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UPSCALING ENERGY EFFICIENCY VIA ENERGY COMMUNITIES

Abstract:

The European Union promotes the concept of energy communities as a tool for achieving ambitious goals in decarbonisation of the European economy. Potentially, energy communities can bring multiple benefits; they are seen as a way for more efficient power sharing and decentralization and decarbonisation of energy generation as well as increasing locally produced renewable energy.

The aim of the article is to examine establishing and operation of energy communities in the context of the Czech Republic. The article explores current and upcoming legislation on energy communities, the first of its kind that would set the regulatory framework for energy communities for a foreseeable future.

The article describes case studies of energy communities with regard to their implementation in the conditions of the Czech Republic. Case studies focus on technical solutions for modern and renewable energy sources suitable for operation in energy communities.

The article concludes with a summary of barriers, e.g. in the field of property rights and their possible solutions, and benefits of energy communities implementation, such as better distribution of investment costs and the possibility of implementing larger projects, subsequent savings in energy costs, facilitation of renewable energy sources and decentralization of energy production.

The article also discusses the necessary steps for removing the barriers, which would subsequently accelerate the implementation of energy communities.

Keywords:

Energy community; Energy production; Energy generation; Energy Decentralization; Decarbonisation

JEL Classification: D00, Q42, Q43

1 Introduction to the issue of energy communities

The energy system is undergoing major changes in recent years. One of the current trends is the effort to decentralize energy production. Large central sources are gradually being replaced by smaller renewable energy sources.

Local energy sources and small domestic energy sources are becoming indispensable part of the energy system. It can be assumed that the number of these energy sources will increase in the future due to decreasing technology prices and due to favorable changes in legislation support.

The Energy Community is one of the possible solutions to achieve decentralization and decarbonisation of energy generation as well as increasing locally produced renewable energy. The basic principle of the energy community is that the production of energy is moved from a central source to a smaller local source operated by the energy community in order to cover primarily its own energy consumption. Secondly, the surplus of energy can be delivered to the distribution network. At the same time, energy communities can serve as a driver for additional energy saving measures.

The legal framework of energy communities is enshrined in EU legislation, however, in the case of the Czech Republic, the necessary legislation is still being prepared. The article deals mainly with the state of implementation of energy communities and their definition within the conditions of the Czech Republic.

1.1 Methodology

First, the article explores current and upcoming legislation on energy communities. Czech regulatory framework is analysed and its compliance with European legislation is compared. The basic elements of energy communities and the possibilities of their solution are described.

Subsequently, the case studies of energy communities with regard to their implementation in the conditions of the Czech Republic with focus on describing barriers and benefits of energy communities are described.

The work is supported by data from the Congregate project and data from the authors' work and research.

1.2 Legislation and National legal framework

The legal basis for Energy communities within the European Union was laid in 2016 with the so-called Winter Package. The Winter Package was a large set of legislative and non-legislative proposals to ensure a better functioning of the electricity market, increase the share of renewable energy sources, increase savings and gradually reduce the production of electricity from coal. The European Commission emphasized energy efficiency and the role of consumers, who were to gain a stronger position vis-à-vis energy suppliers in the future and the opportunity to play a more active role in the energy market. At the same time, the principle of decentralization and simplification in the field of administration and connection to the grid was outlined and supported, i.e., how to generate electricity for own use and supply surpluses to the public grid at market price without losing consumer status.

The Winter Package also included a proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) COM/2016/0864, in which the first definition Energy Communities was given:

„local energy community' means: an association, a cooperative, a partnership, a non-profit organisation or other legal entity which is effectively controlled by local shareholders or members, generally value rather than profit-driven, involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders;“ ('Proposal COM/2016/086')

The Directive (EU) 2019/944 on common rules for the internal market for electricity itself was published in 2019. The directive includes new rules that enable active consumer participation, individually or through citizen energy communities, in all markets, either by generating, consuming, sharing or selling electricity, or by providing flexibility services through demand-response and storage. The directive aims to improve the uptake of energy communities and make it easier for citizens to integrate efficiently in the electricity system, as active participants (European Commission, 2020)

