INTERACT

Integration of Innovative Technologies of Positive Energy Districts into a Holistic Architecture

D 5.2. Business cases for INTERACT Energy Communities

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Leader LEEF

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Disclaimer

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Executive Summary

The aim of the deliverable was to identify business cases that could be relevant for INTERACT EC. Deliverable D 5.2 bases on the division of use cases described in D 4.2, which are divided in normal operation, abnormal operation, flexibilities, and long-term planning. From a business perspective, we structured the business cases finally in four groups: basic operation, advanced operation, and integrated operation and fully integrated operation.

Before naming and describing the possible business cases in detail, it first discusses the factors that affect the viability of business cases for Energy Communities in general, based on the information gained within Work Package 2, D 2.3. There are defined six main categories of factors that influence the viability of business cases:

a. the regulatory framework,
b. the conditions in the energy market,
c. the type of technologies used,
d. the ownership structure within the energy community itself,
e. the size of the energy community, and
f. financing and funding options.

Special focus is given to the ownership structure, as this factor has a major influence on contractual relationships, which is important for the upcoming D 5.3. All three possibilities of ownership are discussed: assets owned by EC members, by the community itself, or by third parties.

Then we focus on the description of the business cases themselves. The creation of INTERACT EC will mean a reorganization of existing relationships and most likely a gradual development towards a more sophisticated operation mode will happen. In the same way, we describe the possible business cases from the basic functioning of the Energy Community toward fully integrated operation into the energy system and business models:

I. Basic Operation: sharing of renewable energy
II. Advanced Operation: optimization of production/consumption profiles
III. Advanced Operation: long-term planning
IV. Advanced Operation: peer-to-peer trading
V. Integrated Operation: providing flexibility to the market
VI. Integrated Operation: provision of back-up power
VII. Fully integrated Operation: connected with the INTERACT Market Structure

After discussion of other possible business models not directly related to the physical process related to electricity, the deliverable draws its conclusions and outlook in Chapter 4.

List of Figures

List of Tables

List of Abbreviations and Acronyms

CAPEX	Capital Expenditures (Investment related costs)
CPMU	Customer Plant Management Unit
DER	Distributed Energy Resource
DSO	Distribution System Operator
EC	Energy Community
EV	Electric Vehicle
ICT	Information and Communication Technology
IT	Information Technology
INTERACT EC	INTERACT Energy Community
LV	Low Voltage
OPEX	Operational Expenditure (Running costs)
P2P	Peer-to-Peer
PV	Photovoltaic power plant
ROI	Return on Investment
TSO	Transmission System Operator
V2G	Vehicle to Grid
WP	Work Package

Table of Contents

1 Introduction

1.1 Purpose of the document

The aim of the document is to describe business cases that may be relevant for the INTERACT Energy Community (INTERACT EC). In Deliverable D 4.2 the technical use cases were described and sorted in four categories: normal and abnormal operation, flexibilities, and long-term planning (see Figure 1). For each use case, the Deliverable D 4.2 gives a process chart in a standardized layout, and the description of the process flow. It defines the actors involved, the goal of the use case, and a potential expected reaction on the process.

Figure 1 – Summary of technical Use Cases of INTERACT ECs

In this Deliverable D 5.2 we look at the INTERACT EC from a business perspective and try to define economic use cases following the structure above, and qualitatively define their cost and revenue structure.

1.2 Relation to other project activities

This document is the second of three deliverables of WP5 and builds on results of WP3 and WP4 – especially D 4.2 Use Cases for the integration of the existing innovative technologies with the *LINK*-solution. The business cases selected and described here will be economically evaluated in the third deliverable of WP5 (D 5.3.) and will contribute to developing the roadmap in the WP6 of the project.

1.3 Structure of the document

The document is divided into two main chapters and the conclusion. The Chapter 2 is describing the six main categories of factors that influence the viability of business cases.

Chapter 3 derives from the technological use cases described in D 4.2 possible business cases starting from the basic operation to advanced and integrated operation into the energy system, and finally fully integrated operation including the proposed new market structure based on the *LINK*-architecture described in deliverables of WP4.

2 Important factors influencing business cases for ECs

In WP4, we defined the possible use cases, described their objectives and procedures. We will now look at the described use cases from a business perspective. Before discussing the business cases, it is useful to start by describing the main categories of factors that influence the viability of business cases, which we summarized into six fields: i) the regulatory framework; ii) the conditions in the energy market; iii) the type of technologies used; iv) the ownership structure within the EC itself; v) the size of the EC; and vi) financing and funding options (see Figure 2).

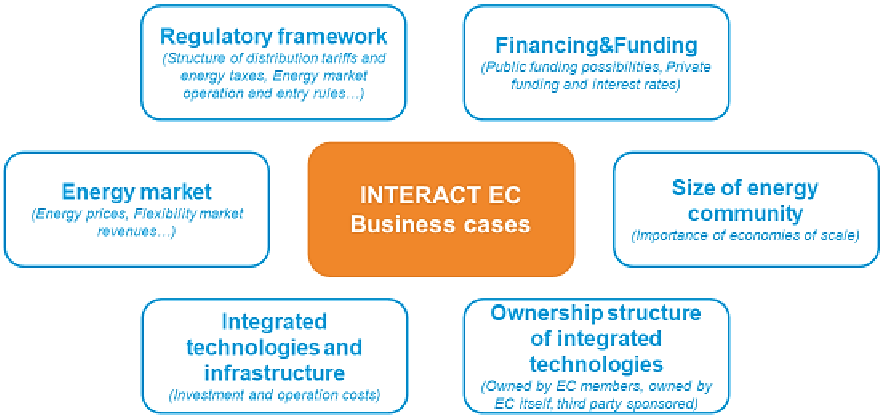

Figure 2 – Energy Community business cases viability factors

2.1 Regulatory framework

We have discussed regulatory framework related to operation of ECs in the Deliverable D 5.1. Of particular importance to the business cases of ECs is the structure and potential reduction of distribution charges, system service charges, renewable energy support charges and taxes, i.e., the portion of end-user energy prices that are regulated.

In D 5.1. we presented the current reduced distribution charge rates and renewable tax exemptions for so-called local and regional renewable energy communities defined in the Austrian legal framework. In Sweden, no such advantage is set yet. In the Czech Republic, legislation for energy communities is not implemented by now, the reduction of distribution charges is being discussed. Already these three examples show the differences of the current regulatory framework and its impact on ECs from a business perspective.

Another regulatory area important to the viability of business cases is the conditions for direct participation in the provision of flexibility on the energy market, which we also described in more detail within D 5.1. In particular, for the area of direct participation in the ancillary services markets for TSOs/DSOs, strict criteria apply to the quality of the ancillary service delivered, especially in terms of stability of the service delivered over time, the granularity of the data measured, and minimum power output (e.g., 1 MW in the Czech Republic while currently 0,1 MW are required in Sweden as a minimum power output). Meeting these criteria, especially for small energy communities, can be quite above their capacities.

Conditions for the participation of smaller actors in the market for ancillary services are being improved (e.g., the minimum required performance or length of service provision is reduced) as it is envisaged and defined by EU regulation, i.e., the European Guidelines on Electricity Balancing (European Commission, 2017).

2.2 Energy market conditions

A key element influencing the economics of energy communities is the achievable price margin resulting from the difference between the market price of electricity that community members would have paid at the electricity market and the production costs from local renewable resources of the EC or its members. In Figure 3 below we show a generalized and simplified price chart with one electricity market price (blue line) and two separate EC production units (orange and yellow lines). The blue area shows the possible price margin available for the EC to distribute in both cases, the orange area the price margin available for the EC to distribute in case of Production Plant 1 only. Both price margins are negative in Period 9, as the market price is below production costs.

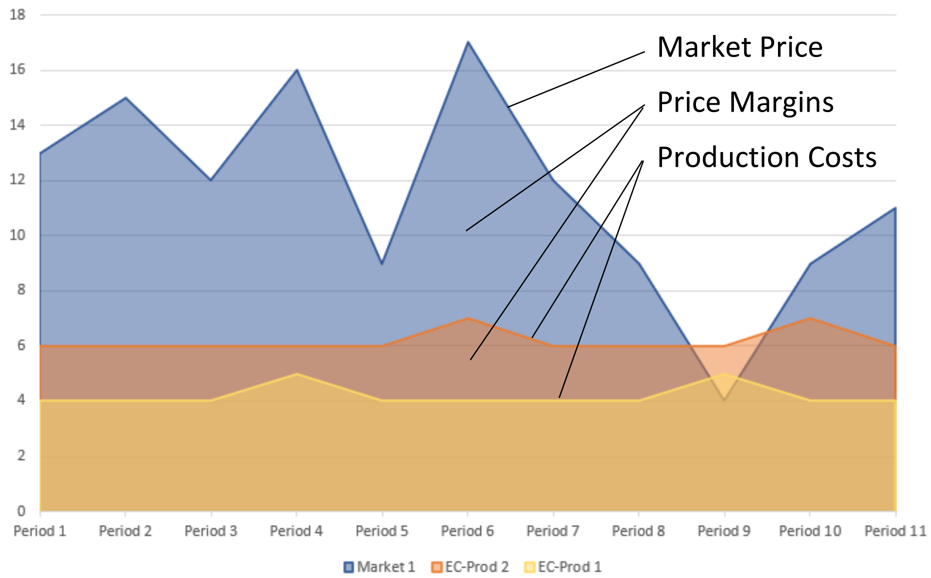

Figure 3 – Price Chart showing Market Price, Price Margin and Production Costs over time

In addition to the above-described price margin the EC members may achieve savings on distribution fees and taxes (see Section 2.1). The price margin can be explained for example by the omission of external energy trader's margin, or lower variable and fixed production costs of locally produced (renewable) electricity.

