CONGREGATE

ANALYSIS OF OPPORTUNITIES FOR SHARED ENERGY PRODUCTION IN INDUSTRIAL AND LOGISTICS PARK - BURGAS

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July 2022

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

European Climate Initiative EUKI

The CONGREGATE project is part of the European Climate Initiative (EUKI). EUKI is a project financing instrument by the German Federal Ministry for Economic Affairs and Climate Action (BMWK). The EUKI competition for project ideas is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It is the overarching goal of the EUKI to foster climate cooperation within the European Union (EU) in order to mitigate greenhouse gas emissions.

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SUMMARY

This analysis discusses the opportunities offered by the aggregation of generating consumers in Energy Cooperatives so as to increase the efficiency of using renewable energy installations to meet the own needs of a group of industrial sites with different characteristics.

The different models for the use of RES to cover own needs are examined and it is concluded that the structuring of an energy cooperative is possible, although there is no specific legal framework for this.

For the needs of the exemplary modelling of the operation of different sites in a common group, an approach for the development of a commodity profile and an energy balance, related to sites in the Industrial and Logistics Park - Burgas (ILPB), is demonstrated. Based on the results of the predictive balance modelling, three scenarios for RES resource utilization in a decentralized system are investigated. The conclusion that combining different sites in a common group with the use of the possibilities of supply from the Anaerobic installation located in the neighbourhood with a direct cable has the best techno-economic indicators is justified.

An exemplary cooperative model within the ILPB is developed to determine electricity price levels and an approach for allocating investment costs among cooperative participants is proposed. Recommendations are given for the next steps to implement the proposed concept.

1. STUDY OF THE CURRENT SITUATION AND PLANNING

To prepare the framework of the analysis, the project team familiarized itself with the preliminary materials for the Industrial and Logistics Park - Burgas (ILPB) and made a site visit to complement the information. A wide range of issues were discussed, including:

- Municipal Energy Efficiency Plan: measures in/around the industrial zone, solar and wind potential assessments, renewable energy investment intentions;
- Organization of sales of electricity and heat from the Anaerobic plant;
- Ownership and development plans for the vacant parcels in the ILPB;
- Street ownership and electrical infrastructure (power for lighting, perimeter security system);
- Presence of municipal property in the vicinity of the ILPB;
- Status of Burgas Lake (nature, fishing area, industrial needs);
- Plans to build charging stations for electric vehicles;
- Location of EVN substation;
- Invoicing of the electricity supplied;
- Use of other energy sources in the area (gas, heat, wood waste);
- Availability or plans for rooftop PV;
- Expressed interest in electric mobility/charging stations.

After familiarizing with the preliminary materials for the ILPB, it was found that some of the enterprises have already installed renewable energy installations - photovoltaics and heat pumps, while others have plans to build similar ones. This information indicates that there is interest in the Park for development in this direction and the study can be used to discuss various development options.

Special attention was paid to the implementation of the project of Burgas Municipality for the construction of a new Anaerobic Plant and the potential of such a site for decentralized production and consumption.

In order to better capture the specifics of the ILPB in the analysis, a questionnaire was provided to industry and land owners to explore interest in harnessing local renewable energy potential.

The questionnaire is presented in Annex 1

Based on the feedback received, the assumption was confirmed that there is significant interest in developing renewable energy projects within the ILPB, whereas the companies in the Park are currently focused on the implementation of individual installations to meet their own needs and to sell electricity to the grid.

This study analyses the innovative possibility of working within an energy cooperative.

2. STRUCTURING AN ENERGY COOPERATIVE

Electricity supply development concepts have evolved in recent years and, in addition to a centralized generation-transmission-distribution-consumption system, various close-to-consumption generation options, or decentralized system concepts, are increasingly applied.

The availability of grid infrastructure and the still low share of renewables limit and hinder the application of decentralised system concepts, but they are becoming increasingly relevant in view of unpredictable free market prices, but also in view of low-emission economy policies that are accompanied by incentives.

The widespread development of decentralised system concepts is associated with the implementation of Energy Cooperative or Renewable Energy Community models, with European legislation already in place and national legislation under discussion.

A renewable energy community, according to an EU directive[1] , is a legal entity that owns and develops renewable energy projects, is based on open and voluntary participation, and is independently and effectively controlled by its members who are located in the vicinity of renewable energy projects owned and developed by that community.

The Renewable Energy Community does at least one of the following - generates, consumes, stores or sells electricity, heat and cooling energy from renewable sources and/or shares within that community renewable energy produced by community-owned projects, including through virtual net metering.

A "prosumer" can be defined as an end-user of electricity operating on its own premises or on other premises located within the same district who generates renewable electricity for its own consumption and who may store or sell the renewable electricity it generates. There may be co-operating prosumers – these should be at least two co-operating producer-consumers located in the same building or in a multi-family residential building.

It is the sale of electricity that involves serious regulatory issues that need to be further developed in national legislation to take into account the specificities of renewables and to account more fairly for the energy produced and consumed by energy communities and prosumers.

[1] EU Renewable Energy Directive 2018/2001 https://bit.ly/2FHtr6o

The establishment of commercial communities can also be implemented under the current legislation, as the specifics of RES generation and consumption should be further developed for specific cases with changes to the Energy from Renewable Sources Act and the Energy Act, including by refining the interaction with grid operators and the metering of commercial electricity generation.

A new aspect is net (virtual) metering, which is evolving in parallel with the development of smart grids and digitalisation in consumers.

Net metering is the ongoing reconciliation of electricity produced and consumed by a producer-consumer at the same renewable energy generation site, owned by the producer who is at the same time a consumer.

Virtual net metering is net metering where at least one of the sites where the energy is consumed is different from the site where the energy is produced.

In this way, consumers who do not have the necessary roof space for solar power generation, for example, may still be part of a renewable energy project that is implemented through an installation at another connection point. In this case, the energy produced can be offset against their consumption as if it had been produced at their site, but with the appropriate grid access charges.

Through virtual net metering, energy flows can be managed and surplus electricity can be used more efficiently, including at times and places other than generation.

A number of European countries already apply net metering. Virtual net metering is regulated, for example, in the legislation of Greece, which also includes the cooperation of public and private consumers, but also of socially disadvantaged consumers.

As a result of the review of the general framework, the following functional groups, defined as Energy Communities, can be identified:

- cooperatives;
- partnerships;
- trusts, foundations, NGOs;
- Community Choice Aggregators;
- public utilities;
- public-private partnerships (PPPs) with local partners.

In the Bulgarian legal framework the forms of association are fully permissible and used for the needs of Energy Communities, for example there are such under the Condominium Act, but the most common are tripartite contracts with the participation of a consumer, a producer (or investor) and a trader.

The final objective of the analysis is to identify opportunities for the development of renewable energy installations within the ILPB and for the cooperation of its participants. In order to make the transition from general forms of cooperation to specific project proposals, a combined overview of the opportunities for association is provided below, together with the technological and commercial issues applicable to the individual cases. To this end, a matrix of clustering opportunities has been developed based on potential activities for generation, supply, distribution, flexibility (storage, aggregation, demand/demand response), district heating, transport (car sharing), energy savings (shared retrofitting of housing). The summary is presented in Table 1.

Table 1. Matrix of association opportunities

Scope of activities	Applicable technologies	Participants for association	Commercial aspects	Regulatory issues
Electricity for own use	PV/other, batteries, control	Owners in a common object, group of objects	Settled by participation contract	Necessity of coordination of a change in an electrical project
Electricity for own use and exchange with the grid	PV/other, batteries, control, commercial metering	Owners in a common object, group of objects	A contract with a trader and an Electricity distribution company (EDC) is required	Necessity of a legal entity that is a party to the contracts with a trader and an EDC
Virtual distribution centers	RES generation Digital environment	Investors	Development of a trading platform	Licensed trader and business model
Energy efficiency services	Combination of consumption, production and management technologies	Owners in a common object, group of objects ESCO	Contract for energy manager and contract with trader and EDC	Overall energy project A legal entity that is a party to the contracts
Provision of utility services	Combination of consumption, production and management technologies	Municipality Industrial zone PPP	Own management structure	Licensing of production, distribution, trade

It should be recognised that there is still a lack of ready-to-use contractual models for cooperation. Due to the still nascent model of energy cooperation, the analyses of relevant research projects point out that at this stage, the leading role of a Cooperative Initiator around which the individual actors join, is crucial.

Often the Initiator is driven by broader goals than commercial gain and includes in its strategy support for new renewable energy projects, support for the application of innovative technologies, addressing social issues, etc. This is the reason why in most cases of cited energy cooperatives, municipalities play a leading role. In these cases, the specific role of municipalities covers:

- Funding or guarantees for new projects;

- Creating an enabling environment, including requiring investors to set targets for citizen participation in projects;
- Provision of information;
- Procurement of community-generated energy;
- Cooperative membership;
- Providing administrative assistance, etc. non-financial resources for citizens.

3. PROJECTED LOAD PROFILE AND ENERGY BALANCE RELATIVE TO ILPB

An important element in the analysis of the possibilities for electricity supply from RES is the preparation of a forecast load profile to be compared with the possible electricity production from RES.

Within the Industrial and Logistics Park Burgas, there are consumers with different product profiles.

For the majority of the sites in the ILPB, general information on requested connection capacity and monthly consumption is available. For some sites, there is data on the distribution of consumption by time zone and for some sites there is hourly usage for selected months.