In addition, Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources aims to strengthen the role of renewables self-consumers. In Article 2.16 the directive introduces a broader definition of “renewable energy community”, which is defined as a legal entity (same definition is used in the directive 2019/944):

- *which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity;*
- *the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities;*
- *the primary purpose of which is 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.”* ('Directive (EU) 2018/2001')

The state of the transposition of the above-mentioned directives into national legislation and development of community energy differs across the EU. While, for example, Greece is being a frontrunner in both legislation development and practical implementation (CONGREGATE Project, 2021) and Austria is already preparing support programmes for community energy (Blažek, 2021), the transposition is still ongoing in the Czech Republic due to the length of the legislative process.

A key point of the new legal framework for community energy is a national official definition of the (renewable) energy community. In the Czech Republic, the energy community will be first defined in the amendment to the Energy Act. The Czech Ministry of Industry and Trade is developing the necessary amendment. Although the transposition should have been done by June 2021, the amendment was approved by the Chamber of Deputies in August 2021 and in case of approval by the Senate it is expected it will enter into force in January 2022 (EnviWeb, 2021).

The amendment to the Energy Act was based on the substantive intent (Czech Ministry of Industry and Trade, 2020), which has been published in 2020 and which serves also as a basis for the whole new Energy Act, which is being prepared and which is expected to be published in

the following two years (Tramba, 2021a). The New Energy Act will include legislation on energy storage, which was omitted from the amendment in the end (Tramba, 2021b).

The amendment on the Energy Act incorporates together the requirements of both directives 2018/2001 and 2019/944 and introduces a uniform definition of "energy community" together with their rights and obligations in accordance with the requirements of the European law.

- The energy community should be a legal person based on the principle of voluntary membership, the main objective of which will not be profit-oriented but rather to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates.
- According to the Ministry's proposal, it does not plan to assign a specific legal form to the community and leaves the choice to its members. The only condition will be to meet the definition features of the energy community.
- Energy communities are subject to registration at the Energy Regulatory Office. Energy communities are allowed to operate a closed or local distribution system and to act on the energy market as an independent entity as well as to retain the customer's rights and obligations at the same time (Czech Ministry of Industry and Trade, 2020).

In addition, an amendment to the Act on Supported Energy Sources is also planned to be published, which will further specify requirements on the renewable energy communities in accordance with the directive 2018/2001 as well as level of support for renewable energy sources (Chamber of Deputies Parliament of the Czech Republic, 2021).

2 Management of energy communities

The chapter describes possible solutions for creating an energy community within the conditions of Czech legislation. The subchapters set out the requirements imposed by the state and the energy regulatory authority.

