

Overview of the Current State of the Art of Existing Energy Community Concepts in Europe and their Possible Implementation in the Czech Republic

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Abstract— This paper presents an overview of the current state of the art of energy communities in Europe and discusses real examples/concepts implemented in some countries that fulfill the issued EU directives by different technical ways. Therefore, it brings so-called allocation keys used in the individual energy community concepts for the distribution of produced energy between consumers and shows the important differences of these keys and their impacts (benefits/disadvantages) for consumers or distribution system operators, so distribution tariffs and the future evaluation of allocation keys are also presented. Furthermore, there is the discussion which energy community concepts (implemented in European countries) or their specific parts can be transferred to the Czech Republic, especially in the context of the current laws and their preparations.

Keywords—Energy community, renewable energy sources, allocation key, tariff, distribution system

I. INTRODUCTION

The idea of energy community (EC), i.e. local energy sharing, can be dated to the second half of the last century and it can be considered that it especially originated in various environmental (ecology) movements in the countries of Western Europe. The main goal of this concept was to reduce greenhouse gas emissions associated with the energy sector. The concept became relevant again in the last ten years after the release of the directives of the European Commission and the Council of the European Union (EU) and after the significant improvement in the availability of renewable energy sources (RES) due to decreasing RES investment costs.

An energy community is a group of people who share or jointly produce electrical energy for their own usage. The establishment of an energy community can be motivated by both environmental thinking and for the purpose of saving electrical energy costs. However, this concept does not represent only sharing electrical energy, but also thermal energy or gas produced in local biogas stations. Above all, in the field of electrical energy, this is a new challenge for distribution system operators (DSOs) due to the possible change in the power flows of electrical energy in distribution system (DS) and due to the additional requirements to measurement, transmission and evaluation of data on the exchange of energy mainly in low voltage DS.

EC was formally defined by two European directives [1] and [2]. The guidelines were created one year apart, and each defines community energy in a different way.

The directive [1] on the promotion of the use of energy from RES, published in 2018, defines EC under the name “renewable energy communities” (REC). A REC could produce, consume, store and above all share electrical and thermal energy. REC would be a legal entity with open access for natural persons, small and medium-sized enterprises and local authorities including municipalities. After joining, it is necessary to preserve the right of members to freely choose an electrical energy supplier, just as in the case of a regular consumer. It is emphasized that the primary purpose of the REC is not to generate profit, but to bring environmental, economic, or social benefits to the members of the community or around operation area. Members of the REC may be partially or completely exempt from certain fees (e.g., for distribution) or taxes. However, the exemption must not occur if the costs are transferred to non-members of the community, or if the public DS is used for sharing.

The directive [2] on common rules for the internal market for electrical energy, published in 2019, defines EC under the name “citizen energy community” (CEC). This directive shares elements of definition, purpose, and rights with [1], but differs slightly in some parts. The important difference is that directive [2] does not talk about electrical and thermal energy, but only about electrical energy. The rights of the CEC are to be expanded to include the provision of energy efficiency services, charging of electric vehicles and other services provided to members of the CEC. It is mentioned that EU member states could allow CEC to own, set up, buy, and lease DS. In such a case, non-members of the community must be able to connect to such a local DS without discriminatory charges for that consumer. The granting of rights associated with the DS is at the discretion of each of the EU member states.

II. ENERGY COMMUNITY MODELS

Existing EC can basically be divided into two models. The first is the EC of an apartment building, the second model is the EC of municipalities, districts or entire regions. The EC of an apartment building is not considered a true community by some countries, as the exchange of energy takes place only in

the given building and is therefore not very different from, for example, factories with rooftop installations of photovoltaic panels. But the allocation keys for energy from a joint production plant are used, which is typical for EC. The EC of municipalities, districts and regions can benefit not only from the installation of renewable sources on buildings, but also from stand-alone wind or photovoltaic power plants. Community members can share the costs of investment and operation of resources in the form of their own fees. The exchange of energy usually takes place via the public DS.

III. ALLOCATION KEYS

According to [3], allocation keys are used to allocate the produced energy. Allocation keys serve only for the economic (or invoicing) equalization of produced and consumed electrical energy and do not necessarily respect the physical flow of electrical energy. The period for which energies are evaluated may vary depending on state legislation. It is usually evaluated every 15, 30 or 60 minutes. Reference [3] informs that allocation keys are divided into static allocation key (SAK) and dynamic allocation key (DAK), or a combination of both. When using a SAK, production is distributed according to a fixed value. In the evaluated time, one consumer is therefore allocated an agreed share up to the agreed maximum (e.g., 10 kWh), but it must always be less than or equal to the consumption. Energy not allocated to any consumer is sold to an agreed energy trader. The DAK distributes energy proportionally according to the current amount of consumption and thus enables more efficient use of energy from the community source. There can also be a combination of both keys, i.e., re-allocation of energy surpluses remaining after the first allocation, which is allowed in France as is mentioned in [4].