On this basis, general conclusions about the consumption profile are drawn, which boil down to:

- various sites by consumption level (from 20 to 500 kW connected power),
- variations by consumption mode, but those with intensive daily consumption prevail.

Annex 2 presents the data processing and compilation of load profiles and energy balance for selected sites on the ILPB site.

Illustrative monthly load profiles have been prepared for three sites based on data from a real PV plant in southern Bulgaria for 2021 and consumption profile data. Where hourly consumption profile data is not available, consumption profile data prepared by EDC South has been used.

At present, for customers connected at low voltage, the traders on the free market offer pricing of the supplied electricity on the basis of the Standardised Load Profiles (SLP). These have been approved by the state Energy and Water Regulation Commission and are intended to facilitate the aggregation of a large number of profiles and the forecasting of end-use demand profiles. The SLPs used for the analysis are those of the Southern Electricity Distribution Company (https://elyug.bg/Customers/free_market/Standardized_load_profiles.aspx):

Profiles for 2021:

- Business customer general profile, G0
- Business customer with intensive daily consumption (8.00-18.00), G1
- Business customer with intensive evening consumption (18:00-22:00), G2
- Business customer with intensive night consumption (18:00-08:00), G3.

Profiles for 2022:

- Non-domestic customers with up to 10% night energy consumption, G0
- Non-domestic customers with night energy consumption from 10 to 20%, G1
- Non-domestic customers with night energy consumption of 20 to 30%, G2
- Non-domestic customers with night energy consumption above 30%, G3.

Standardised Load Profiles (SLPs) reflect baseline and peak demand in two time bands (06-22 and 08-20), but actual load management is based on more zones. In the case of the ILPB sites, it was found that the most frequent load profile approximated the SLP with a general profile, (G0) and the one with an intensive daily consumption (G1), which were used in the cases with no hourly data.

As a result of the statistical data processing and the energy balance, the efficiency of the use of an exemplary photovoltaic installation is evaluated.

In order to analyse the performance of a PV installation relative to a specific case, two PV installation power options for 4 sites are considered. The last site is conditional and corresponds to a virtual site with aggregated power from several sites in the ILPB. The results of the data processing are shown in Appendix 2, and a summary with performance evaluation is shown in Table 2.

Table 2 summary of data processing for sites in the IMPB

Site	Associated power	PV power	Electricity supplied from the grid	Unused electricity from PV	Electricity used from PV
Administration of the ILPB	23 kW	30 kWp	41%	54%	59%
		60 kWp	33%	74%	67%
Real object 1	70 kW	30 kWp	65%	26%	35%
		60 kWp	47%	44%	53%
Real object 2	375 kW	200 kWp	65%	26%	35%
		400 kWp	52%	52%	48%
Conditional object	1 300 kW	1 300 kWp	42%	42%	58%
		2 000 kWp	34%	57%	66%

The efficiency of use of a PV installation is determined by two parameters: 1) what part of its own needs is met by it; 2) what is the unused on-site electricity produced by the PV installation used for.

On the basis of the processed data and analysis the following conclusions can be drawn:

- in the case of a PV installation with a lower capacity than the connected capacity of the production site, most of the energy produced by the RES is used, but in general it covers a limited share of the site's needs, i.e. the supply from the grid and the costs are high;
- when a PV installation with a higher capacity than the connected capacity of the production site is deployed, the part of the energy produced from renewable sources that is not used and has to be fed outside increases. However, the installation covers a higher share of the site's needs, i.e. the supply from the grid and its costs decrease.

The main conclusion is that for a PV system to be effective, it must be combined with other applications, such as:

- selling into the grid - this approach makes full use of the amount of electricity produced, but cannot achieve good financial performance because the management of the purchase (production forecasting) and balancing is outsourced to another entity that has access to the market;
- combining with another inert consumer on site - such as heat pumps, batteries or other industrial processes where consumption can be controlled. This approach may be effective if such consumers are already in place, but if additional ones are planned, the total investment will increase significantly and an acceptable rate of return cannot be achieved;
- combining with other consumers in the vicinity of the site - this option can take advantage of the different load profiles of the individual sites as well as the greater variety of consumers. In this case, the need for additional investments is limited and the usability of the on-site installation is increased.

It should be stressed that the use of an on-site renewable energy installation reduces not only the direct costs of active electricity, but also those of grid services and additional charges.

These options will be discussed more specifically in the next section 4.

4. DEVELOPMENT OF MODEL SCENARIOS FOR THE USE OF RENEWABLE SOURCES IN A DECENTRALISED SYSTEM

4.1. Photovoltaic installation for own consumption

This scenario has the highest prevalence and is being applied to more and more industrial sites primarily to satisfy their own consumption needs.

This proliferation is due both to the simplified procedures for joining and building, and to the possibilities of obtaining financial support.

There are already dozens of applications in industrial sites of photovoltaic installations for their own needs, but due to the variable nature of the energy produced by them, they are used partially by combining them with contracts for the purchase of part of the energy produced. Due to the need to sell the surplus energy, but also due to third party financing possibilities, most industrial projects are implemented on the basis of ESCO contracts with grid companies. Such projects are usually of large industrial users - cement plants, pharmaceutical companies, chemical plants, etc. In these projects, on-site generation can usually cover less than 20% of consumption. For example, the project of Aurubis Bulgaria for a photovoltaic installation, which the company is building in Pirdop for its own consumption, has a capacity of 10 MW, and it covers 2.5% of the annual electricity consumption of the Pirdop plant.

In the case of small systems or the use of RES with small capacity, their adaptation to the existing system is simplified. However, for existing sites, when integrating RES with a capacity of more than 30 kW, a conformity assessment of the design parts, at least Structural, Electrical and HVAC, is required and for larger systems a complete design is necessary.

In all cases, it is necessary to ensure the implementation of an investment project concerning the installation of generating capacity, facilities for the transformation and transmission of electrical energy with the necessary standardized parameters, installation of management and control systems in the plant.

It should be noted that the concept of "small-capacity RES" is very conditional and is treated differently in the applicable legislation. References to the applicable legislation on this issue are presented in **Annex 3. Regulations for the connection of RES.**

In relation to the discussion on the extension of the preferential regimes for the implementation of RES projects, it should be noted that according to Directive (EU) 2018/2001 only the notification regime should be used for installations up to 50 kW, when they do not use a three-phase connection and when grid security is guaranteed.

This shows that, despite the desire to accelerate the processes of building new RES, the application of the general system principles will remain for the foreseeable future.

4.2 Renewable energy supply within the industrial and logistics park

Meeting the needs of end users for electricity generated from renewable energy sources will increasingly be based on decentralised solutions. In this context, the following three categories of renewable electricity producers are now clearly emerging:

- those that build generating capacity in order to sell electricity from renewable energy on the market (utility installations),
- those that use the energy produced from renewable energy only for their own consumption, without selling it (a subset of this category are consumers who only use their own source or "off-grid"),
- those whose aim is both to satisfy their own consumption and to sell the surplus energy produced (Prosumers).

These three categories differ in terms of the grid connection process, their possible role as users of the grid, and their status as commercial players in the electricity market. For example, sites with self-consumption installations that operate in parallel with the grid, rather than being 'off grid', therefore need to determine an optimal connection scheme and investigate the supply voltage values of existing consumers, which is best done using specialised software.

In Bulgaria, combining consumers into a common group for electricity production and consumption is still an exception.

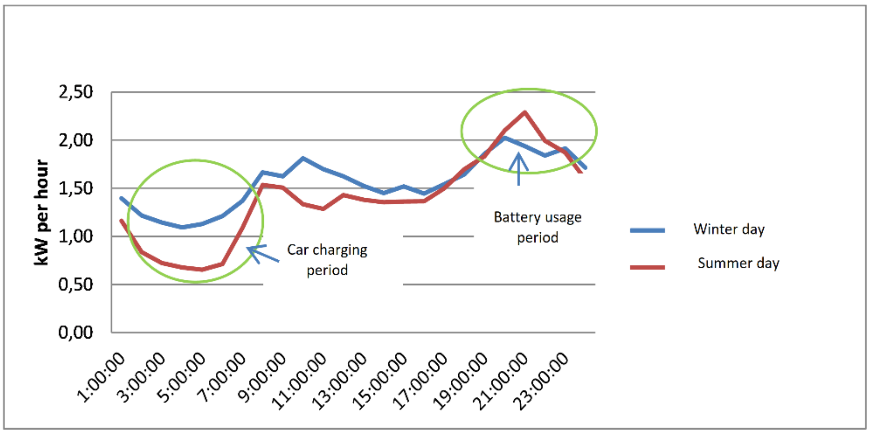
For the moment, the following examples can be offered:

- for pooling users to cover common costs - such as condominiums or users with space in commercial buildings like large shopping centres;
- pooling of consumers who have a common energy installation - such are available in condominiums, where the energy produced is sold and the amounts received are used to cover the common costs;
- pooling of a RES producer and a remote consumer through the grid - these are examples of targeted RES contracts.

Work is already underway to combine consumers into a common group for electricity production and consumption under the "after the meter" model, whereby the management of production and consumption in the group is carried out by intelligent systems. At this stage, public information on these projects is scarce.

The practice in Europe is increasingly embracing a mix of renewable applications that includes electro-mobility. A typical electric car today can travel 300 km after charging, but in urban areas cars are only used for about 100 km of range on weekdays, and the same applies to the use of electric mobility in enterprises. This indicates that there is unused electric capacity in the battery by the end of the day when the car is usually parked for the night. For network capacities up to 15 kW, charging stations with a capacity of 7 kW can be installed, but also during peak load periods the energy saved in the car battery can be used as its own source of electricity. A typical load curve can be taken from the standardised load profile developed by the EDC as shown in Figure 1.