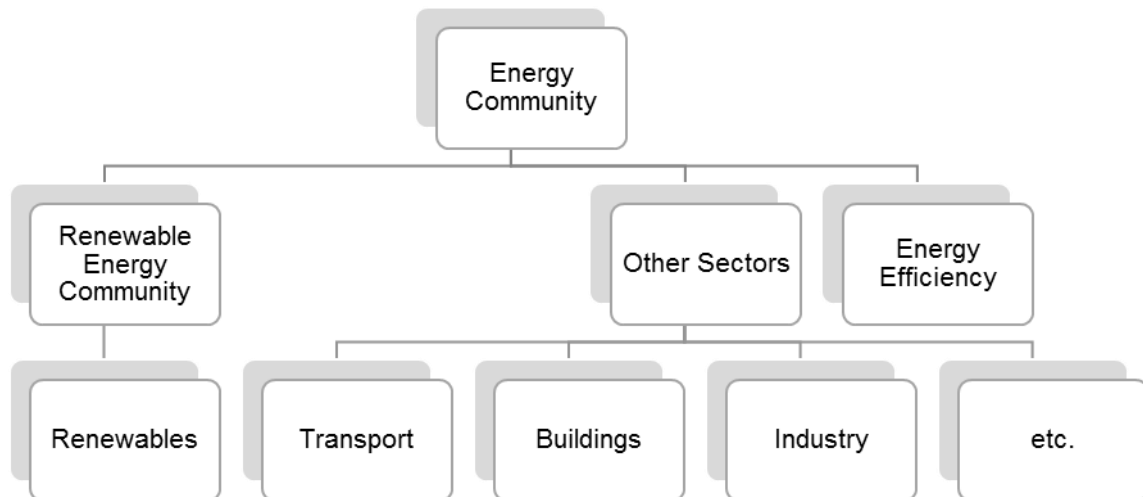


Figure 1 - Scheme of the scope of energy communities

Energy communities can consist of citizens, legal entities and municipalities. This differs in the way they are implemented and in scope. (Frank Bold, 2021) The scope of the non-energy community can be at the level of:

- single apartment building;
- groups of buildings (both houses and apartments buildings);
- neighbourhoods or housing estates;
- villages or towns.

The energy community is established on the basis of a contractual agreement and the establishment of a legal entity that will cover the functioning of the community. At the same time, it is necessary to establish contractual relations between community members as well as with other interested parties or stakeholders.

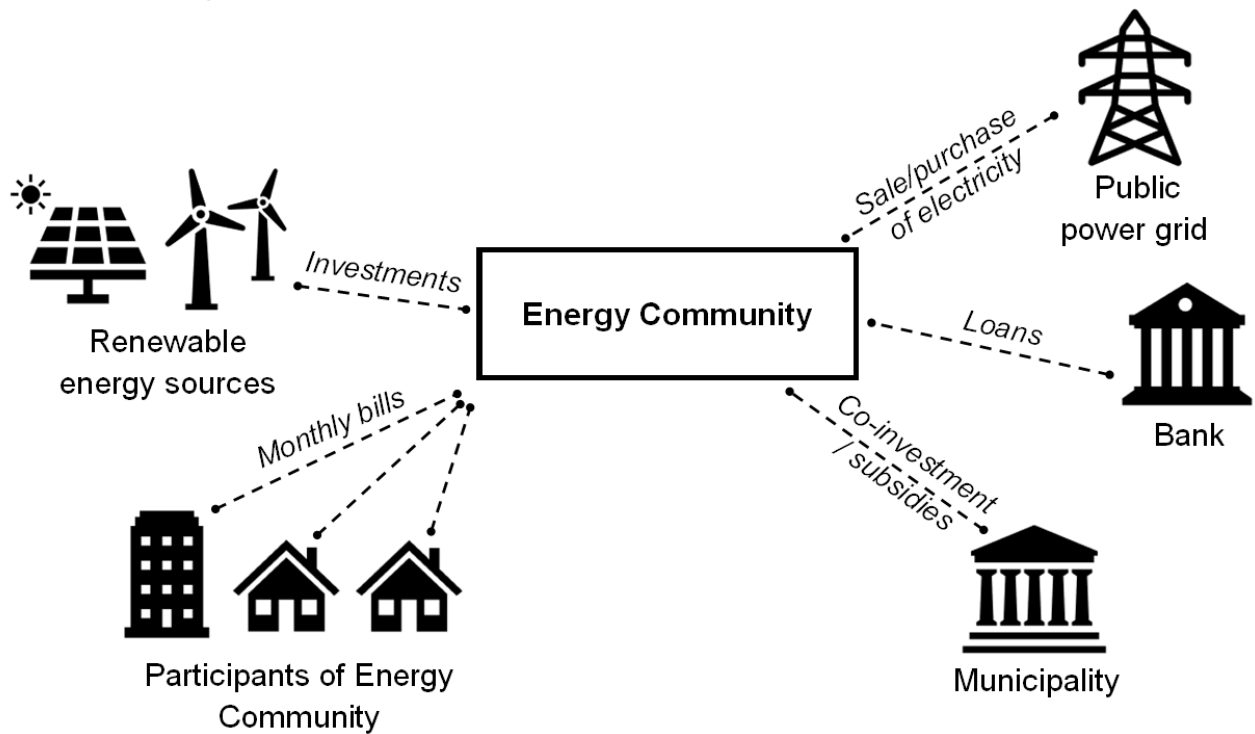


Figure 2 – Financing and contractual structure of energy communities

2.1 Aspects of establishing an energy community

The establishment of an energy community, with regard to proposed Amendment to the Energy Act, is not limited to the selected legal form in the Czech Republic, i.e. the legal form is at the discretion of the founders of the community. It can take the form of an association, cooperative or other legal entity.