In the case of participation in an ancillary market, there is important to consider the size of revenue opportunities associated with providing flexibility of the consumption/production diagram to the energy market.

Furthermore, INTERACT is proposing a new market structure, which would allow a direct connection between the different electricity markets (national, regional, and local), and an optimal operation on each level. Details are available in D4.3, as well as under Business Case Fully Integrated Operation in Chapter 3 below.

2.3 Energy Community integrated technologies

Another group of factors relates to the energy community itself and focuses on the types of technology involved and their ownership structure (see 2.4).

Integrated technologies of ECs are described in detail in Work package 3. In very general terms, they can relate to

1. technologies producing energy (e.g., PV, wind turbines, water turbines, …),
2. technologies storing energy (e.g., batteries, EV-cars, heat pumps, …), and
3. technologies enabling the operation of the EC (e.g., ICT infrastructure, …).

For the viability of business cases, most important is the cost structure both on a short-term during operation and on a long-term as investment. For the fully integrated functioning of an INTERACT EC not only the distributed sources themselves are important but also an adequate ICT infrastructure including the CPMU for each EC member that enables seamless communication with the Local market facilitator as described in technical use cases in D 4.2

2.4 Ownership structure of integrated technologies

From a business and legal perspective, the ownership of the integrated technologies is very important. Regarding different needed contracting models, we will go into further within D.5.3. "Required contracting models and economic evaluation of the solution". Basically, the technologies can be either privately or community owned, and there can be also direct and indirect third-party involvement.

We have described existing technologies and infrastructure as well as necessary replacements/upgrades/additions to the infrastructure and measuring devices in pilot regions in Deliverable D 3.2. Here we summarize the technologies into 2 groups:

1) Technologies related to the Customer Plant: storage of energy, production of energy, and consumption of energy.
2) Technologies related to the infrastructure necessary for the operation of the EC: power grid, ICT infrastructure.

From the ownership point of view, integrated technologies and infrastructure can be owned by three different types of counterparties:

1) Integrated technologies and necessary infrastructure may be **owned directly by members of the energy community.**
2) Integrated technologies and necessary infrastructure may be **owned by the energy community itself** as a legal entity with ownership stakes held by individual members.
3) Another possibility is **third-party ownership** of the assets that affect the functioning of the energy community. Third parties are a very broad group of potential partners for the energy community. It can be divided into two sub-categories:
    3.1) **Sponsored ownership of third parties**: here third parties invest into EC related technologies (e.g., into buildings, into production facilities, or in a local distribution grid) and then transfer usage rights in the form of rent/lease

contracts to the EC or EC members. An example could be a real estate developer.

3.2) **Direct ownership of third parties:** Here, third parties own and operate the assets having an impact on Energy Community operation. An example could be a regional DSO owning the distribution grid and metering devices, or EV owners who are not members of the energy community and who could use charging stations belonging to the assets of the energy community.

Table 1 summarizes the possibilities of ownership structure in relation to the energy community. It is clear from the Table 1 that most assets and infrastructure can be owned by all variants of owners, suggesting a multitude of different contractual relationships forming the different variants of ECs.

Table 1 – Ownership of integrated technologies and infrastructure - possibilities

	CUSTOMER PLANT						INFRASTRUCTURE			
Ownership	Elect. production	Heat pump	Energy storage	Charging station	EV	Household appliances with contr. load	Metering device	CPMU	EC commu-nication platform	Cables and lines
INTERACT EC members	✓	✓	✓	✓	✓	✓	(✓)	✓		✓
INTERACT EC (itself)	✓	✓	✓	✓	✓		(✓)	✓	✓	✓
3rd party sponsored ownership (lease/rent)	✓	✓	✓	✓	✓	✓			✓	✓
3rd party direct ownership					✓		✓			✓

For each asset type, examples of specific technologies that can be used in operation of energy communities are provided. On the side of customer plant this can represent electricity production sources such as rooftop solar PV, heat pumps, local energy storage (stationary battery storage), charging stations and EVs, or other household appliances with a controllable load such as air conditioning. Their investment and operation cost are key factors that influence the viability of the various business cases.

On the infrastructure side, there are four important components. The metering equipment that interfaces with the distribution network (normally owned by the DSO, but theoretically also be the EC itself or its members respectively), the ICT components that are indispensable part for INTERACT EC: the customer plant management unit (CPMU) and the energy community communication platform and finally cables and lines that can be in the ownership of DSO or owned by the energy community or third party in case of creation of local distribution grid for energy community (which is more relevant for green field development projects).

Functionalities of CPMU were described in deliverables of WP3 and WP4. Presence of own advanced metering device CPMU is key for a fully integrated INTERACT EC and enables to have own data on EC operation and acts also an operation forecasting and communication tool: CPMU automatically generates the day-ahead schedules and send them to the local market facilitator. The device creates additional costs for the EC which are difficult to specify at this time, as the CPMU is not physically developed yet. The development and testing of the CPMU should be part of a follow-up research / industrial project.

The EC communication platform can have various forms both related to the front-end devices (e.g., web portals or mobile apps) as well as to the server and its functionalities such as billing, management of the local energy market access, management of own technologies, communication and engagement tools that share information and advice within the community, or simple information display showing how the systems performs. Therefore, costs related to its development, installation and operation can vary significantly.

2.5 Energy community size

The larger the Energy Community the more viable business cases can get, as economies of scale are valid, and some business cases are only available once a certain total capacity of offered services is reached (see above 2.2). Figure 4 below shows the generalized structure of economies of scale, where long term average costs are first decreasing in relation to the total output quantity, afterwards reaching an optimum quantity, and then as a rule of thumb increasing again with increased complexity and administration of large enterprises.

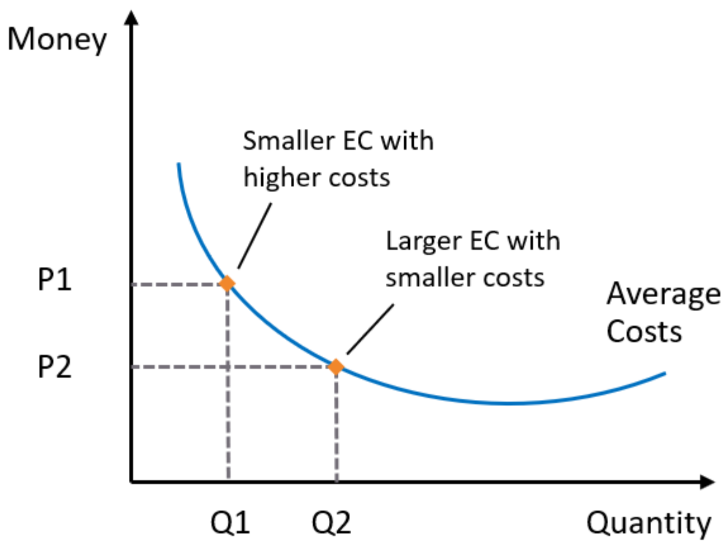

Figure 4 – Economies of Scale for ECs

With larger ECs the cost of investing in the operation of the communication platform and the local energy market platform can be divided among a larger number of members. A larger number of members will also have a better bargaining position when negotiating the price of installing new technologies (volume rebates). And finally with a larger total margin of money available for distribution, the EC might also decide to enlarge itself by investing into its own technologies, further adding to the above stated economies of scale.

2.6 Financing and Funding

We have already discussed price and tax related regulatory support under success factors in WP2. In addition to these operational supporting items, also the investment into technologies for the EC or its members as well as the creation of the EC itself might receive public or private funding and support. Now, various public funding schemes related to the investment into renewable energies, the improved resilience of the power grid, as well as improved services and possibilities for an energy efficient lifestyle are available at all levels of administration: at the local municipality, at a regional level, at a national level, or at different multinational levels. Each EC initiator and EC member needs to check the options available at the specific locations.