Figure 1. Example of a combined use of an electric vehicle based on a SLP



It can be seen that combining an electric vehicle's battery with meeting peak hour consumption can have financial benefits. Incorporating a photovoltaic system into this mix can also help to improve the overall efficiency of the internal system, but in this case it is imperative to use elements of a smart grid and specialist control software.

Based on the review of the different applications, the main problems faced by this type of projects are now clearly visible, namely:

- the selection and implementation of hardware and software for production and consumption management;
- the choice of a business model that includes a contract, in accordance with the applicable regulatory framework, and an approach to allocating revenues and costs that complies with accounting standards.

Although they have their specific features, the selection and implementation of hardware and software for production and consumption management already have concrete solutions. The engineering tasks to be solved for the implementation of intelligent energy flow management, both for an individual site and for a group of sites, require the deployment of metering and data exchange facilities to the main units that consume electricity and to those that produce electricity. The next step is the implementation of an adequate power supply system that allows power from its own renewable energy source and from the grid, depending on the applicable solutions.

For small systems or using RES with small capacity, the adaptation of the smart system does not require a change in the design project, but as stated above, when integrating RES with a capacity of more than 30 kW a compliance assessment of the design parts, at least Structural, Electrical and HVAC, is required.

The National Assembly has adopted a change in the Law on Renewable Energy Sources[2] to facilitate the procedure for the construction of renewable energy sources on roof and facade structures of buildings for production and storage activities and on real estate attached to such buildings in production zones with a total installed capacity of up to 5 MW, in cases where they are used for their own needs. According to the EDCs, such high connected capacity still requires coordination to ensure local supply stability.

The discussion of the possibilities of extending the scope of application of targeted energy management at a site with electricity generation and consumption shows that their development is linked to the application of smart grid concepts.

References to the applicable legislation on this issue are provided in **Annex 4. Closed electricity distribution network.**

The issue of the choice of a business model that includes a contract under applicable law is discussed below.

4.3 Renewable energy supply within the ILPB. Connection to the Anaerobic plant with direct cable

The renewable energy supply options discussed above for individual industrial sites are already being implemented within the ILPB by sites with their own PV and geothermal installations. These are implemented under the self-supply and for-sale model. A large number of companies have expressed interest in participating in the development of new renewable energy projects.

To justify specific cooperative proposals, the following features are taken into account as a result of the development of the ILPB:

- The site is fed through the medium voltage network of EVN (with the exception of one enterprise which is connected to the Electricity System Operator (ESO)).

[2] Act to supplement the Renewable Energy Sources Act (SG 42 of 7 June 2022). Production of electricity from installations with a capacity of up to 5 MW for own needs and for the grid.
Resulting amendments to the Law on Spatial Planning (ZUT) - Art. 124 - Creation, announcement and approval of spatial plans; Art. 137 - Categorization of constructions - third category; Art. 137 (item 14a).

- Some of the sites are supplied through an EVN transformer substation and some - through their own transformer substation.
- The supply of active electricity is within the free market by various traders.

Section 3 above presented data on the current consumption in the ILPB and modelled the effect of supplying an individual site from a PV plant. It was concluded that an increase in the efficiency of renewable energy installations can be achieved by combining different sites within the site.

Due to the existence of already developed infrastructure and established contractual relationships of different nature, the opportunities for cooperation on a wide range of sites are limited. Based on an analysis of alternatives, two models are discussed here:

In a variant where the Energy Cooperative manages the project independently, it is necessary:

- To develop a financial and technological model of production and distributed consumption;
- To develop a project for the distribution of the generated electricity to each consumer in the cooperative, including the provision of metering facilities;
- To develop rules for the operation and control of energy flows.

At the outset, it is advisable that consumption exceeds production by a significant margin in order to implement a fair revenue-to-cost model.

One example of a joint project between "n" sites within a zone (ILPB) involves the deployment of PV installations on the roofs of "m" sites (where m<n). The investment for the deployment of the PV installations, additional cabling and installation of intermediate metering and control points is provided by the SPV-A conditional company. SPV-A forms a price including the recovery of the investment (over a period of about 10 years) and operating costs, but without making a profit. The distribution of the electricity produced is based on a predefined hierarchy and is paid after monthly reconciliation and with the application of a fixed price.

The optimal hierarchy for the use of the generated electricity includes the following levels:

- Level 1 - use of the generated electricity within a site with a rooftop PV installation, i.e. to cover own needs;
- Level 2 - use of the generated electricity within another site between "n-1" participants in SPV-A;
- Level 3 - use of the generated electricity to charge a battery (this level may appear at a later stage and is associated with the formation of another price for the use of electricity stored in the battery).

The aspiration is to achieve a business model where electricity generated within the SPV-A is not exported to the grid and with the application of virtual net metering. SPV-A prices should be lower than grid supply (which includes active electricity, grid services and charges). This will ensure that requests for use of the electricity generated within the SPV-A will exceed the amount generated.

SPV-A Participants retain the freedom to negotiate deliveries of electricity from the grid as long as these deliveries are made through a commercial meter and the distribution of self-generated energy is made upstream of the meter.

The development of such a model requires in-depth knowledge and qualified staff in at least one of the cooperative members. Based on this knowledge and competence, contracts will be prepared between the participants, but also with suppliers, designers and the network company. The latter should be informed and coordinate the changes in the Electrical part of the design projects in the respective sites participating in the SPV-A.

There is a possibility to involve the network company as a facilitator. Such a possibility is based on the availability of network infrastructure and competence at the relevant EDC. In this case, the Energy Cooperative defines the planned RES capacities to be built and the commitment to consume the energy produced, but transfers the role of technical and financial coordinator to the respective EDC and its trader, reducing the need to invest in grid services or to maintain its own qualified staff.

Bringing in EVN as a partner to build such a cooperative will provide the necessary skills and infrastructure to help optimize costs.

Experience so far has shown that this type of collaborative projects involves increased trust between the participants (based on transparent procedures for financial participation and benefit sharing), but also the presence of a unifying figure. In this sense, the following model with municipal participation is proposed.

In Model B, the Municipality of Burgas is the initiating party, committing to utilize the result of the investment in the Anaerobic Plant, through a contract with sites in the ILPB for the supply of electricity from renewable energy with a direct cable.

Technologically, the anaerobic plant can operate in variable power supply mode and to supply two or more users in the ILPB. In this case, the consumers remain connected to the main grid of the EDC and use renewable energy according to the agreed schedule. RES supply with direct cable has the following advantages:

- Certified RES supply;
- Reduction in the cost of network services and additions as a "public service obligation";
- Transfer of management responsibility to a third party.

For Burgas Municipality, this model allows to conclude a supply contract directly with the consumer, avoiding the need to work with a trader. On the other hand, it is necessary to develop additional competence for energy supply management.

This model can be built upon by attracting producers from the ILPB who join the cooperative with their own PV installations, providing "surplus" electricity under the conditions under which the main supplier - Burgas Municipality - operates.

It should be reiterated that each of the models confronts critical technological issues for which additional expertise and/or infrastructure is required. In addressing critical technology issues, additional innovative technical solutions may be sought or responsibility may be transferred to a third party, for example in relation to:

- The balancing of loads:
    - via batteries/charging stations,
    - through a contract with a trader.
- The use of network infrastructure and metering:
    - by building a parallel electrical system,
    - through a contract with EPC.

An example of the estimated costs and final electricity prices for this option is presented in Annex 5.

5. SOURCES OF FUNDING

The main source of funding for Energy Cooperatives is the investments made by its founders.

In relation to the EU policies to support the development of decentralised systems involving RES, the following financial sources can also be used:

- National programmes - measures under the National Recovery and Resilience Plan include a number of funding opportunities for renewable energy projects that require a deductible. Such funding can be integrated into an overall concept for an energy cooperative, but one should be established prior to applying for funding.
- Specialized funds - the first priority here is funding from the Energy Efficiency and Renewable Sources Fund, which is targeted at this type of projects. In this category are also the programmes of banking institutions that provide loans for renewable energy projects and energy efficiency - for example the BDB.
- Green bonds - provide opportunities to raise significant loan capital to be invested in energy efficiency measures, including renewable energy. Financing is linked to the achievement of certain technical criteria and targets, energy savings and reduction of harmful gas emissions. They are mainly applicable to municipal projects and form part of the cumulative volume of municipal debt.
- ESCO contracts - a well-developed mechanism in which EDCs are a stakeholder for financing and sharing the profits. Again the Energy Cooperative should be structured in advance to negotiate funding.
- Energy efficient ("green") mortgages - this financial instrument allows to obtain financing on more favourable terms if it implements energy efficiency measures and can be used when structuring an energy cooperative.

In general, access to finance can be secured once the framework of the energy cooperative has been developed in detail, including:

- Participants and their commitment;
- Investment plan;
- Revenue and expenditure management plan;
- Framework contracts.

6. CONCLUSIONS AND RECOMMENDATIONS

1) The implementation of stand-alone measures for the deployment of RES installations for own needs has a limited effect and is linked to the sale of electricity through the grid. The efficiency of the investment depends on the possibilities to manage the load profile on site. In this case a contract with a third party electricity trader is needed.

2) The scenarios for operation in the form of an "Energy Cooperative" allows for full use of the energy produced on site. At the same time, cooperating in an existing industrial area should take into account the established conditions and limit the possibilities for large-scale cooperation. The presence of the Municipality's renewable energy facility in the vicinity, the Anaerobic Plant, allows for the development of a unique cooperative with the application of the direct cable supply option.