The difference in the principle of SAK and DAK can be seen in Fig. 1 and Fig. 2. In the sample cases the production of 10 kWh every 15 minutes is distributed between two consumers. With a SAK, energy is equally distributed between both consumers. In the second quarter hour with time stamp 30 minutes, consumer B is not using his share and the electrical energy is therefore sold to the energy trader. Consumer A, on the other hand, uses more energy than his share and had to buy electrical energy from an energy trader. This problem is eliminated by the DAK in Fig. 2. In the second quarter of an hour with a time stamp of 30 minutes, electrical energy was redistributed in favour of consumer A. If both consumers have a combined consumption higher than the volume of energy produced, a proportional distribution will occur between them. However, if consumer B had a significantly higher consumption than consumer A, it may happen that only a small part of the energy will be allocated to consumer A. Therefore, it is appropriate to divide the costs between consumers according to how much energy they use from the community source.

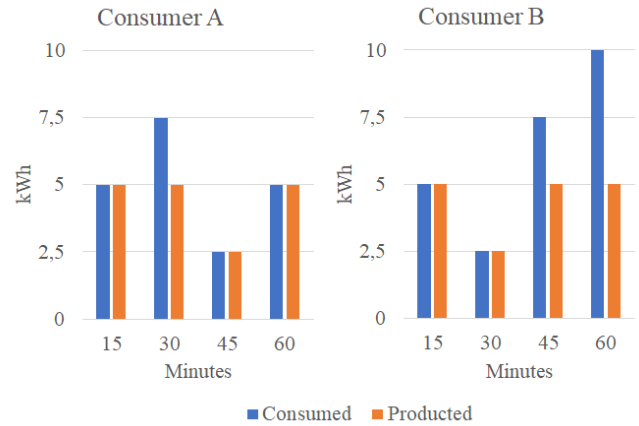


Fig. 1. A demonstration of static allocation key in a case of 10 kWh energy production in every 15 minutes

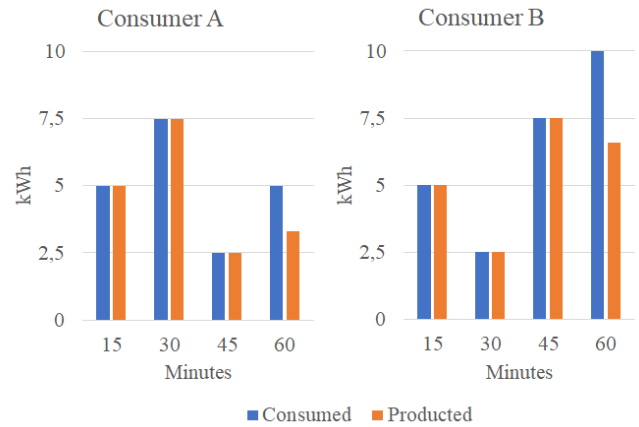


Fig. 2. A demonstration of dynamic allocation key in a case of 10 kWh energy production in every 15 minutes

IV. EUROPEAN EXAMPLES

EC are currently not very widespread across Europe. The reason for this is the lack of legislation in many countries preventing community sharing over a public DS. The pioneers in this field are France, Spain, and Austria. Each of the countries approached the EC in a different way.

A. France

Reference [3] mentions that France was the first country to allow community sharing of electrical energy under the name of collective self-consumption. The first definition appeared in the legislation in 2016 and since then there have been adjustments based on experience. Total power of no more than 3 MWp can be installed within the entity of one EC. Reference [3] also mentions that the area of the EC is set so that the farthest places involved in the EC must be within a maximum distance of 2 km in an urban area or 20 km in a rural area. The areas of two EC may overlap, but each place of production or consumption may be involved in at most one of them. The place of production and consumption must be equipped with smart meters and connected to the low voltage DS, although electrical energy can also be transmitted through the medium voltage DS. Energy allocation is evaluated in 30-minute intervals.

According to [4], it is allowed to use SAK or DAK, including their combination. Multiple allocation keys can be selected for different parts of the year. There are no discounts on distribution fees for energy transmitted within the community.

B. Spain

In [3] is mentioned that Spain also calls EC as community self-consumption. Installed power is not limited both production and consumption sites using the public distribution network must be connected in one of the three following ways:

- In the low voltage DS behind one transformer station.
- In the low-voltage DS at a maximum distance of 500 meters from the most distant points.
- In the same cadastral district determined by the first 14 digits.

Reference [5] informs that energy allocation is evaluated in hourly intervals. It is possible to choose between a SAK or SAK with a variable value. No distribution fees are paid for the energy produced and transmitted in the low voltage DS.

C. Austria

Austria was the last of the mentioned countries to enable community sharing. Austria has separately defined REC and CEC in its legislation. The difference between them is in resources, area, rights, and distribution fee discounts.