With respect to the business cases, public subsidies and preferential interest rates on the private financing side have the same effect as any other measure increasing the total margin. In this case, they for example reduce the cost of construction and thus the cost of local energy production. When the funding is targeted directly to energy communities, they reduce the initial investment into ECs, and sometimes even the operational costs of the initial phase of its operation.

Also, the EC itself can be seen a means of financing the implementation of DERs, where the EC members are together investing into the new technology, and then together benefit from its operation.

3 Use cases and relevant business cases

The analysis of possible business models for Energy Communities has been the focus of several research projects and researchers in recent years. European Commission initiative BRIDGE within its Energy Communities and Self-Consumption Task Force (BRIDGE, 2021) analyzed collective energy actions, including energy communities and their business models in 2021 on country-level approach. Horizon 2020 funded project NEWCOMERS has analyzed over 50 research papers on this topic since 2015 and conclude with following division into five types (Mlinarič, M. et al., 2019):

I. Local renewable energy generation and supply
II. Innovative contracting and community-based products (including e-mobility)
III. Community energy storage services
IV. Peer-to-peer energy trading platforms
V. Community energy aggregators

In its analysis NEWCOMERS also conclude that new business models rarely, if ever, start from nothing; instead, they re-order existing relationships between consumers and wider energy system actors, to create a range of new (complementary) value propositions (Hansen, P. Barnes, J. and Darby S., 2022).

It can be assumed (based also on our research and expert interviews done in WP2 deliverables) that this reorganization of relationships and identification of possible business models will happen gradually, from the basic functioning of the energy community towards fully integrated operation into the energy system concepts and business models (see Figure 5). In following sections, we will describe selected business cases in detail.

While the technological use cases describe the physical flows of electricity and their management in case of INTERACT EC, within the business cases here we describe the flows of the cost and revenue structure on the interface towards distribution grid and energy markets. The different layers of markets were described in detail in WP 4 (Deliverable D 4.2): from local to regional, national, and international level.

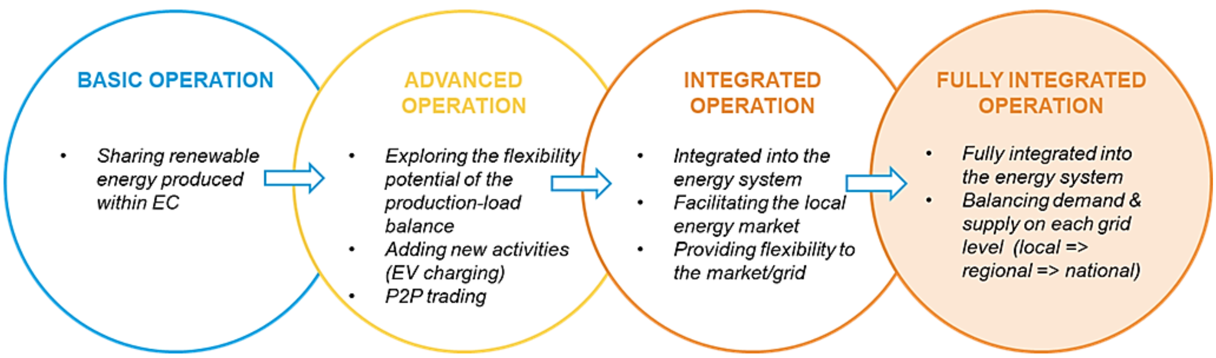

Figure 5 – Possible transition from basic towards fully integrated operation and business cases of energy communities

3.1 Basic operation

The basic operation describes the baseline situation for community renewable energy operation (see Figure 6) and can be further extended to more advanced business cases related to INTERACT EC.

Within the basic operation, we assume that the EC members and the EC are selling within the community surplus electricity, which means the produced electricity after own consumption. The consuming members are using the electricity as it goes. In comparison to more advanced operations, there is neither an active local optimization of consumption and production, nor is there a permanent communication and integration with the local power grid or the different types of energy spot markets.

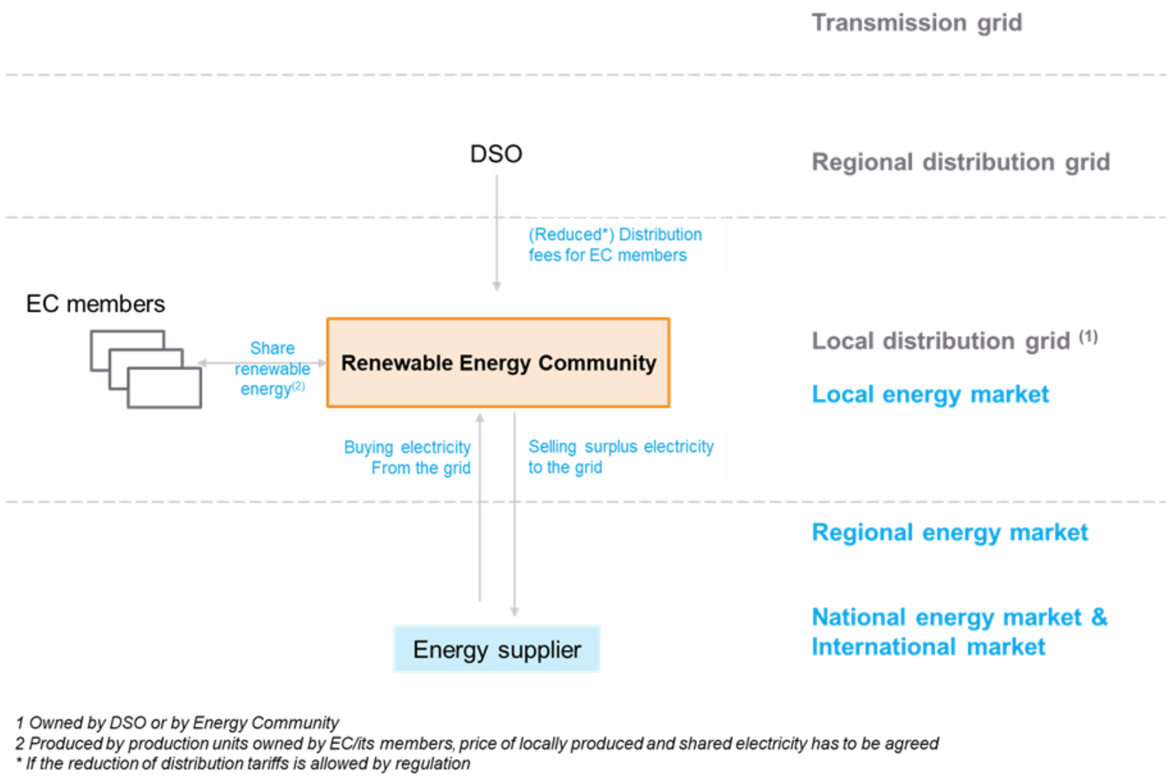

Figure 6 – Basic operation business case

3.1.1 Short description

EC members can share renewable electricity produced by local production facilities which are either owned by EC members or the EC itself.

3.1.2 Possible Configurations and Freedom of Design

During the formation of an energy community, the community members must set the **rules for pricing** of produced and consumed electricity and the **allocation key** for sharing of produced electricity among themselves.

Pricing in relation to the energy produced, stored and/or consumed can be either fixed for a specific period with subsequent review, or dynamic in relation to some indicators (e.g., linked to certain market prices, linked to certain inflation indices, linked to certain energy supplier prices, etc.). For dynamic prices different rules can be applied for consumers and producers, e.g., different indices taken as a base. Each EC member has the right to choose its own energy supplier, both for supply needed for consumption as well as for selling of produced surplus electricity. Market prices of these energy suppliers will in most cases act as limiting borders for the prices set by the ECs, as otherwise the EC members most likely will prefer to use the offer from the energy suppliers.

In addition to the demand-based charges, the distribution fee must be paid as well. Depending on the ownership of the grid (owned by the DSO or owned by the EC itself), the distribution fee is either giving by the national rules or can be set individually by the EC as well. In several countries the formation of ECs is supported by the state with reduced distribution fees, which are enabling the EC to set its own priorities: e.g., motivate producers and/or consumers to join with better pricing; save and invest into own facilities for production and/or storage; improve the services of the EC, etc.

For its services also the EC itself needs to cover its costs and charge them in some way to the EC members.

And finally, all necessary taxes and duties must be considered and charged.

Allocation can be done as well either with static or dynamic allocation rules. These rules are essential for the "fairness" of the EC, and the final electricity bill of all EC members. The more EC members, the more different technologies (different types of production facilities, storage facilities, EV car loading facilities, etc.) and the more different ownership models (EC owned production and EC member owned production, etc.), the more complex is finding "the fair" or "a fair" allocation key.

