS.01601

Roberts, J. (2021). What Are Energy Communities Under the EU's Clean Energy Package?. *Renewable Energy Communities and the Low Carbon Energy Transition in Europe*, 23-48.

Roberts, J. (2020). Power to the people? Implications of the Clean Energy Package for the role of community ownership in Europe's energy transition. *RECIEL*., 29: 232– 244. HTTPS://DOI.ORG/10.1111/REEL.12346

Sciullo, A., Gilcrease, G. W., Perugini, M., Padovan, D., Curli, B., Gregg, J. S., ... & Muiste, M. (2022). Exploring Institutional and Socio-Economic Settings for the Development of Energy Communities in Europe. *Energies*, *15*(4), 1597.

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. *Business Horizons*, *48*(3), 199–207. HTTPS://DOI.ORG/10.1016/J.BUSHOR.2004.10.014

Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2–3), 172–194. HTTPS://DOI.ORG/10.1016/J.LRP.2009.07.003

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van Wees, Mark, Beatriz Pineda Revilla, Helena Fitzgerald, Dirk Ahlers, Natalia Romero, Beril Alpagut, Joke Kort, Cyril Tjahja, Gabi Kaiser, Viktoria Blessing, Lia Patricio, and Sander Smit (2021). Energy Citizenship in New Energy Concepts, *Environmental Sciences Proceedings* 11, no. 1: 27. HTTPS://DOI.ORG/10.3390/ENVIRONSCIPROC2021011027

Wierling, A., Schwanitz, V.J., Zeiss, J.P. et al. (2023). A Europe-wide inventory of citizen-led energy action with data from 29 countries and over 10000 initiatives. Sci Data 10, 9. https://doi.org/10.1038/s41597-022-01902-5

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning*, *49*(1), 36–54. HTTPS://DOI.ORG/10.1016/J.LRP.2015.04.001

Zott, C., Amit, R., & Massa, L. (2010). *The Business Model: Theoretical roorts, recent developments, and future research* (Vol. 5).

REFERENCES TECHNOLOGICAL DIMENSIONS

[1] E. Mengelkamp, J. Gärttner, K. Rock, S. Kessler, L. Orsini, and C. Weinhardt, 'Designing microgrid energy markets: A case study: The Brooklyn Microgrid', *Appl Energy*, vol. 210, pp. 870–880, Jan. 2018, doi: 10.1016/j.apenergy.2017.06.054.

[2] A. Samy, H. Yu, H. Zhang, and G. Zhang, 'SPETS: Secure and Privacy-Preserving Energy Trading System in Microgrid', *Sensors*, vol. 21, no. 23, p. 8121, Dec. 2021, doi: 10.3390/s21238121.

[3] L. Thomas, Y. Zhou, C. Long, J. Wu, and N. Jenkins, 'A general form of smart contract for decentralized energy systems management', *Nat Energy*, vol. 4, no. 2, pp. 140–149, Jan. 2019, doi: 10.1038/s41560-018-0317-7.

[4] G. van Leeuwen, T. AlSkaif, M. Gibescu, and W. van Sark, 'An integrated blockchain-based energy management platform with bilateral trading for microgrid communities', *Appl Energy*, vol. 263, p. 114613, Apr. 2020, doi: 10.1016/j.apenergy.2020.114613.

[5] S. K. Singh, S. Rathore, and J. H. Park, 'BlockIoTIntelligence: A Blockchain-enabled Intelligent IoT Architecture with Artificial Intelligence', *Future Generation Computer Systems*, vol. 110, pp. 721–743, Sep. 2020, doi: 10.1016/j.future.2019.09.002.

[6] M. Mihaylov, S. Jurado, N. Avellana, K. Van Moffaert, I. M. de Abril, and A. Nowe, 'NRGcoin: Virtual currency for trading of renewable energy in smart grids', in *11th International Conference on the European Energy Market (EEM14)*, IEEE, May 2014, pp. 1–6. doi: 10.1109/EEM.2014.6861213.

[7] S. Zhou, Z. Hu, W. Gu, M. Jiang, and X.-P. Zhang, 'Artificial intelligence based smart energy community management: A reinforcement learning approach', *CSEE Journal of Power and Energy Systems*, 2019, doi: 10.17775/CSEEJPES.2018.00840.