The establishment and subsequent operation of the energy community is conditional on meeting the definition points under the law. It means, that the purpose of the energy community is not to generate profit, community should meet energy, economic, environmental or social needs of the members of the energy community, which can freely join or leave the community.

An association or cooperative thus appears to be the most appropriate legal forms for an energy community. Contrary the energy community cannot be, for example, a foundation or a fund, because they are not based on the membership principle. Similarly, according to the Ministry of Industry and Trade, the energy community cannot be a community of housing unit owners, so

called “SVJ”, because it cannot be left without losing the ownership of the unit - thus the condition of voluntary membership is missing (CONGREGATE Project, 2021).

2.2 Energy Office license

The application for a license must be submitted by the body, which will operate electricity generation with an installed capacity of more than 10 kW. According to the amendment to the Energy Act No. 131/2015 Coll. a license for electricity generation is not required for the operation of a PV plant with an installed capacity below 10 kW (inclusive). The condition is that the production from the newly connected production plant will serve primarily for own consumption (Act 131/2015 Coll.). The license is issued by the Energy Regulatory Office (ERO). The intention of the new Energy Act does not stipulate or state exceptions.

If no license is required, therefore; the installed capacity does not exceed the value of 10kW, the operator of technical equipment does not become an entrepreneur. Stricter legal conditions and regulations apply to entrepreneurs.

An unlicensed operator as well as licensed operator, must comply with the operator's obligations under the Energy Act. Amendment to the Act 350/2012 Coll. is valid from January 2013. According to this amendment, a building permit is not required for facilities with an installed capacity of up to 20 kW (Act 350/2012 Coll.).

2.3 Financing the energy community

Funding for the energy community and its projects can be secured in several ways.

One of the options is direct (disposable) funding by community members, which, however, presupposes sufficient equity of members and their consent. An easier way is the financing via the common fund, to which regular contributions are sent. It is basically a variant of the repair fund. For established communities, it is possible to use part of its secondary profits for financing, e.g. from the sale of (surplus) energy.

In the event that the energy community does not have sufficient equity, it may use external funding like bank loans, investor involvements, co-investments, subsidy grants or other means of financing (e.g. crowdfunding or bonds).

Grant programs

In the Czech Republic, various subsidy support for the utilization of renewable energy sources is available. In case of the photovoltaic systems, which will probably be the most common solution within the energy communities and aside from interest free loans, three main subsidy sources can be used for funding.

First one is New Green Savings programme. For the period from 2021, it will be possible to obtain support for photovoltaics on apartment buildings in the amount of EUR 384.6¹ per kWp up to a maximum of EUR 19,230.8 (State Environmental Fund of the Czech Republic, 2021a).

¹ The Czech crown / EUR exchange rate used was EUR 1 = CZK 26

Subjects with license for electricity production and renewable energy communities can apply for a support from Modernisation Fund for installation of new photovoltaic power plants (PV) with an installed capacity of up to 1 MWp. Under the call 01/2021 it is possible to receive up to 80% of eligible costs up to a maximum of 50% of the total project costs (State Environmental Fund of the Czech Republic, 2021b).

It will probably be possible to obtain subsidies also from the Operational Programme Environment 2021-2027, however the program is still in the preparation (Ministry of the Environment of the Czech Republic, 2021).

2.4 Costs and revenues within the Energy community

Costs and revenues allocation is set on the basis of a contract between the energy community and apartment owners or tenants. Energy community can choose the method of financial settlement according to its own decision.