On the **cost side** of the EC operation, we can differentiate between CAPEX (investment related costs) and OPEX (running costs). The key components of the investment are – if available – the investment costs of the local renewable energy production facilities, as well as the EC ICT structure, including some type of communication platform, which enables communication between members, information of members, and should also handle the routine administration like billing and mailing. Regarding the running costs, it highly depends on the size of the EC, its available resources, and the necessary human resources to run the business. It can be expected that IT-costs and administration costs will account for a large share of the running costs.

Configuration List:

- 1 or more producers
- 1 or more consumers
- 0, 1 or more storage facilities
- 1 or more production technologies
- 1 or more ownership models
- Other offered services (EV car loading, etc.)

3.1.3 Cost- and Revenue Structure

Table 2 summarize the cost structure and revenues streams for the defined basic business case. During “Basic operation” the interface towards the energy market is done via external energy suppliers within the current market structure. A direct connection to the energy market might be available in future set-ups.

Table 2 – Cost structure and revenue streams – Basic operation

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including EC Communication platform
	Operation	Purchase of electricity from EC Members Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Sales of electricity to EC members Sales of surplus electricity to the market (Energy Supplier) Support through reduced distribution tariffs (if available) Support through direct funding of EC operations (if available) Membership fees / Service Fees (if available)

3.2 Advanced operation 1: Optimization of Production/Consumption profiles

Moving from the basic operation to advanced operation, we assume that the Energy Community starts to actively manage the electricity flows within the community, and therefore optimizing the community-wide self-consumption rate.

As described in Chapter 2, an important part of INTERACT EC is the CPMU, which is a community-wide upgrade of the ICT infrastructure at each EC member. With installing a CPMU at each EC connection point, INTERACT EC receives its own data and information, and can build more advanced processes on this data. Furthermore, the CPMU enables also to communicate set-points for different processes, which trigger optimization processes on the EC member level based on the settings of each EC member. This operation is different from the basic operation business case of the renewable energy communities, which relies on data from the DSO (or similar data quality in the rare cases of EC-owned LV-grids). Proprietary data may come at a higher cost but allows the full potential of the flexibility of energy communities to be exploited.

3.2.1 Short description

In Advanced operation 1, we assume that the flexibility potential is captured at the Energy Community level by optimizing the process of balancing the load of local generation and local consumption within the community (e.g., by adjusting the potential controllable load of consumption in relation to the local energy generation profile), see Figure 7.

The local market facilitator is using the information and data from the CPMU to set also correct pricing information, motivating the EC members to adjust their load profiles in accordance with the suggestions, and therefore both optimizing the community-wide self-consumption rate as well as optimizing the community-wide monetary benefits.

3.2.2 Possible Configurations and Freedom of Design

With the **CPMU** additional services are enabled for the EC itself as well as for every community member. These services can be offered with an advanced version of the **EC communication platform**, and might contain:

- different administration possibilities for each EC member,
- more detailed information regarding production and consumption,
- alert settings,
- community wide energy-related services, like
    - EV charging solutions
    - EV sharing solutions
    - Tailored energy efficiency advice
- community wide non-energy services, like
    - Member administration
    - Event scheduling
    - Info-Board

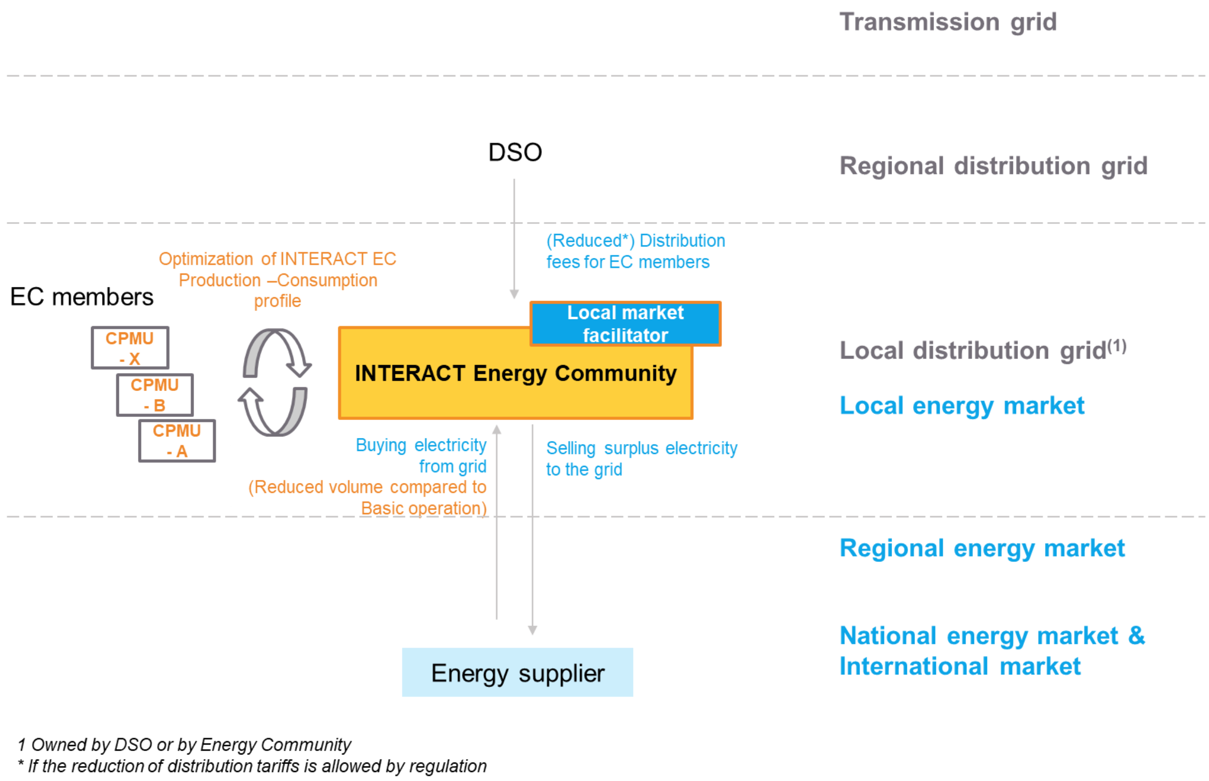

Figure 7 – Advanced operation 1: Optimization of Production/Consumption profile

In Chapter 3.8. we describe some additional business cases resulting from these new possibilities, created by the usage of a CPMU within the EC.

Or course, a community might decide to offer these advanced services only to selected EC members, who are willing to participate within the advanced operation, and other EC members stay in basic operation mode.

Regarding the **optimization of EC-wide self-consumption**, several possibilities exist. Based on forecasted demand and production, theoretically the EC itself can directly control loads which have been made available for this action to the EC by the members. Alternatively, the EC can inform the EC members about the results of the predictions and keeping the execution of potential load optimization steps at the discretion of the EC members themselves.

Within the INTERACT EC, we propose the second variant, establishing an automated 2-stage communication and decision process. This is solving data privacy and individual decision-making topics: the EC is performing the prediction and is communication results via set-points to the EC members. The EC members have their controllable loads under their own control and management and establishing automized rules for using this possibility and optimizing the own and community-wide load profile.

Same as with the basic operation, all possible configurations regarding additional energy facilities (production, storage, consumption) are still valid. Electric vehicle charging stations can also be installed and made available to community members or to the public, at prices set in line with the availability of locally generated electricity from renewable sources

3.2.3 Cost- and Revenue Structure

Regarding the cost and revenue structure (see Table 3), the additional possibilities in reference to the basic operation are highlighted in orange color. Whether the benefits outweigh the costs in this case will be significantly influenced by the size of the Energy Community and the total installed capacity of renewables in the community. Furthermore community-wide benefits and individual benefits might differ. A more detailed monetary evaluation will be done in D.5.3 – Required contracting models and economic evaluation of the solution.

Table 3 – Cost structure and revenue streams – Advanced operation 1: Optimization of Production/Consumption profile

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member
	Operation	Increased Purchase of electricity from EC Members Reduced Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Increased Sales of electricity to EC members Reduced Sales of surplus electricity to the market (Energy Supplier) Support through reduced distribution tariffs (if available) Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available)

Changes compared to Basic operation

3.3 Advanced operation 2: Long-term planning, joint development, and enlargement of the EC

The future development of the Energy Community should be based on coordinated decision-making by members on further investments in local renewable energy sources. Joint negotiation of multiple members with technology suppliers will contribute to the potential for better pricing of new installations. Another area for price reductions in collective bargaining by members may be reductions in electricity prices in negotiations with energy suppliers.

3.3.1 Short description

Long term planning in our sense is a proactive design and development process of the EC towards more advanced services and towards increased benefits for the EC and its members. Figure 8 below shows a potential development path of an EC.