3) During the survey it was noted that Burgas Municipality has plans to build a new industrial zone in the southern part of the city. This warrants the consideration of a development concept with a focus on renewable energy and optimal energy management of loads when co-located in a new industrial zone, which would be based on predefined conditions for the development of the site infrastructure as well as commitments for its maintenance.

4) In both cases, options for stand-alone or joint investments in renewable energy, cable infrastructure, charging stations, batteries, etc. are applicable. In these cases, the provisions of the Energy Act (Articles 117, 119 and 35a), the Renewable Energy Act (Articles 30 and 31) and Regulation No 6 on the connection of producers and customers of electricity to the electricity transmission or distribution grids apply.

5) From the analysis of the statistical data for a sample of sites in the ILPB, the technical advantages of combining the load schedules of different users can be seen. It is a good basis for energy flow management, schedule optimization and internal self-balancing.

6) The current legislation allows for legal regulation of joint forms of work of a group of objects. Technological interconnection involves a detailed analysis of network connections, which can best be achieved when plans are coordinated with the local EDC.

7) In the case of a new industrial estate, the use of the 8 March 2021 Industrial Parks Act definitions and conditions for the implementation of a closed electricity distribution network could be planned.

8) The potential benefits of developing renewable energy and energy solutions in the industrial zone include:

- Revenue from electricity sales;
- Achieving predictable prices for electricity consumption;
- Optimisation of electricity consumption;
- Reduction of costs for network services and additions to the electricity supplied;
- Creating conditions for the use of new technologies;
- Eco-labelling.

9) The following sequence is recommended for the preparation and implementation of the energy cooperative option, with Burgas Municipality taking the lead:

9.1. Identification of the participants in the initiative, with which the Municipality of Burgas signs a framework agreement for cooperation with the ultimate goal of "Establishment of the Energy Cooperative ILPB"

9.2. Preparation of Terms of Reference for the study, conceptual design and procurement of the activity

Within this step, the Municipality of Burgas, at its own expense, undertakes actions to specify the technical parameters and commission the activity of detailed study of the load profiles of the participants in the initiative, the conditions for the management of the main units, the conditions for the deployment of photovoltaic installations, the conditions for the grid connection of the participants. The conceptual design shall indicate at least three options, including an option using the existing EVN grid. The conceptual design shall include an energy audit that provides an estimate of the energy savings and carbon footprint reduction under the different options.

9.3. Choice of option

In this step, the participants in the initiative decide on the best option for the implementation of the initiative. It is recommended to negotiate with third parties of competence - for example with EVN or an independent trader, which will allow to find the most optimal option for the management of the Cooperative.

9.4. Establishment of an Energy Cooperative based on the existing legal framework (partnership under the Obligations and Contracts Act)

Participants in the initiative are committed to initial funding for both the establishment of the Cooperative and the design project to realize the necessary investments. At this stage, rules for the distribution of the energy produced within the Cooperative are being developed.

9.5. Financial structuring of the project

In this step, a decision is made to self-invest and raise loan capital or apply for programmes.

Annex 1. Preliminary evaluation questions

Feedback was obtained from companies within the ILPB based on the following questions:

- Is an environmental policy and carbon footprint reduction included in the company's strategic documents?
- Does the company have a RES installation, and if so, what parameters does it have - type, installed capacity, use for own needs or sale or both?
- Does the company have plans/interest in building a renewable energy installation - rooftop photovoltaic installation, heat pump installation using geothermal energy, energy storage capacity?
- What is (or what would be) the company's interest in using the renewable energy – own consumption, sale or both?
- What is the normal production mode in the company - shift (single shift, double shift, triple shift), weekly (5, 6, 7-day working week), seasonality?
- Does the company have a responsible person on staff qualified in electrical networks/ heating, ventilation and AC installations?

Annex 2. Analytical and statistical data

In the area of Burgas there are suitable conditions for the production of electricity from photovoltaic installations, which is confirmed by the meteorological data of NASA Surface Meteorology and Solar Energy:

- Average daily radiation on horizontal surface, kWh/m^2 /day (over 10 year period)

Ian	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1,60	2,22	2,98	4,26	5,26	5,94	6,23	5,60	4,32	2,75	1,70	1,33

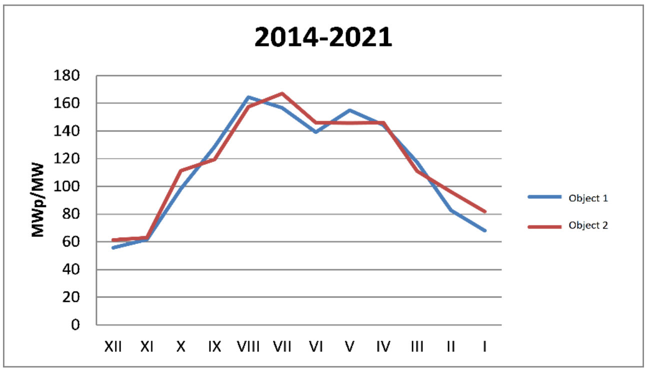
- Average temperature (°C) (over a 10-year period)

Ian	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average per year
0,47	1,65	5,80	11,2	15,6	20,2	23,2	23,0	18,7	12,1	6,19	1,29	11,7

The processed statistics for two sites operating in the area of the town of Burgas, which have an installed capacity of more than 1 MWp, show an effective hourly utilization of the installed capacity of 1380 hours per year, which is a very good indicator for the country.

The following Figure P-2.1 shows the monthly energy production over a seven-year period and shows the typical high values in the summer months and low production in the winter.

Figure P-2.1. Aggregated data for electricity production from real photovoltaic installations in Burgas municipality



In connection with the development of specific analyses applicable to the ILPB, illustrative monthly load schedules were prepared for three sites based on production data from a real PV plant in southern Bulgaria for 2021 and consumption profile data. Where hourly consumption profile data is not available, consumption profile data prepared by EDC South was used.

Figures P-2.2, 2.3 and 2.4 show examples of the balance between the production from different PV capacities and the consumption of the administration building at the ILPB.

Figure P-2.2 presents an example of the balance for a week with sunshine, when the daytime load is successfully covered by a PV installation with a capacity around the maximum demand, and there are surpluses on weekends.

Figure P-2.2. Balance in a week with sunshine

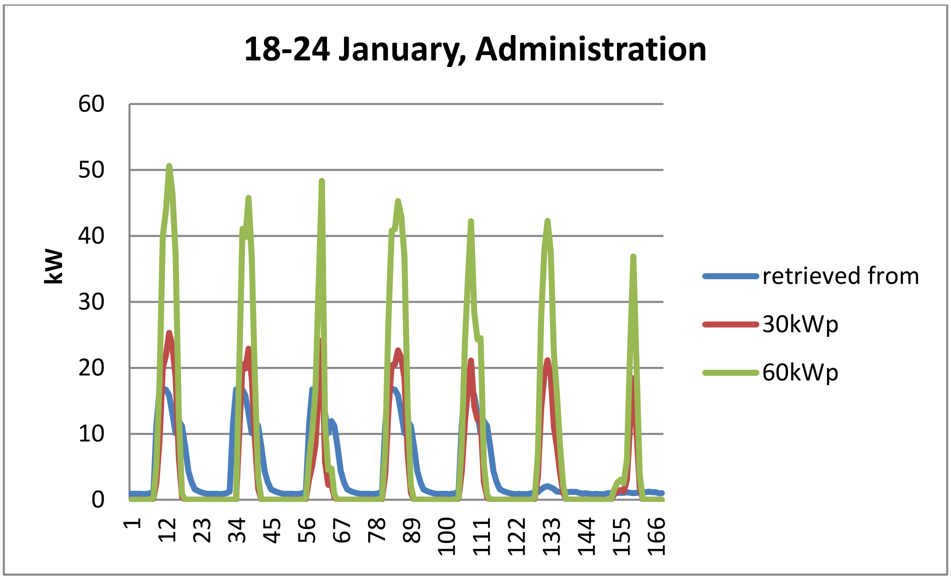


Figure P-2.3 presents an example of the balance in a week with low sunshine, when the daily load cannot be covered even by a PV installation with a capacity above the maximum demand, but there are surpluses on weekends.