Federal law [6] informs that CEC can use any sources to produce electrical energy and can operate in the entire area of Austria and offer services to its members (for example charging electric cars). In comparison with the CEC, the REC can only use renewable resources and can only operate at the low and high voltage levels. The REC is further divided into local and regional EC according to the voltage level they connect to. The local EC is only at the low voltage level. The regional REC is at both the low and medium voltage level, alternatively only at the medium voltage level.

Reference [7] mentions that energy exchanged within the REC is discounted according to how much of the grid is used, but energy bought or sold to an energy trader has full distribution fees. The following discounts are applied:

- A low-voltage customer in the local REC receives a 57 % discount on shared energy due to not using medium-voltage and high-voltage DS.
- A medium voltage customer the REC receives a 64 % discount on shared energy, because he only pays for the medium voltage DS and receives a discount for the high voltage DS.
- A low voltage customer in the regional REC receives a 28 % discount on shared energy, as they must pay for the medium voltage DS in addition to the low voltage DS.

Federal law [6] allows a selection between SAK and DAK for both REC and CEC. Evaluation of energy flows based on allocation keys takes place in 15-minute intervals.

V. SITUATION IN THE CZECH REPUBLIC

From the beginning of 2023, community sharing within apartment buildings in the Czech Republic is allowed by [8]. Before the new legislation came into force, it was only possible to combine the entire house under one supply point. However, consumers thereby lost their rights to freely choose an energy supplier.

In the new legislation [8], a leading and a subordinate collection point are introduced. An installed community source is connected to the leading collection point. Only SAK is allowed. The energy distributed according to the allocation key is evaluated in 15-minute intervals. Adequate electrical energy meters must be installed for a 15-minute measurement. It is not necessary to involve all supply point in the apartment building EC.

A. The Future of Energy Act

The amendment to the Energy Act [9] is currently being revised following a comment procedure. In the future, an EC and a REC could be established. Both entities could generate, consume, share, sell electrical energy and provide other services to their members. The difference between them would be that even medium-sized enterprises can participate in the REC in contrast to EC. But the problem with the current proposal is the missing mention of the possibility of building community energy storage and allowing providing flexibility. The proposal does not even mention the possibility of operating a local DS.

B. Data Hub

In summary report [10] from Ministry of Industry and Trade is written that Data Hub is to be established for the purpose of keeping a database of data from electrical energy meters. It would also be possible to find out real-time information about the possibilities of providing flexibility based on the state of the network. It would also be possible to offer and demand flexibility here. The Data Hub would also participate in the coordination of the preparation for the operation of the electrical energy system of the Czech Republic.

VI. DISTRIBUTION TARIFFS

Current EC of apartment buildings pay only fixed DS tariff for energy shared within the community, and variable DS tariff depending on the amount of energy consumed are exempt. In the future, when the legislation allows sharing over a public DS, this situation might not be sustainable. It is therefore advisable to think about whether to provide discounts, or how big the discounts should be.

The first option is to provide a discount along the lines of Austria, which may not be sustainable in the long term. Costs for servicing DS would be passed on to consumers without EC membership.

The second possibility is to change the ratio between the fixed DS tariff for the size of the circuit breaker and the variable DS tariff for energy taken. According to unpublished document [11] made by DSO, a large part of the network operation costs are fixed, the distribution system operator would be interested

in turning this ratio around and then it would be possible to provide discounts from the variable tariff adequate to the benefits of the community. On the basis of unpublished statistics obtained from the Energy Regulatory Office and on the basis of the price list [12] published by the energy supplier E.ON company, the average payment for distribution tariffs were calculated. Current fixed-to-variable ratio is approximately 30/70. However, calculations also showed that changing ratio to 70/30 would lead to the fact that the customer would pay a large part of the distribution fees in the fixed tariff and would be motivated to reduce consumption primarily by the commercial prices of energy.

The third option is to leave consumers without discounts on DS tariff and motivate only by saving on power electrical energy.

VII. CONCLUSION AND DISCUSSION

The paper shows that EC are and will be gradually implemented in the EU. The reason is the common environmental interest associated with the fulfilment of partial targets for the development of renewable and emission-free sources. ECs are not the only solutions to achieve targets, but they open the other way. The paper also shows that each state approaches EC implementation with different technical and non-technical solutions. Before implementation in the Czech Republic, it is necessary to prepare extensive impact studies and compare the concept that is most suitable for local conditions from the point of view of EC and DSO.

In connection with this, it will be necessary to evaluate the various allocation keys. Anonymized data on the consumption of an example apartment building with 26 electricity meters were obtained for this purpose from EG.D company. Data were recorded every 15 minutes for the entire year 2022. Data from the apartment building will be paired with data from the photovoltaic system. This will also obtain values determining the use of the installed capacity of the photovoltaic system within the apartment building and the potential overflow into the network. After the evaluation at the apartment building level, the community will be expanded to include family houses. The monitored data will result in recommendations for consumers, distribution system operators and possibly also the Energy Regulatory Office.

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