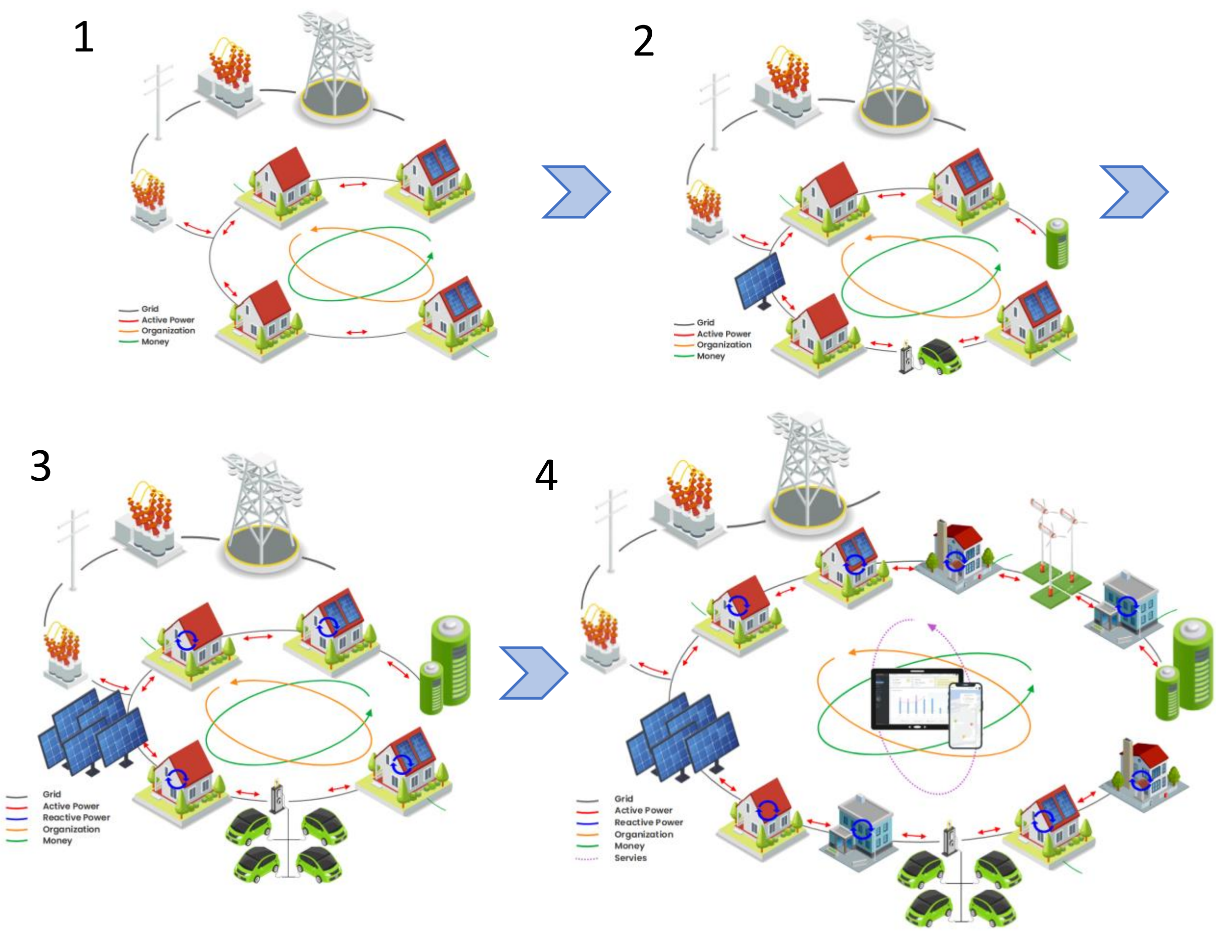

Figure 8 – Advanced operation 2: Long term planning and joint investment

In the shown development path, the EC starts with basic operation and only few EC members in step 1 to more complex basic operation in step 2. It moves to advanced operation with installed CPMUs, control of reactive power, and additional energy facilities in step 3, and finally becomes an integrated INTERACT EC with additional services and advanced EC communication platform in Step 4. Full Integration both towards the grid as well towards the market can be reached with the appropriate market structure, as proposed in D4.3.

3.3.2 Possible Configurations and Freedom of Design

Long term planning also has economic effects and can be a direct business case when this process is executed together with the neighboring grid owners. In that case reduced or controlled needed capacities from the grid can be agreed, which decrease investment costs and/or future investment costs of the DSO owning the grid. Such reduced investment costs can be forwarded subsequently by a decreased distribution tariff for the EC. Furthermore, during this process the communication interfaces and standards should be agreed on, enabling the fully integrated operation of the EC: communication with the power grid and execution of different demand-response processes: price-triggered, emergency-based, or emission-triggered.

3.3.3 Cost- and Revenue Structure

Table 4 below shows the changes in the Cost- and Revenue Structure in comparison to the Advanced Operation 1, highlighted in orange color. The only direct visible change is the possible reduction of distribution fees due to reduced investments needed by the DSO.

Other positive effects of proper long-term planning go in line with the economies of scale described above in chapter 2.5: administration costs per EC member decrease with the size of the EC, revenue streams and price margins are increasing, and additional funds are created for further development of the EC.

Table 4 – Cost structure and revenue streams – Advanced operation 2: Long term planning

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member
	Operation	Increased Purchase of electricity from EC Members Reduced Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Increased Sales of electricity to EC members Reduced Sales of surplus electricity to the market (Energy Supplier) Increased Support through reduced distribution tariffs ~~(if available)~~ Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available)

Changes compared to Advanced operation 1

3.4 Advanced operation 3: Peer-to-Peer trading

Peer-to-peer trading of renewable energy is defined in the REDII Directive (Directive (EU) 2018/2001) as

'*The sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant, such as an aggregator. The right to conduct peer-to-peer trading shall be without prejudice to the rights and obligations of the parties involved as final customers, producers, suppliers or aggregators.*'

While P2P trading is a special form of energy exchange, which must be considered in the context of digitalization and the sharing economy, EC stands for a new form of organization of plant ownership, energy distribution and participation in the energy system (de Almeida et. al, 2021).

An overview of possible P2P markets and current R&D projects in this area is given in Sousa et.al. (2019). They compare three P2P structures found in literature:

a. full P2P market (= direct negotiation among peers),
b. community-based market (= role of intermediator/community manager who manages trading activities with the community),
c. hybrid P2P (hierarchical) market (= combination of a. and b., with different layers for trading energy – within the community and with the energy market. It can be seen as co-existent design of the two previous ones).

3.4.1 Short description

Peer-to-peer trading is opening additional price flexibilities within an EC, as it allows all EC members to trade with each other based on their agreed pricing strategies. The EC itself acts either purely as administrator of these trades, and subsequently operates only with the remaining energy potential, or might offer special separate pricing algorithms for such bargains. Figure 9 below shows the additional trading possibilities when P2P trading is enabled as separate service with an EC.