Figure P-2.3. Balance in a week with low sunshine

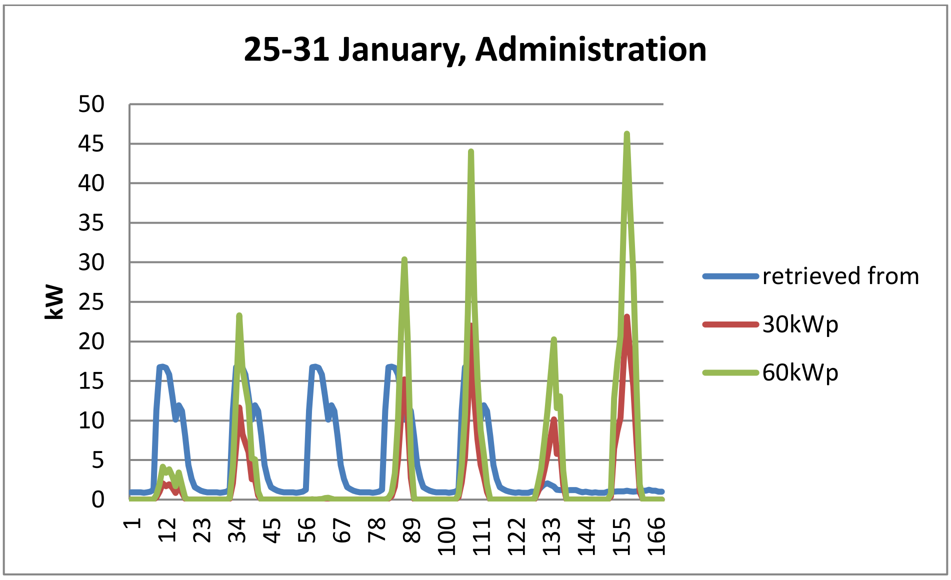
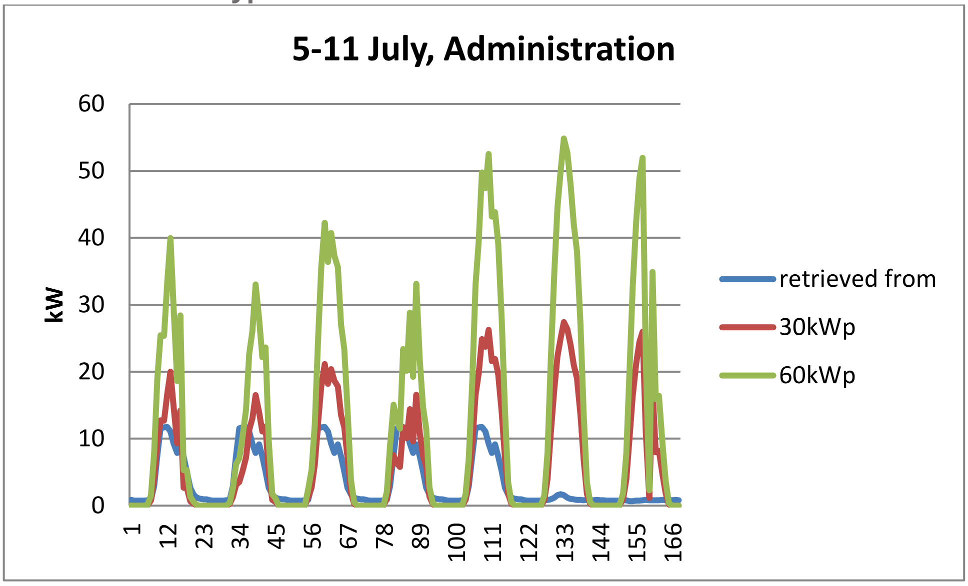


Figure P-2.4 shows an example of the balance for a typical summer week with sunshine, when the daytime load is successfully met by a PV installation with a capacity around the maximum demand, and there are significant surpluses on weekends.

Figure P-2.4. Balance in a typical summer week



Figures P-2.5, 2.6 and 2.7 show examples of the balance between the production of different PV capacities and the consumption of one of the companies in the area.

Figure P-2.5 presents an example of the balance in a week with sunshine, when the daily load is covered by a PV installation with a capacity around the average demand, but does not cover the peak demand. On weekends there are surpluses.

Figure P-2.5. Balance in a week with sunshine

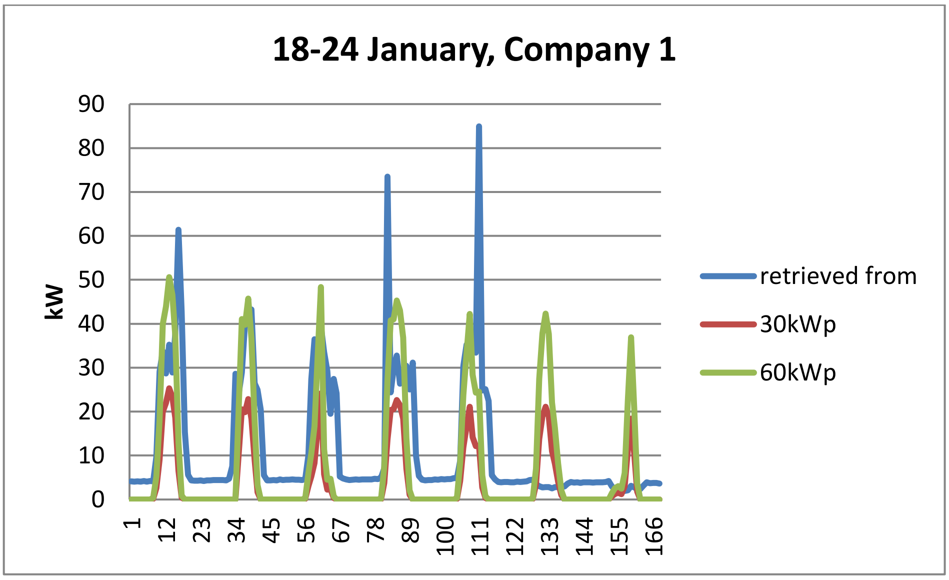


Figure P-2.6 presents an example of the balance for a week with low sunshine, when the daytime load cannot be covered by a high capacity PV installation, but there are surpluses on weekends.

Figure P-2.6. Balance in a week with low sunshine

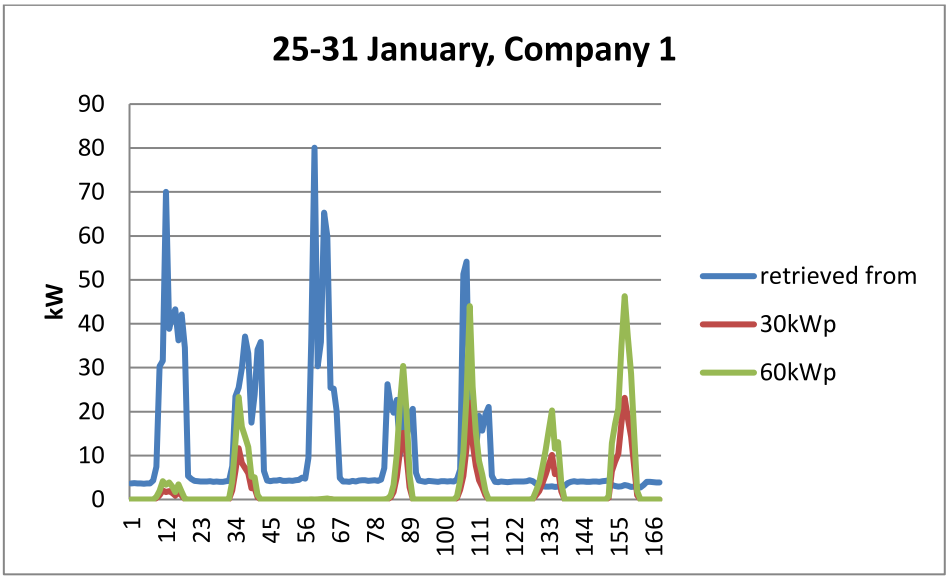
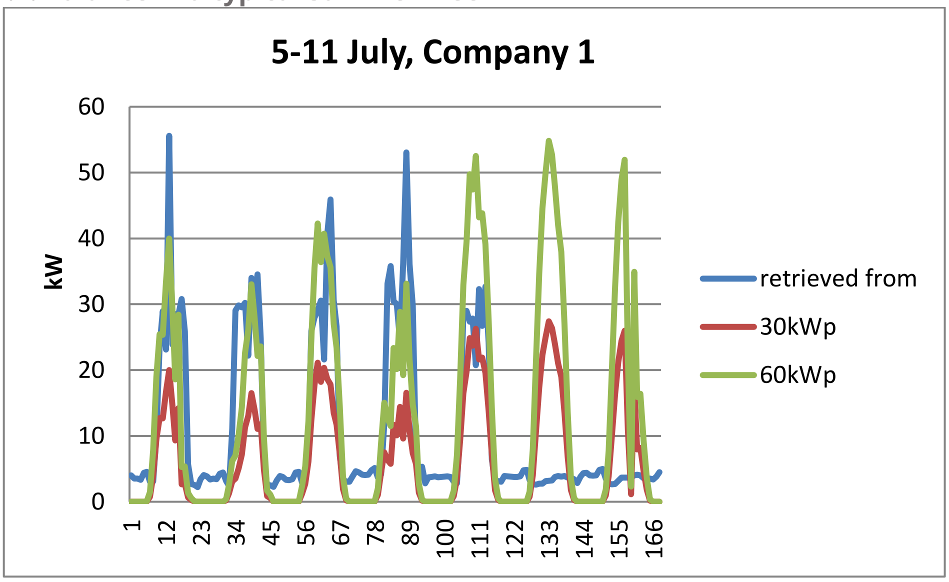


Figure P-2.7 shows an example of the balance for a typical summer week with sunshine, when the daily load is covered by a PV installation with a capacity around the maximum demand, but the peak values require management. On weekends there are significant surpluses.

Figure P-2.7. Balance in a typical summer week



Figures P-2.8, 2.9, and 2.10 show examples of the balance between generation from different capacity PV installations and consumption by another firm in the area.

Figure P-2.8 presents an example of the balance in a week with sunshine, when the daytime load is covered by a PV installation with a capacity around the average demand, but does not cover the night-time demand. In the presence of storage, efficiency can be increased.