- Costs and revenues can be allocated in proportion to the share in energy community. The proportion may depend, for example, on the floor area owned.
- In the case of an apartment building, it can be agreed that the energy produced will first be accounted to common areas (lighting in corridors, cellars ...) and only then to residential parts.
- The energy community acts as the sole supplier of electricity to its members and common areas. Surplus energy can be sold through the energy community to the public grid.
- In the case of joint accounting or own energy production, it is usually necessary to unite the customers supply points and install switchboard with secondary measurement and special energy budgeting.

With regard to the investment costs of projects within energy communities, such as the construction of renewable energy sources, the method of financing depends on the contractual agreement. Of course, the assessment of project costs is subject to economic evaluation.

2.5 Available technical solutions

One of the targets of energy communities is to promote and increase the production of renewable energy. Energy communities can achieve this with various technical solutions. These are:

- Construction of a new energy systems based on renewable energy technology – photovoltaic panels, solar heat collectors, heat pumps, local wind turbines and combined heat and power generation.
- Modification of the existing systems – heat recuperation, water recycling, other energy saving measures such as improvement of thermal characteristics.

The main solutions can be considered especially in the use of solar energy – photovoltaic and photothermic power plants – and the construction of large energy sources such as cogeneration units. It is energy communities that should allow the use of larger energy resources, because they are expected to have greater financial strength and can associate more objects and share the energy produced between them.

3 Case studies in CZ

There is not much experience in implementation of energy communities in the Czech Republic so far. Only recently, the first pilot projects of the energy community were implemented, for example photovoltaics power plants on apartment buildings in city of Litoměřice (Frank Bold, 2020; Congregate, 2021) or in Prague (The City of Prague, 2020).

It is also likely that most current "communities" stick to the ground – they build photovoltaics up to 10 kW, which are not subject to a license to produce energy and further requirements. According to statistics on holders of licenses for energy production, in the case of photovoltaics, the number of licenses between 2014 and 2021 remained almost unchanged. There were 27,956 licenced establishments with installed capacity 2,125.91 MWe in 2014 and 28,987¹ establishments with installed capacity of 2,147.02 MWe in 2021 (Energy Regulatory Office, 2021). This development also includes cancelled establishments, but the trend shows that in recent years there are not too many new or rather larger solar power plants.

This chapter presents main attributes of upcoming pilot project of energy community in Prague and one theoretical case with a community established in order to build a solar power plant on an apartment building.

3.1 Energy PV community in the city of Prague

Following the "Climate Plan of the Capital City of Prague until 2030" from May 2021 at the end of August, Prague approved the establishment of a contributory organization of the Prague Renewable Energy Community (Capital City of Prague, 2021)

The organization should not only prepare and implement the construction of new sources of energy and heat within buildings owned by Prague, but also operate the sources. In the future, it will also work as a consulting and contact point for citizens and legal persons who wish to participate in the development of the energy communities.

The plan for 2022 envisages the implementation of a pilot project for the construction of a total of 40 solar power plants at selected schools, social and cultural facilities. An application for subsidy support was submitted for these projects.

This pilot project is specific in several respects:

- The conditions for the subsidy must be met - primarily the use of installed capacity for own consumption and obligation of total energy savings of 30%. Some buildings will undergo additional energy saving measures.
- The consumption of buildings and production from PV plants are interconnected and balanced (with an hourly calculation step) so as to minimize the overflow of unused electricity into the grid. The production of electricity from PV plants installed on the roofs of schools, which are closed in the summer, covers the part of the consumption of other buildings.
- Electricity produced from PV power plants will be shared and distributed between the buildings via the public distribution network. In the future, after further legislative changes,

¹ The big boom in the construction of solar power plants was in the years 2009 to 2013 due to increased (overestimated) state support for the renewable sources, however, most of these power plants were built for business and are not relevant to energy communities.

it is expected distribution fees will be reduced or removed. These amount to approximately 30 percent of the price of electricity in Prague.

The current total final energy consumption of all objects is almost 158,000 GJ/year, consumption after the project implementation will decrease to 107,700 GJ/year. Total final electricity consumption will decrease from 33,462 GJ/year to 8,582 GJ/year. Newly installed PV system performance exceeds 4,500 kWp with the total production assumed to be at the level of 14,749 GJ/year with 57% being used to cover local electricity consumption and 43% Exported to the distribution system. Emissions CO₂ will be reduced by 2,744 tonnes/year.