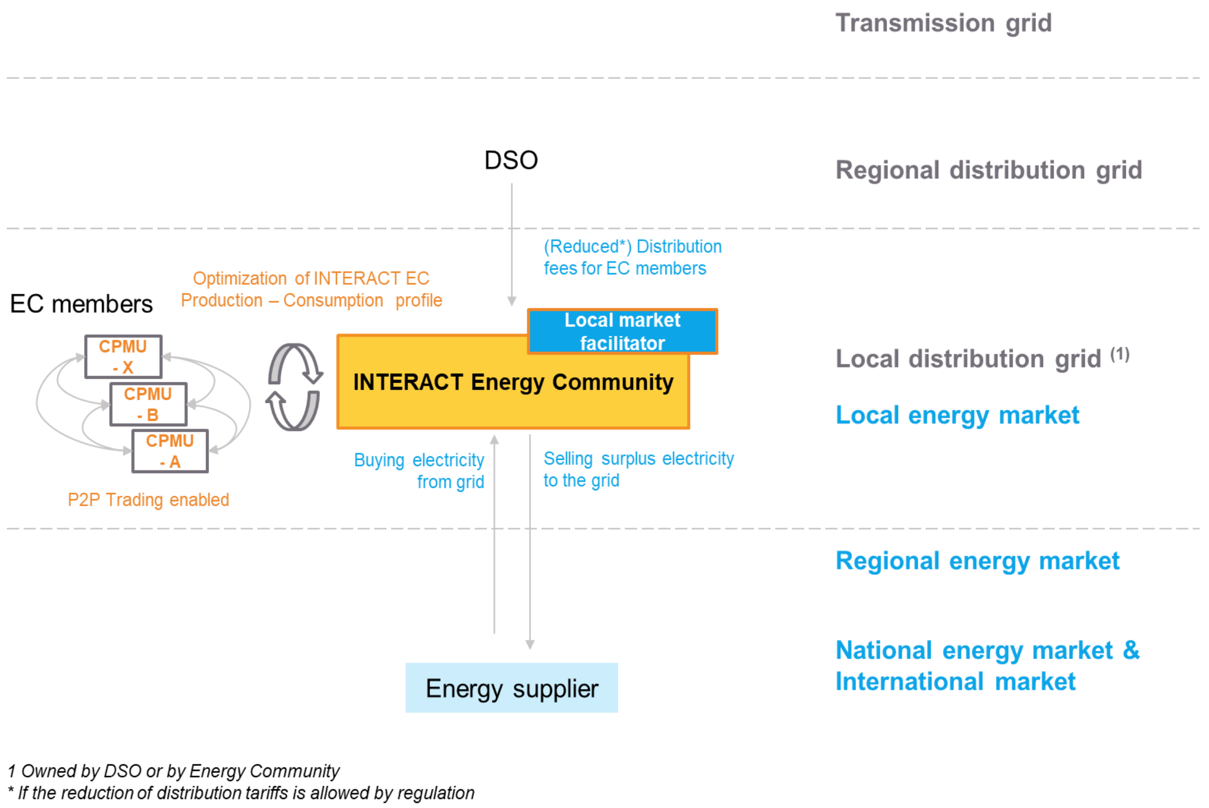

Figure 9 – Advanced operation 3: Peer-to-peer trading

3.4.2 Possible Configurations and Freedom of Design

INTERACT EC use case for P2P trading is defined in D.4.2 and describes the checking of the technical feasibility of community-based market transaction. In accordance with the description above the role of community manager (in our case named local market facilitator) is crucial both for technical reasons (i.e., communication with DSO to check on grid contingencies) and for business reasons (i.e., price settlement, execution, and administration of the process).

The local market facilitator either helps to set the price or directly organizes the local market where the price is being created by bid-order mechanism or other automized algorithms. We can therefore broadly speak about two different mechanisms of price settlement valid for P2P within the Energy Community:

1. **long term price approach**: price settlement reflecting the total cost of production and amortization over the life-time period (which can be perhaps more valid in community developed energy projects) defined in long term power purchase agreement among community members.
2. **merit order settlement linked to short term market**: standard principle for functioning mainly the short-term energy markets. Currently, we can observe the effects of this

approach in extreme conditions with sharp increases in energy prices on the spot market above 500 EUR/MWh in summer 2022.

Whether P2P trading needs to be a separate functionality of the EC could be more clearly defined, as the EC itself can be seen as an enabler of P2P from the beginning.

Opening the possibility for EC members to start trading between each other with own set prices by using the set-up of the EC might cause disharmony between the EC members, especially when it reduces the benefits of the other members.

Adding a separate automated market for P2P with its own algorithm in addition to the market for local EC trading seems rather far-fetched, redundant, and without much additional benefit.

3.4.3 Cost- and Revenue Structure

The CAPEX cost structure for this business case will be like the cost structure in Table 4, as there will be needed investment and operating costs for CPMU unit and the cost for EC Communication platform including the local market facilitator function. OPEX depends in a same way as the revenue streams on the chosen mechanism of price settlement for the P2P trading in comparison to standard EC trading. Ideally, the margin of the EC stays the same, and only the price agreement between selling and purchasing EC member differ.

Table 5 – Cost structure and revenue streams – Advanced operation 3: Peer-to-peer trading

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member
	Operation	Increased Purchase of electricity from EC Members Reduced Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Increased Sales of electricity to EC members Reduced Sales of surplus electricity to the market (Energy Supplier) Increased Support through reduced distribution tariffs Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available)

No changes compared to Advanced operation 2

3.5 Integrated operation 1: Providing flexibility to the market

Providing flexibility to the energy market is one of the key potential future activities analyzed. INTERACT ECs are enabling this by using a standardized structure and common interfaces – as proposed with the holistic *LINK*-architecture (Ilo & Schultis 2022, p. 61). With the correct ICT structure, the trigger points from the grid starting different Demand-Response processes are processed by the EC and forwarded to the EC members. On the market side, with the current structure of the energy market, the service can be (theoretically) offered either directly on the ancillary services market, to energy suppliers or through flexibility aggregators, depending on the flexibility potential of the EC. How the process would look with the proposed INTERACT energy market structure is described below in Business Case 3.7 – Fully integrated Operation.

3.5.1 Short description

Integrated operations are reached when the communication chain with the grid is enabled, supporting the grid processes, and providing additional stability to the power system. Providing flexibility to the market is the first and most important process at this stage. It is reached by defining and accessing flexibility potential within the EC and using this potential based on the power grid needs. Figure 10 shows the involved actors and the principle of this operation from a technical and market view.

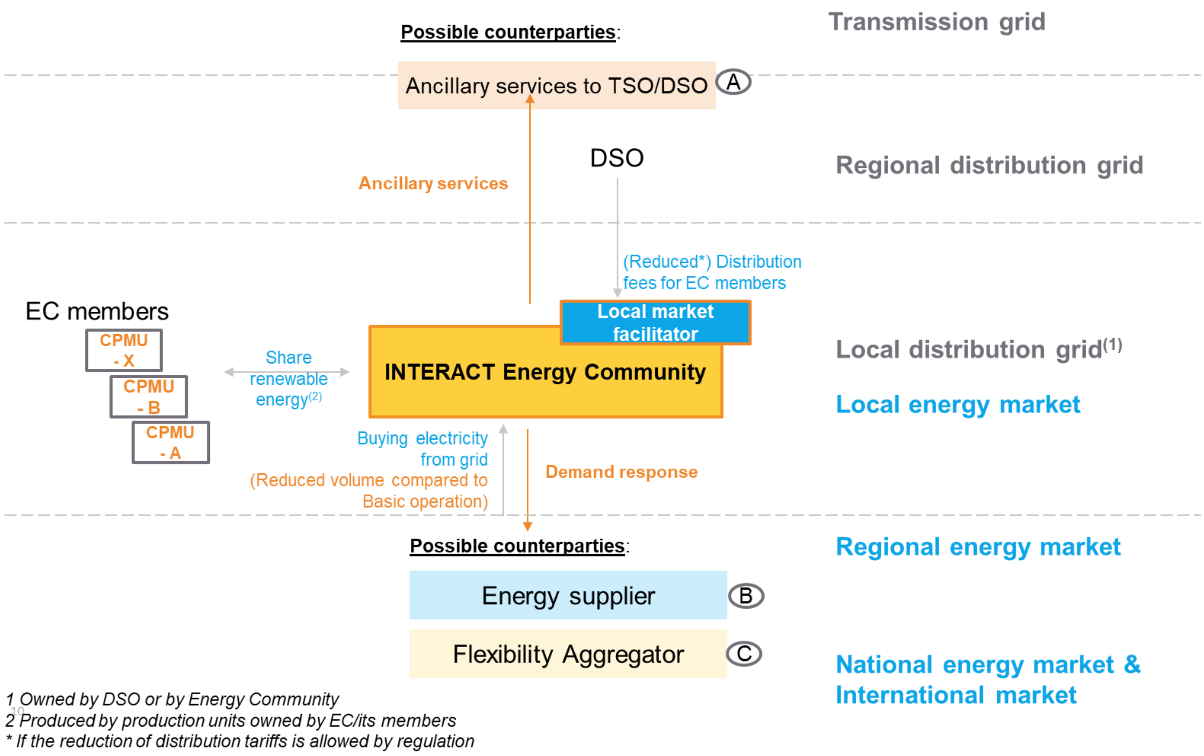

Figure 10 – Integrated operation 1: Providing flexibility to the market

3.5.2 Possible Configurations and Freedom of Design

There are three types of possible counterparties for providing flexibility, which differ in the type of service provided (see Figure 10) via bilateral agreements or flexibility markets:

A. DSO or TSO and provision of ancillary services.

B. Energy supplier and provision of Demand-Response service to reduce his trade imbalances in the short-term market.

C. Flexibility Aggregator and provision of Demand-Response service to reduce his trade imbalances in the short-term market or to contribute to an aggregated diagram for ancillary services.

These services can be provided on the side of INTERACT EC by shifting energy consumption to a different time – by various appliances (so called controllable loads: smart chargers, energy storage appliances, or other appliances with controllable load). Local market facilitator embedded in the INTERACT EC notifies the respective CPMUs to execute the demand increase. Specific case for deploying e-mobility in the INTERACT EC to promote additional and valuable flexibility resources was described at Ilo, A. et al. (2022).