Figure P-2.8. Balance in a week with sunshine

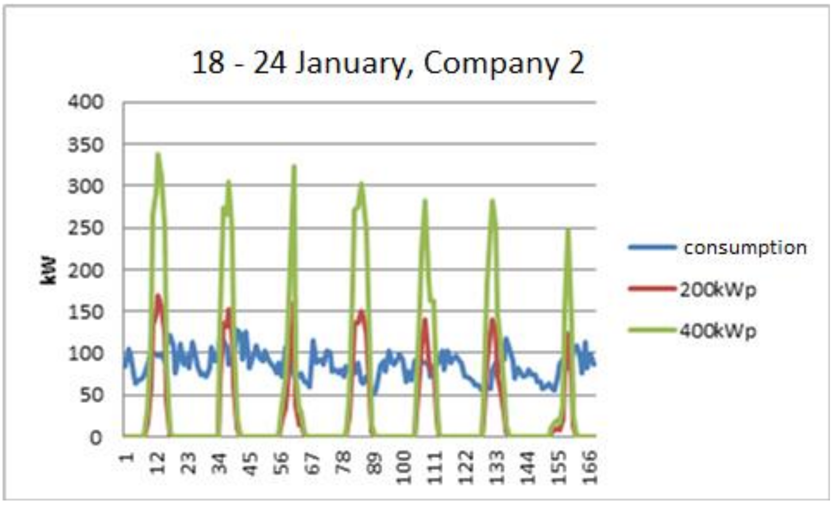


Figure P-2.9 shows an example of the balance in a week with low sunshine, when the daily load cannot be covered by a PV installation even if there is battery storage.

Figure P-2.9. Balance in a week with low sunshine

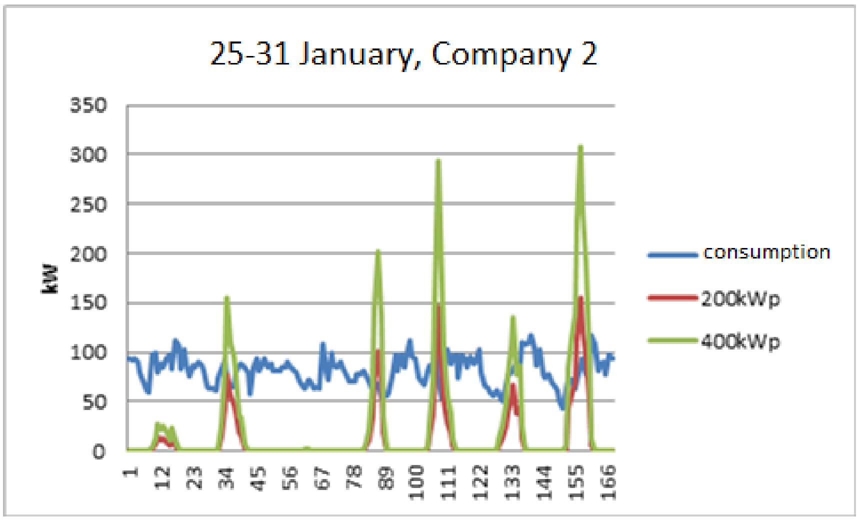
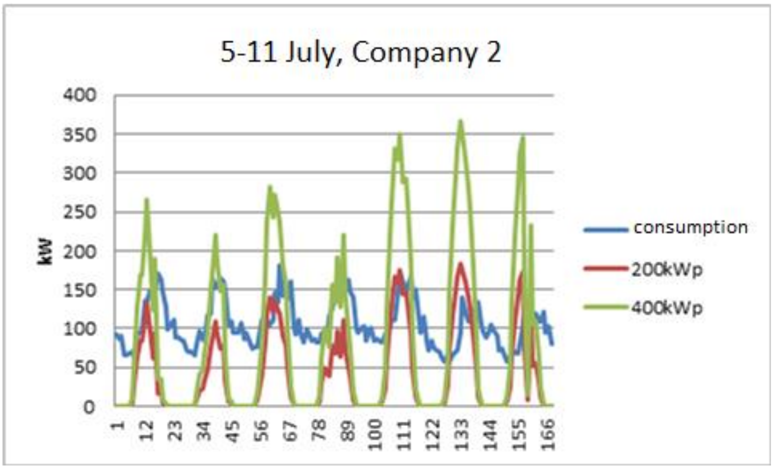


Figure P-2.10 shows an example of the balance for a typical summer week with sunshine, when the daytime load is covered by a PV installation with a capacity around the average demand, but does not cover the night-time demand. In the presence of storage, efficiency can be increased.

Figure P-2.10. Balance in a typical summer week



Annex 3. Renewable Energy Connection Regulations

Energy site for production of electricity from RES

In addition to the energy resource used (wind, solar, hydro, biomass, etc.), energy sites differ in their installed capacity. This aspect is particularly important in the case of photovoltaic applications, as they are most widely used in urban and industrial areas.

According to the Energy from Renewable Sources Act, the treatment of energy facilities according to their capacity can be graded as follows:

1. Construction and commissioning of energy facilities for the production of electricity from renewable energy sources with a total installed capacity of **up to 30 kW** including on roof and facade structures of buildings and on real estate adjacent to them within urbanized areas;

- no assessment of available and projected resource potential is required;
- no opinion is required from the operator of the relevant electricity network, but requests are made to study the conditions and method of connection;
- no preliminary connection contract is concluded, but a connection contract and an access contract are concluded under common conditions;
- a simplified procedure under the Spatial Act is in force;
- may benefit from a preferential price set by the Energy and Water Regulation Commission (EWRC).

2. Construction and commissioning of energy facilities for the production of electricity from renewable sources on roof and facade structures of buildings for production and storage activities with a total installed capacity **of up to and including 200 kW**;

- no assessment of available and projected resource potential is required;
- no opinion is required from the operator of the relevant electricity network, but requests are made to study the conditions and method of connection;
- a simplified procedure under the Spatial Act is in force.

3. Construction and commissioning of energy facilities for the production of electricity from renewable sources on roof and facade structures of buildings for production and storage activities and on real estate adjacent to such buildings in production zones with a total installed capacity **up to and including 1 MW**;

- no assessment of available and projected resource potential is required;
- a simplified procedure under the Spatial Act is in force.

In addition to the above, the producer of electricity from renewable energy sources with an installed capacity **of more than 200 kW** is obliged to provide real-time data transmission to the transmission or distribution network operator.

The following power limits shall apply to how electricity is purchased when it is fed into the grid:

- The public supplier and the final suppliers shall purchase the electricity from renewable sources, produced by sites with a total installed capacity of **up to 500 kW**, at the preferential price determined by the EWRC.
- Producers of electricity from renewable energy sources with a total installed capacity **of more than 500 kW** shall conclude a contract with the Electricity System Security Fund for compensation with a premium for the quantities of electricity they produce up to the amount of their net specific electricity production, on the basis of which their preferential price was determined.

Connection of an energy site for the production of electricity from RES

The connection to the energy system of an energy facility for the production of electricity from renewable sources is regulated in the Energy from Renewable Sources Act, the Energy Act and the Regulation No. 6 for the connection of producers and customers of electricity to the transmission or distribution grids, and the conditions for the investment design are regulated in the Spatial Act.

The connection of sites with an installed capacity of up to 5 MWel shall be made to the network of the respective EDC, and for sites above 5 MWel - to the network of ESO, for which a license from the EWRC is required. In all cases, the EDC shall coordinate the connections with the ESO.

Special operating conditions for RES are mainly regulated in the Energy from Renewable Sources Act (Art. 30 and 31), the Energy Act (Art. 117, 119 and 35a) and the Spatial Act (Art. 147).

When planning new RES, the following cases should be distinguished:

- Sites that will benefit from a preferential price according to Article 30 of Energy from Renewable Sources Act, namely:
    - up to and including 30 kW, to be built on roof and facade structures of buildings in urban areas (for the time being it applies to photovoltaics, but could also apply to other RES - e.g. small wind installations);

- up to 1.5 MW and use biomass, including animal manure;
- up to 500 kW and use biomass from vegetable waste from own agricultural production;

- Sites that will not benefit from the preferential price, but will be connected to the grid of the EPC or ESO - in these cases, installations up to and including 200 kW, which are planned to be built on roof and facade structures of buildings in urban areas, benefit from preferential conditions of connection and operation;
- Sites that will satisfy their own needs without using the network of the EPC or ESO (in these cases the provisions of the EA, Art. 119 and 35a may apply).

The costs for the construction of the facilities for the connection of the energy producer's facility to the relevant network from the property boundary of the electrical facilities to the point of connection, as well as for the development, including reconstruction and modernisation, of the electrical networks in connection with the connection shall be borne by the owner of the relevant network, but this provision is not applied in practice, as conditions are imposed on the investor to finance the necessary network improvements.

It is easiest to connect sites up to 30 kW, and the conditions for more powerful sites become more complex with increasing power. In the case of self-supply sites, it may also be necessary to change the power supply scheme at the site concerned, but this process is not well regulated and is subject to discussion. In general, self-consumption sites without grid return, with or without battery, are not explicitly regulated.

The process of constructing a RES starts with a reasoned request for a design visa to the municipality and a request for a study of the conditions for connection, on which a site-specific opinion with conditions is obtained.

The following are required to submit a request for an investigation of the conditions of accession:

- general site data (type, production characteristics, capacity, etc.)
- a design visa or an enacted master plan (not required for sites up to 30 kW)
- land/building ownership documents (including right of use documents).

The operator of the relevant electricity network shall examine the applications and shall give a reasoned opinion on the admissibility of each application, the time limit being 14 days from receipt for sites up to 30 kW and 30 days for those above 30 kW. In the event of an opinion determining the application to be admissible, the electricity network operator concerned shall carry out a study and issue an opinion on the conditions and method of connection.