3.2 Energy community for an apartment building

The case study deals with the establishment of an energy community for a selected residential building and construction of a photovoltaic power plant.

The building is located in Prague, it is a five-storey residential panel house with a flat roof. The building consists of 40 apartments with an average of 90 inhabitants.

The electricity consumption of the building and its cost were calculated based on the consumption of the reference apartment. The reference apartment with 2 inhabitants had a consumption in the period from 12 December 2019 to 11 December 2020 in the amount of 2,202 kWh and overall costs of 461.93 EUR. Electricity consumption for common areas of the house (lighting) was 616 kWh with costs of 248.76 EUR. The resulting total electricity consumption of the building was 88,696 kWh with a total cost of EUR 18,726.06 per year.

The building has a total of 41 different owners, so mutual agreement between the owners is very difficult, especially regarding larger investments. The establishment of an energy community would facilitate the decision-making process with regard to energy issues and enable, for example, the construction of a photovoltaic power plant on the roof of the building.

The total consumption of the building was transformed into an hourly load profile based on (Mihaylov et al., 2018) and (Oprea et al., 2021). Using PV SOL software, 7 variants of PV power plants were created – 2 horizontal systems (Var1 and Var2) and 5 mounted systems with an angle of 15° (Var 3 to Var 7). Although photovoltaic panels in the Czech Republic achieve the highest performance at an angle of 35°, a lower angle was chosen, because the system has significantly lower static demands on wind protection, i.e. cheaper construction. Panels with maximum power of 350 Wp and module efficiency 20.74% were used.

Table 1 – Parameters of designed PV systems

| System | Installed power (kWp) | Number of PV modules | Total energy production (kWh) | Direct own consumption (kWh) | Share of total building consumption (%) | Share of total PV production (%) |
|--------------|-----------------------|----------------------|-------------------------------|------------------------------|---|----------------------------------|
| Var 1 | 77.35 | 221 | 62,679 | 21,454 | 24% | 34% |
| Var 2 | 18.20 | 52 | 14,978 | 12,008 | 14% | 80% |

| | | | | | | |
|--------------|-------|-----|--------|--------|-----|-----|
| Var 3 | 45.15 | 129 | 40,660 | 18,880 | 21% | 46% |
| Var 4 | 22.75 | 65 | 20,488 | 14,214 | 16% | 70% |
| Var 5 | 19.60 | 56 | 17,968 | 13,475 | 15% | 75% |
| Var 6 | 14.70 | 42 | 13,370 | 11,177 | 13% | 84% |
| Var 7 | 9.80 | 28 | 8,847 | 8,289 | 9% | 94% |

Subsequently, the investment costs and savings in operating costs were calculated. Investment costs are based on the aggregated model provided by SEVEN, The Energy Efficiency Center, z.ú. and calibrated to current market prices. The evaluation uses the method of payback period assessment. The evaluation also includes a variant for the sale of surplus electricity to the public distribution network. The basic price for electricity is 178.06 EUR / MWh and average sale price is 39.56 EUR/MWh.

The calculation of yearly savings per apartment considers an even distribution of savings. Another option is to divide savings by apartment floor area, however, it requires more detailed information about individual apartments that were not available.

The sale of surplus electricity to the grid is possible in the Czech Republic (No. 165/2012 Coll.), however, it entails a number of administrative burdens and the need to ensure guarantees for deviations in the prescribed supplies to the grid. The guarantee can be transferred to another entity. The following table summarizes the results of the project evaluation.