Providing these services are not mutually exclusive – in fact all these services fulfill the same defined goal: to modify the load to balance surplus in the grid. This can be driven either by congestion alleviation in case of ancillary services (see description of D 4.2 Flexibility Use case: Congestion alleviation – Emergency-driven demand response) or by price in case of reduction of trade imbalances in the short-term market (Use case: Price-driven Demand Response in D 4.2).

It is more likely that only one option of service to be provided will be chosen for a given community. The choice will be influenced by market opportunities (price for the service provided and qualification conditions for the delivery of the flexibility service). Stricter conditions will be required for the direct provision of ancillary services in terms of minimum power provided and granularity of measured data.

The least complicated option might be to provide these services to the energy supplier that is selling electricity to INTERACT EC.

3.5.3 Cost- and Revenue Structure

Table 6 below shows the changes in the Cost- and Revenue Structure in comparison to the Advanced Operation 3, highlighted in orange color. As can be seen in the table, no additional OPEX occurs in comparison to the advanced operation, as the CPMUs and the necessary advanced EC Communication platform are already in place.

The service needs to be set-up, both internally with defining and accessing the available flexibilities within the EC, and afterwards externally by linking the EC to one or more of the counterparties named above.

Table 6 – Cost structure and revenue streams – Integrated operation 1: Providing flexibility to the market

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member
	Operation	Increased Purchase of electricity from EC Members Reduced Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Increased Sales of electricity to EC members Reduced Sales of surplus electricity to the market (Energy Supplier) Increased Support through reduced distribution tariffs Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available) Revenue from Flexibilities sold to the energy market

Changes compared to Advanced operation 3

3.6 Integrated operation 2: Provision of back-up power

The second described business case for the integrated EC is derived from the abnormal operation use case described in D 4.2 In this case, the EC is providing back-up power during emergency times, meaning during black-outs.

3.6.1 Short description

INTERACT EC via coordination and activation of free capacities within the community can reduce the recovery time after partial or complete power outage. For this business case, special storage facilities might be kept by the EC. Figure 11 below shows next to the share of renewable energy the storage of renewable energy for emergency cases.

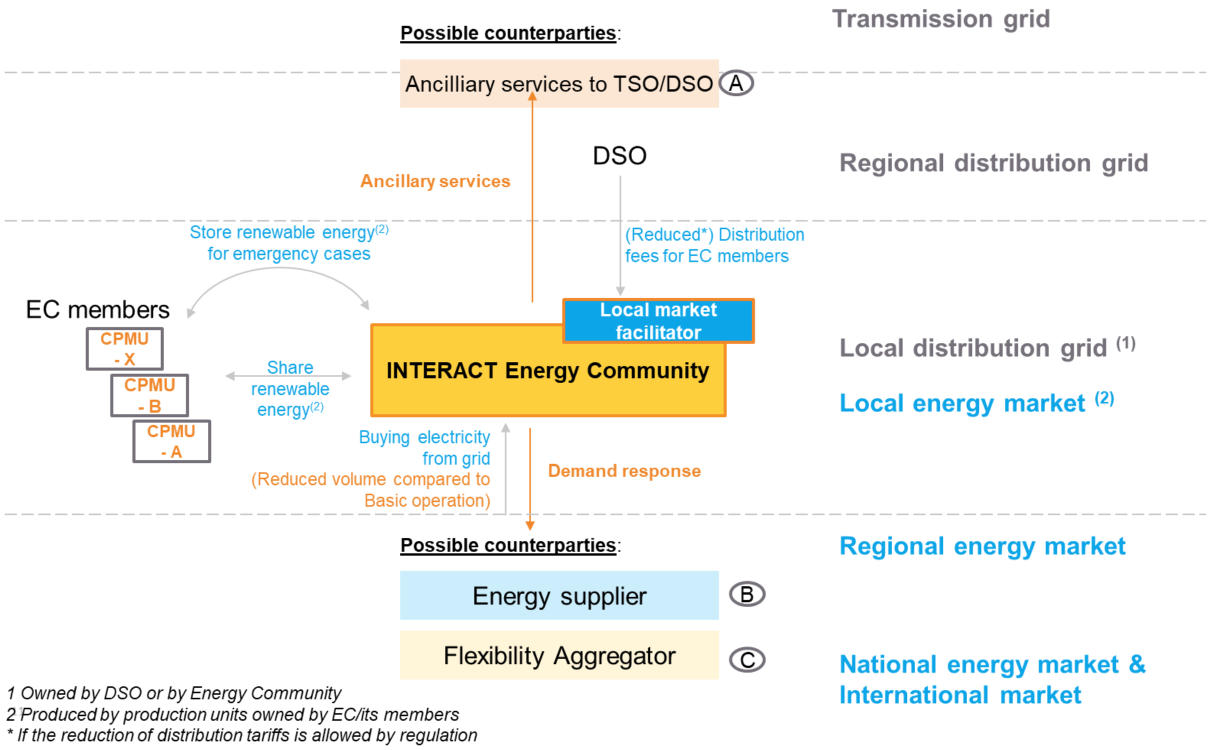

Figure 11 – Integrated operation 2: Providing back-up power

3.6.2 Possible Configurations and Freedom of Design

This business case can be a supplementary case to case Integrated operation 1– Provision of the flexibility to the market, as provision of back-up power (black start) is one of the ancillary services.

Depending on the requests of EC members, the provision of back-up power in emergency cases can be offered first within the community, and only afterwards to the market. To enable this business case EC probably needs to invest in additional energy assets (on the side of energy storage) to guarantee the availability of energy at emergencies.

Pricing of the service can be either on demand, or like insurance services with a flat fee, and no extra charges when the services is actually needed. As the EC is a non-profit organization, the overall expected revenue of the service should correlate with the overall total investment costs of the storage over its expected lifetime. A potential price margin of the service to market prices might be shared between the EC members or used for further development of the EC.

3.6.3 Cost- and Revenue Structure

Regarding the cost structure, CAPEX of additional storage might be necessary. On the other hand, additional revenues through the new provided service can be added, see Table 7.

Table 7 – Cost structure and revenue streams – Integrated operation 2: Provision of back-up power

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member Additional storage facilities for emergency cases (if needed)
	Operation	Increased Purchase of electricity from EC Members Reduced Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Increased Sales of electricity to EC members Reduced Sales of surplus electricity to the market (Energy Supplier) Increased Support through reduced distribution tariffs Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available) Revenue from Flexibilities sold to the energy market Revenue from Back-up power provided and/or ensured

Changes compared to Integrated operation 1

3.7 Fully Integrated operation: INTERACT Market Structure

The fully integrated operation is reached, when the EC is both connected and embedded into the power grid, as well as into the electricity market structure. INTERACT is proposing a new energy market structure, which is enabling this connection in a standardized and seamless manner based on the *LINK*-architecture. More information on this structure and connection can be found in D4.3.

3.7.1 Short description

The proposed new market structure is derived from the structure of the power grid and follows the current technical grid levels: high-voltage grid, medium-voltage grid, and low-voltage grid. Subsequently, national, regional, and local markets are derived, which are connected to each other, see Figure 12.

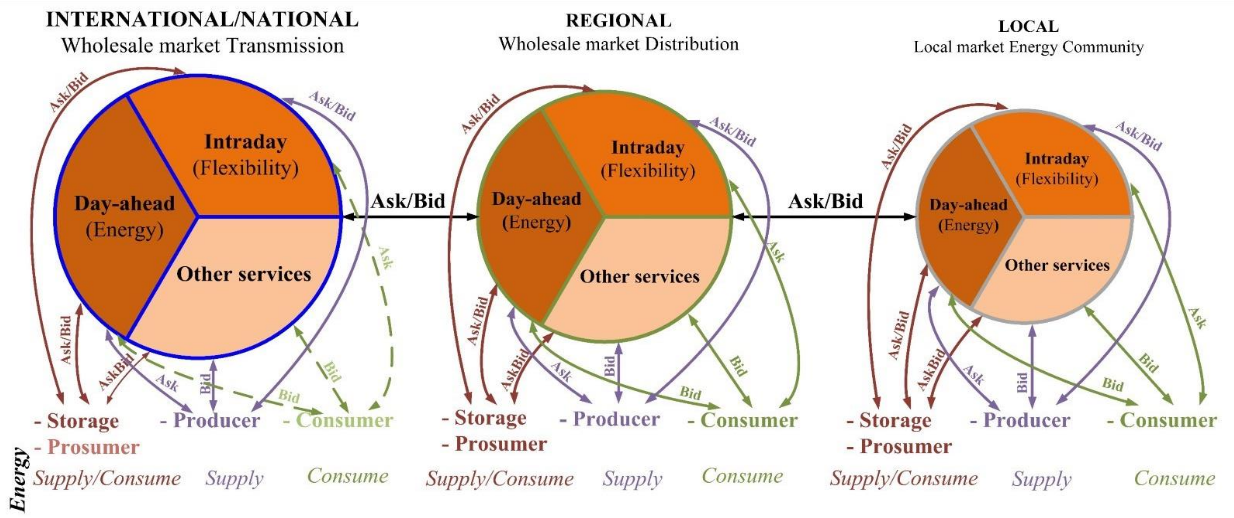

Figure 12 – Connected national, regional, and local energy markets in accordance with the *LINK*-architecture

Thanks to this proposed market structure, prices are generated on each level in an iterative way, balancing demand and supply on each grid level in connection with the demand and supply of the level above. No aggregator is needed, as each market is automatically included in the market on the next level as one consolidated participant. This has positive implications on data privacy and information security aspects.