In practice, only after receiving the opinion of the study on the conditions for connection, the investor can plan in full both the costs and the timeframe for the implementation of a site with a connected capacity above 30 kW.

The commissioning of the design project is based on the design vision and the opinion. According to the Spatial Act, the approval of investment projects is not required for the issuance of a building permit for the installation of installations for the production of electricity from renewable sources with a total installed capacity of up to and including 1 MW to existing buildings in urbanized areas, incl. the roof and facade structures and the adjacent land properties, and the opinions of a structural engineer, an electrical engineer and/or a thermal engineer with drawings, schemes, calculations and instructions for their implementation and an opinion defining the conditions for connection to the distribution network shall be submitted. Thus, for Category VI sites under the Spatial Act, the project documentation package includes: an opinion from a structural engineer, designs for the electrical part with drawings, schematics and a single line diagram, calculations and implementation instructions.

The construction of the power plant shall be carried out with the participation of technical persons possessing the necessary qualifications in accordance with the requirements of the Energy and Environmental Protection Act (Article 21).

Upon completion of the installation, the network operator shall establish the suitability of the plant by carrying out an on-site inspection and form a compliance report with the owner and installer.

For the operation of a photovoltaic power plant are required:

- single-linear scheme;
- instruction for safe maintenance and operation;
- facility passport;
- a specific order for the person who will operate the facility;
- qualification group certificate;
- a statement of the condition of the internal electrical installation on the site;
- protocol for measured transient resistance of the earthing switch by an accredited laboratory.

Customs registration and meter registration are also required.

According to the Law on Excise Duties and Tax Warehouses, subject to mandatory registration are those persons:

- who **sell** their own electricity produced from renewable energy sources from a plant with a total installed capacity of up to 5 MW to consumers for domestic and/or commercial use;

- who **consume** their own electricity produced from renewable energy sources for their own needs from a power plant with a total installed capacity of up to 5 MW, **excluding** persons who consume their own electricity for **domestic** purposes.

Annex 4. Closed power distribution network

Of particular interest is the recently introduced possibility of operating a "closed power distribution network", which is only relevant to the park area and should only serve activities taking place in this area.

The 'closed distribution system' definition application implied that when a closed distribution system is used to ensure the optimal efficiency of integrated supplies requiring specific operational standards, or where a closed distribution system is maintained primarily for the use of the system owner, it should be possible to relieve the distribution system operator from obligations which would constitute an unnecessary administrative burden due to the specific nature of the relationship between the operator and the distribution system operator. Industrial and commercial sites, sites applying shared services such as buildings and railway stations, airports, hospitals, large campsites with integrated facilities and chemical plants may include closed distribution systems due to the specific nature of their activities.

The definition of "closed power distribution system" includes various assumptions, such as:

- a system that distributes electricity within a geographically separated industrial or commercial site or a shared service site;
- a system in which, for certain technical or safety reasons, the activities or production process of the users of that system should be integrated; or
- a system that distributes electricity primarily to the owner or operator of the system or to entities related to them.

The rights and responsibilities of a "closed grid" operator are not yet spelled out, which determines the very limited nature of the application.

The organization of a closed system depends on how the following issues are addressed:

- The whole industrial park is one site, where individual users do not have access to the electricity market.
- The costs for different types of industrial or other consumers on the territory of an industrial park may be increased by the costs of network services related to the delivery of electricity to the place of consumption and which they will have to pay to the owner and operator of the closed electricity distribution network.
- The electricity generated and consumed for own use should be metered, which requires a means of metering within the technical scheme of the area other than the commercial means of metering of the EPC. This additional means is owned by the closed system operator and should be registered by the Customs Agency.
- The security of electricity supply to the point of consumption will no longer depend only on the external grid to which the park is connected, but also on the operation and maintenance of the closed distribution network that feeds the consumer.

- The procedure for increasing the required capacity of an individual consumer in the industrial park will no longer be linked to one but to two distribution network operators.
- If a closed distribution network is constructed in an industrial park, the existing (if any) distribution network facilities cannot be used, which is inefficient.
- If distribution network facilities or sites that are already fed by the distribution network fall within an industrial area, it will be the case that there will be an element of two different distribution networks in one area and two different companies in that area will be carrying out distribution activities.

Annex 5 Sample model for cooperation within the ILPB

For the purpose of the preliminary analysis, a model of cooperation was drawn up with the Municipality of Burgas as the lead and 7 participants from the ILPB - 6 of which are prosumers and 1 is only a consumer - Figure 5.1.

The tasks of the leading member of the cooperative - Burgas Municipality, include:

- Detailed energy analysis and design for the needs of the cooperative;
- Connection of Anaerobic Plant and ILPB;
- Provision of balancing energy to the cooperative from the Anaerobic plant;
- Operational management and coordination of the cooperative's electricity supply.

Producers in the group and the area available for PV deployment are:

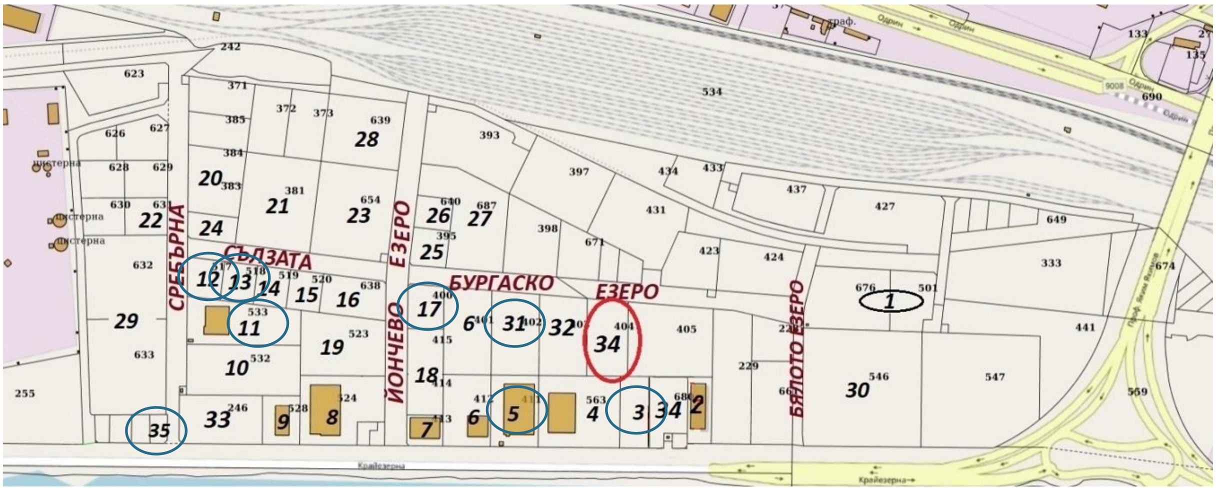
- **Volvo Group - 1000 m^2**
- **STIB - 600 m^2**
- Bletsov Brothers ~ 2400 m^2
- **Tandem 1991 - 900 m^2**
- **Administration - 500 m^2**
- BMK BURGAS ~ 400 m^2

Total area of the producers: 5800 m^2 .

Total computing power of the virtual plant - two options were considered: at full area utilization ~ 645 kWp, and at partial area utilization ~ 480 kWp.

Property R Consult is included as a non-production user, and JLP is included as a potential partner outside the cooperative due to fact that it is already building its own PV installation.

Figure P-5.1. Sites covered by the current cooperation model



The following steps were applied to build a generalized model:

1. Technical data

To build an example model, the following data about the cooperative participants are important:

- Current and forecast electricity consumption and forecast consumption schedule for each individual site - current consumption is established from historical data on an hourly basis for at least 12 months, and forecast consumption depends on the business plans of the respective company;
- Connection level - the data is available in the site design;
- Presence of significant single electricity consumers - an overview of the consumption structure by sites and sub-objects;
- Roof areas suitable for PV deployment - data from the site design.

Two questionnaires were developed to obtain technical data on the IPLB sites. The preliminary data obtained are very indicative at this point, but allow for the construction of an example model, which is commented below.

When cooperative action is taken, more thorough efforts will be needed to complete the technical data.

2. Estimation of possible production and expected consumption

At this stage, a preliminary estimate of the possible production from the roof areas has been prepared, based on 9 m^2 per 1 kWp, and an estimate based on 12 m^2 per 1 kWp has been applied for an alternative option.

Estimated consumption is based on preliminary data and using EVN's Standardised Load Profiles for business customers.

The estimates are presented in Tables P-5.1 and P-5.2.

Table P-5.1. Summary of data processing for sites in the IMPB

Participant	Role	Connected power	Roofing area	Electrical consumption	Installed power, PV	Electrical production
		kW	m²	kWh/y	kWp	kWh/y
Burgas Municipality	lead initiator		Anaerobic installation		500	3 500 000
	cooperative members					
Volvo Group	prosumer	130	1000	110 000	111	144 444
STIB	prosumer	100	600	220 000	67	86 667
Bletsov Brothers	prosumer	500	2400	440 000	267	346 667
Tandem 1991	prosumer	100	900	40 000	100	130 000
Administration	prosumer	100	500	35 000	56	72 222
BMK BURGAS	prosumer	100	400	155 000	44	57 778
Property R Consult	user	30	0	20 000	0	0
	Partners					
JLP	Prospumer-Partner	1000		750 000	515	669 500

Table P-5.2. Estimate of consumption and production at decreased space use

Participant	Role	Connected power	Roofing area	Electrical consumption	Installed power, PV	Electrical production
		kW	m²	kWh/y	kWp	kWh/y
Burgas Municipality	lead initiator		Anaerobic installation		500	3 500 000
	cooperative members					
Volvo Group	prosumer	130	1000	110 000	83	108 333
STIB	prosumer	100	600	220 000	50	65 000
Bletsov Brothers	prosumer	500	2400	440 000	200	260 000
Tandem 1991	prosumer	100	900	40 000	75	97 500
Administration	prosumer	100	500	35 000	42	54 167
BMK BURGAS	prosumer	100	400	155 000	33	43 333
Property R Consult	user	30	0	20 000	0	0
	Partners					
JLP	Prospumer-Partner	1000		750 000	515	669 500

The combined modelling of PV production and consumption at the cooperative's sites allows to estimate:

- the time to use electricity from PV for own needs;
- the time with need for power from an external source;
- the time with higher production from PV compared to own needs.