Table 2 – Economic evaluation of designed PV systems

| | Var 1 | Var 2 | Var 3 | Var 4 | Var 5 | Var 6 | Var 7 |
|---|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Savings (EUR/year incl. VAT) | 3,820 | 2,138 | 3,362 | 2,531 | 2,399 | 1,990 | 1,476 |
| Sales of electricity to the grid incl. VAT (EUR/year) | 1,629 | 117 | 860 | 241 | 177 | 86 | 21 |
| Investment cost (EUR incl. VAT) | 134,544 | 31,741 | 84,538 | 42,597 | 36,717 | 27,771 | 18,824 |
| Payback period - savings only (years) | 35.22 | 14.85 | 25.15 | 16.83 | 15.30 | 13.95 | 12.75 |
| Payback period including sales | 24.69 | 14.08 | 20.02 | 15.37 | 14.25 | 13.38 | 12.58 |

| | | | | | | | |
|---|---------|--------|--------|--------|--------|--------|--------|
| (years) | | | | | | | |
| Savings per apartment - only savings (EUR/year) | 47.75 | 26.73 | 42.02 | 31.64 | 29.99 | 24.88 | 18.45 |
| Savings per apartment - with sale of surplus electricity (EUR/year) | 68.11 | 28.19 | 52.77 | 34.65 | 32.20 | 25.95 | 18.71 |
| With subsidy from New Green Savings programme | | | | | | | |
| Investment cost with subsidy (EUR incl. VAT) | 115,314 | 24,741 | 67,173 | 33,847 | 29,179 | 22,117 | 15,055 |
| Payback period - savings only (years) | 30.19 | 11.57 | 19.98 | 13.37 | 12.16 | 11.11 | 10.20 |
| Payback period including sales (years) | 21.16 | 10.97 | 15.91 | 12.21 | 11.33 | 10.65 | 10.06 |

The results of the calculation are clear from the presented tables.

- Smaller systems with a larger share of utilization of electricity for own consumption are more economically advantageous. However, smaller systems do not use the full potential of the roof area, which don't correspond with political trends emphasizing increase in production of energy from renewable sources.
- In order to use larger systems, it is necessary to find another consumption for the utilization of the production. In this way, energy communities that can associate more objects are favourable.
- Sale price for electricity (relevant to power energy), which is low compared to purchase price (consisting of both power energy and distribution fees) currently are not able to compensate for larger PV systems. In addition, higher production is subject to more requirements and restrictions. These should be lowered for energy communities.
- Larger photovoltaic power plants can become more favourable with energy prices rising.

4 Conclusion

There is no massive development of energy communities in the Czech Republic. Difficulties with the implementation of energy communities in the Czech Republic are caused mainly by unresolved legislation, low consumer education in the given issue and a certain distrust of renewable energy sources. However, a growing trend in this area can be expected due to legislative changes and gradual decrease of technology prices as well as by energy prices increase. This is also confirmed by the authors' experience, who met with interest in procedures for establishing energy communities.

New legislation on energy communities will be published in the Czech Republic in the near future. It will provide necessary legal basis for energy communities, however, the proposed wording is still quite general. A practical guide, which would define the individual steps for the establishment and operation of energy communities, will need to be developed.

4.1 Energy and financial potential of energy communities

An increase in the number of energy communities will help to meet the goals of decarbonisation and decentralization of the energy network as well as utilize and implement other energy savings measures. Energy communities also offer the advantage of better investment and operating costs allocation and the possibility of implementing larger projects that could not arise without an umbrella organization as well as simplification of contractual relations.

Greater support for energy communities in line with EU legislation is expected to lead to greater use of energy from renewable sources. Energy communities will make it easier to group more buildings together and to balance their energy consumption with energy production. This will activate one of the main advantages and directions of the energy communities – utilization of most of the produced energy locally.

Based on the case study on the economic feasibility of the photovoltaic power plant project, the current issue lies in exploiting all potential of renewable energy sources. In Czech legislation, smaller energy sources with an output of up to 10kW, which are subject to less stringent legislative requirements, are more advantageous at the current state.

There are still barriers to selling surplus of energy to the distribution network. Sale prices are not high enough to make larger projects profitable. In addition, the sale of energy entails further legislative and administrative burdens, e.g. loss of consumer status. However, this will be addressed in new legislation, where energy communities will retain both consumer and entrepreneurial status. It can be expected this will endorse and accelerate the implementation of energy communities.

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