The fully integrated Energy Community is making prices on the local level based on the internally agreed pricing strategy. Excess production and/or required consumption are gained based on the prices set by the regional market. The same is valid for potential intraday flexibility and other services. The automatic connection to the higher-level market should avoid inefficiencies. Further research is needed to simulate and validate this proposed energy market model.

Figure 13 below shows the impact on the business operation of the Energy Community, based on the fully developed business case „Integrated Operation 2". Energy flows on the grid level are mirrored by money flows on the market level.

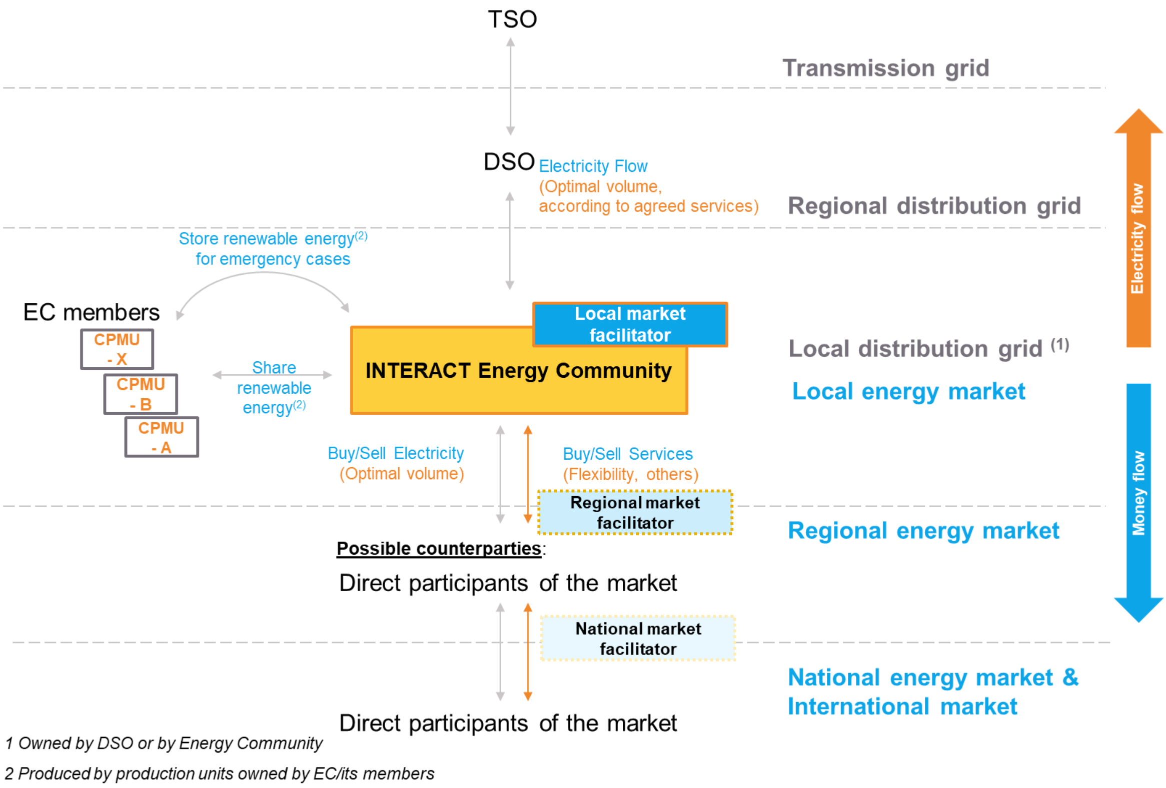

Figure 13 – Fully integrated operation of the INTERACT EC

3.7.2 Cost- and Revenue Structure

Regarding the cost- and revenue structure (see Table 8 below), no additional elements are necessary. The revenue streams should be optimized in accordance with the market needs and local possibilities. Automated market participation should minimize related indirect costs.

Table 8 – Cost structure and revenue streams – Fully integrated operation of the INTERACT EC

Cost structure	**Investment**	Community assets (production facilities, storage facilities, etc.) ICT structure, including advanced EC Communication platform and CPMU unit for each member Additional storage facilities for emergency cases (if needed)
	Operation	Optimal Purchase of electricity from EC Members Optimal Purchase of electricity at the market (Energy Supplier) Maintenance of ICT structure, incl. CPMU Administration (Billing, Memberships, Bookkeeping, etc.)
Revenue streams	**Operation**	Optimal Sales of electricity to EC members Optimal Sales of surplus electricity to the market (Energy Supplier) Increased Support through reduced distribution tariffs Support through direct funding of EC operations (if available) Membership fees / additional Service Fees (if available) Optimal Revenue from Flexibilities sold to the energy market Optimal Revenue from Back-up power provided and/or ensured

Changes compared to Integrated operation 2

3.8 Other possible services

3.8.1 Basic operation

3.8.1.1 Joint purchasing of electricity

Acting jointly and choosing one energy supplier for the whole community may bring better price for the whole community.

3.8.1.2 Joint purchasing of Equipment, Maintenance and Services

Choosing one supplier for energy facilities may not only bring better prices for the installation, but also the option of better service levels, standardized processes, and a faster build-up of technical knowledge about troubleshooting within the EC

3.8.1.3 Consulting and Advisory Services in energy-related topics

Being the organization responsible for green energy within the local community, the competences of the EC might be directed towards becoming the single-point-of-competence in energy-related and energy-efficiency related topics. Potential services offered to EC members but also to non-EC member could be:

- Identification of energy saving measures.
- Administration of energy facility installations (building allowances, technical allowances, communication with the DSO and other actors).
- ROI calculations of investments into energy facilities (production, storage, mobility, metering equipment, etc.)
- Organization of schoolings, workshops, and events
- Information regarding Financing and Funding

3.8.2 Advanced operation

3.8.2.1 EC community services

With the installation of a common platform enabling interaction between the EC members, various community services might be developed, which could bring additional benefit to the EC members and potential revenue streams to the EC. Here some possibilities:

- Renting service of special equipment.
- Database of experts and good quality professionals.
- Electronic bulletin board, FAQ, and technical forum.

3.8.2.2 Customer Plant services

The CPMU might be enlarged to serve further functionalities requested by the EC members, which are going towards smart homes: comfort features, alert systems, remote-controlled steering of appliances, etc.

3.8.3 Integrated operation

3.8.3.1 Mobility Services

With the availability of renewable electricity, the EC might expand its offer towards mobility on demand services and invest into Electric Vehicles available to rent for the EC members. The EVs in that case should be usable as storage for the EC, which is enabled with new bidirectional charging technologies like V2H (vehicle-to-home), V2B (vehicle-to-building), V2L (vehicle-to-load) or V2G (vehicle-to-grid).

Together with the EC Communication platform an easy booking and reservation system might be developed. And during the idle times of the EV, the battery can be used as storage to provide flexibility, or as storage to provide back-up power.

4 Conclusions

Business models in the energy sector are changing and becoming more customer-centric: The customers play an active role in energy supply. The way in which the power grid should be managed, as well as the interaction between all actors in the energy value chain, should become more direct, simpler, and more structured.

Optimizing the allocation of energy produced and increasing stability of the system are goals of Energy Communities, which shall lead to the establishment of Positive Energy Districts and Neighborhoods.

The role and functioning of Energy Communities within the European energy market will gradually find its main and complementary business cases. In this deliverable, we have outlined the possible business cases of Energy Communities on their transition from basic towards fully integrated operation within the power grid and energy market.

We have described the following business cases and their possible cost-revenues streams structure:

I. Basic Operation: sharing of renewable energy
II. Advanced Operation: optimization of production/consumption profiles
III. Advanced Operation: long-term planning
IV. Advanced Operation: peer-to-peer trading
V. Integrated Operation: providing flexibility to the market
VI. Integrated Operation: provision of back-up power
VII. Fully integrated Operation of the INTERACT EC: INTERACT Market Structure

Furthermore, we outlined other possible services of Energy Communities, which are in line with their general aims and might help them to reach their self-set goals.

Reaching the fully integrated operation stage is the intention of INTERACT ECs.

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