[8] I. Hussain, G. Samara, I. Ullah, and N. Khan, 'Encryption for End-User Privacy: A Cyber-Secure Smart Energy Management System', in *2021 22nd International Arab Conference on Information Technology (ACIT)*, IEEE, Dec. 2021, pp. 1–6. doi: 10.1109/ACIT53391.2021.9677341.

[9] G. Suciu, L. Necula, R. Iosu, T. Usurelu, and M. Ceaparu, 'IoT and Cloud-Based Energy Monitoring and Simulation Platform', in *2019 11th International Symposium on Advanced Topics in Electrical Engineering (ATEE)*, IEEE, Mar. 2019, pp. 1–4. doi: 10.1109/ATEE.2019.8724961.

[10] Y. Liu, C. Yang, L. Jiang, S. Xie, and Y. Zhang, 'Intelligent Edge Computing for IoT-Based Energy Management in Smart Cities', *IEEE Netw*, vol. 33, no. 2, pp. 111–117, Mar. 2019, doi: 10.1109/MNET.2019.1800254.

[11] A. Giordano, C. Mastroianni, L. Scarcello, and G. Spezzano, 'An Optimization Model for Efficient Energy Exchange in Energy Communities', in *2020 Fifth International Conference on Fog and Mobile Edge Computing (FMEC)*, IEEE, Apr. 2020, pp. 319–324. doi: 10.1109/FMEC49853.2020.9144901.

[12] K. O. Adu-Kankam and L. M. Camarinha-Matos, 'A Framework for the Integration of IoT Components into the Household Digital Twins for Energy Communities', 2022, pp. 197–216. doi: 10.1007/978-3-031-18872-5_12.

[13] W. Li, M. Rentemeister, J. Badeda, D. Jöst, D. Schulte, and D. U. Sauer, 'Digital twin for battery systems: Cloud battery management system with online state-of-charge and state-of-health estimation', *J Energy Storage*, vol. 30, p. 101557, Aug. 2020, doi: 10.1016/j.est.2020.101557.

[14] K. Friansa, I. N. Haq, B. M. Santi, D. Kurniadi, E. Leksono, and B. Yuliarto, 'Development of Battery Monitoring System in Smart Microgrid Based on Internet of Things (IoT)', *Procedia Eng*, vol. 170, pp. 482–487, 2017, doi: 10.1016/j.proeng.2017.03.077.

[15] G. F. Savari, V. Krishnasamy, J. Sathik, Z. M. Ali, and S. H. E. Abdel Aleem, 'Internet of Things based real-time electric vehicle load forecasting and charging station recommendation', *ISA Trans*, vol. 97, pp. 431–447, Feb. 2020, doi: 10.1016/j.isatra.2019.08.011.

[16] K. N. Kumar, P. Badrinath, S. Vickraman, and G. Satheesan, 'Charging Station for E-Vehicle Using Solar with IoT', in *2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT)*, IEEE, Dec. 2022, pp. 1–5. doi: 10.1109/ICERECT56837.2022.10060451.

[17] C. I. Kang and P. H. Oh, 'A Design of Technological Infrastructure for Citizen Participation in Public Value Co-creation', in *Proceedings of the 2022 2nd International Conference on Public Management and Intelligent Society (PMIS 2022)*, Dordrecht: Atlantis Press International BV, 2023, pp. 677–689. doi: 10.2991/978-94-6463-016-9_69.

[18] P. Balakumar, T. Vinopraba, and K. Chandrasekaran, 'Real time implementation of Demand Side Management scheme for IoT enabled PV integrated smart residential building', *Journal of Building Engineering*, vol. 52, p. 104485, Jul. 2022, doi: 10.1016/j.jobe.2022.104485.

[19] Mazzola Luca, Denzier Alexander, and Christen Ramon, 'Towards a Peer-to-Peer Energy Market: an Overview', *ArXiv*, 2020.

[20] U. Cali and O. Cakir, 'Energy Policy Instruments for Distributed Ledger Technology Empowered Peer-to-Peer Local Energy Markets', *IEEE Access*, vol. 7, pp. 82888–82900, 2019, doi: 10.1109/ACCESS.2019.2923906.

[21] L. R. Vásquez-Ordóñez, C. Lassala, K. Ulrich, and S. Ribeiro-Navarrete, 'Crowdlending for renewable energy projects: key factors to improve performance', *Academia Revista Latinoamericana de Administración*, vol. 35, no. 2, pp. 223–238, Jul. 2022, doi: 10.1108/ARLA-07-2021-0135.