In the first option, the PV self-consumption rate is 57%, with 39% PV energy produced but not used. In the second option, the PV self-consumption is 49%, with 30% PV energy produced but not used, i.e. with lower installed capacity, the self-consumption increases, but the need for additional electricity supply increases.

The combined use of the cooperative's and the partner's installations results in an improvement in performance only for the second option with low area utilisation. This indicates that co-operation should be sought between sites with a different balance of production and consumption - for example those with a high share of renewable energy production and those with high consumption.

In the cooperative model under consideration, there is a participant with the potential to provide the electricity not available through PV generation - the Anaerobic Plant. In order to provide additional supply to the cooperative, electricity in the order of 180 MWh per year would be required in the first option, and ~390 MWh in the second option.

The comparison of the periods of surplus and shortage and the main types of consumers allows to draw the following conclusions:

- It is possible to smooth load profiles based on centralized management of selected consumers within the cooperative, which has a significant contribution on an hourly basis, but cannot be used for longer periods;
- Having its own electricity consumption at the Anaerobic Plant allows balancing services to be provided to the cooperative.

3. Estimated investment and operating costs

For the purposes of the preliminary analysis, it was assumed that new cable connections would be required to connect all of the cooperative sites.

In this case, the estimated investment costs were determined under the following assumptions:

- Making a new cable connection from the Anaerobic installation of the Municipality of Burgas to the common transformer substation of the ILPB - total 182 000 BGN for connections.
- Laying new networks from the common transformer substation to each member of the cooperative - total 285 000 BGN for connections.
- Development of smart grid elements within the sites of each member of the cooperative ("smart" grid covers large consumers with power above 4 kW individually and grouped by consumption type, e.g. lighting, small technological and office consumers, etc.). An assumption of BGN 500/point has been made for a total of 40 points and a common cost of establishing a control desk for the cooperative.

- Construction of a rooftop photovoltaic installation under the assumption of BGN 2 per Wp.
- Design and project management: 3% of the investment, or about 60 000 BGN.

The total budget is calculated to 1 825 000 BGN for the installation of 645 kWp installations, and 1 500 000 BGN for the alternative with the installation of 480 kWp installations.

It should be pointed out that these are conservative estimates, and there is scope to optimise them in the design process, including by using existing cable routes in places.

4. Choice of a model for the distribution of shares in the investment

Two models are discussed for the distribution of shares in the investment among the members in the cooperative, without taking into account the costs at the lead initiator:

- share of investment in capacity allocation
- share of investment by consumption.

Table P-5.3 shows the different allocations of the investment share between the IPLB cooperative members for the two models for the 645 kWp installations:

Table P-5.3. Distribution of investment share among cooperative members in IPLB

Participant	Electrical consump.	Instal. power, PV	Electrical works.	Surplus ratio	For sharing	Share of investments spread by capacity	Share of investment by consumption	
	kWh/y	kWp	kWh/y		kWh/y			Lv.
Volvo Group	110 000	111	144 444	0,75	108333	17%	11%	169 733
STIB	220 000	67	86 667	0,25	21667	10%	22%	339 466
Bletsov Brothers	440 000	267	346 667	0,5	173333	41%	43%	678 932
Tandem 1991	40 000	100	130 000	0,75	97500	16%	4%	61 721
Administration	35 000	56	72 222	0,75	54167	9%	3%	54 006
BMK BURGAS	155 000	44	57 778	0,25	14444	7%	15%	239 169
Property R Consult	20 000	0	0	0	0	0%	2%	30 861

It can be seen that in the first model there are participants with no share due to the lack of possibility to put a PV installation on the roof, but also there are participants with low production potential but high consumption needs.

Due to the need for a fair distribution of costs in relation to electricity consumption, but also due to the possibility of attracting participants with different profiles, the second model of distribution of shares in the investment is recommended. In this case, it is the stated forecast consumption that is expected to be met, irrespective of the roof area occupied by PV, that takes the lead.

5. Suggested approach to meet the projected consumption of the cooperative members

The mismatch of PV power generation schedules and consumer load profiles creates the following management challenges:

- Provision of electricity during the period of no or very low production from PV - provided by the operation of the Anaerobic Plant, which in the case under consideration provides 5-10% of the electricity produced on an annual basis.
- Use of electricity generated by PV when there is no consumption - this mode occurs mainly on weekends and requires advance planning and optimization. In this study, one of the possible solutions is adopted, i.e. using the electricity produced by the cooperative for the own needs of the Anaerobic Plant, which is then deducted from the energy supplied when there is a shortage. Other solutions are to increase loads on weekends or to gradually introduce storage and electric mobility.

In periods of small deviations (surplus/shortage) are covered at the expense of dispatching groups of consumers, without causing a violation of technological regimes.

It can be seen that the combination of different consumers and producers, such as load profile, production capacity, but also type of production installations, allows for maximizing the consumption based on RES and minimizing the need for electricity from the grid.

6. Electricity price formation within the cooperative

A simplified model with recovery of the investments made over a 10-year period (without accounting for depreciation) was constructed to form the price of electricity within the cooperative.

Annual energy production of 1,300 effective hours per year and an assumption with a reduction in electricity production of 1% per year is applied.

Operating costs for managing and coordinating the work of the cooperative - BGN 100,000 per year and reflecting an annual inflation rate of 2.5%.

The price for balancing the electricity consumption in the cooperative covers the investment of the Municipality of Burgas for design, network costs, as well as management and coordination.

The price is formed by two components:

- Price for electricity produced by the photovoltaic installations located on the roofs of the participants of the cooperative by the ILPB;
- Price for balancing provided by the Anaerobic Plant, including the work of a management and coordination team.

Tables P-5.4 and P-5.5 show the results for the two rooftop PV production capacity options.

Table P-5.4. Price parameters for a ~645 kWp installation

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Annual operating costs	100 000	102 000	104 040	106 121	108 243	110 408	112 616	114 869	117 166	119 509
Depreciation 1 (promoters)	157 389	157 389	157 389	15 7389	157 389	157 389	157 389	157 389	157 389	157 389
Depreciation 2 (municipality)	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000
Production	837 778	82 9400	821 106	812 895	804 766	796 718	788 751	780 864	773 055	765 324
Price 1, BGN/kWh	0,188	0,190	0,192	0,194	0,196	0,198	0,200	0,202	0,204	0,206
Price 2, BGN/kWh	0,686	0,697	0,708	0,720	0,731	0,743	0,755	0,768	0,780	0,793
final price, BGN/MWh	287	291	295	299	303	307	311	315	319	323
price, €/MWh	144	146	147	149	151	153	155	157	159	162

Table P-5.5. Price parameters for installation ~ 480 kWp

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Annual operating costs	100 000	100000	102000	104040	106121	108243	110408	112616	114869	117166
Depreciation 1 (promoters)	125 167	125167	125 167	125 167	125 167	125 167	125167	125167	125167	125167
Depreciation 2 (municipality)	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000
Production	628 333	622 050	615 830	609 671	603 574	597 539	591 563	585 648	579 791	573 993
Price 1, BGN/kWh	0,199	0,201	0,203	0,205	0,207	0,209	0,212	0,214	0,216	0,218
Price 2, BGN/kWh	0,686	0,697	0,708	0,720	0,731	0,743	0,755	0,768	0,780	0,793
final price, BGN/MWh	370	375	380	385	391	396	402	408	413	419
price, €/MWh	185	187	190	193	195	198	201	204	207	210

It should be pointed out that the prices thus determined are final, as no network service and public service obligation surcharges are due.

In order to provide a realistic basis for comparison with the current way of forming a final price, Table P-5.6 shows summary estimates of the annual costs of the network service and public service obligation surcharges.

Table P-5.6. Prices for supply from the network

Prices for delivery from the network	Lv./year.
Networks, transmission	12 209
Networks distribution n.n / c.n	7774 / 20 278
Duty to society	7324
Commercial surcharge, BGN 30/MWh	30600
Delivery cost, BGN/MWh	**77**

Therefore, for comparison with the current electricity price formation, it should be assumed that for active electricity price contracts below 210 BGN per MWh it is more profitable to maintain the current model with grid supply. For deciding on investments in PV installations and cooperatives, it should be considered that the lifetime of PV installations is 20 years, whereby after paying off the investment in the first 10 years, the price within the cooperative will drop dramatically.

An additional contingent valuation was made for the effect of JLP's involvement as a partner with the cooperative and as a stand-alone site. The estimate is presented in Table P-5.7 and is made under the same conditions to form the investment for a 515 kWp stand-alone PV installation and 10-year payback.

Table P-5.7. Assessment of partnership opportunities with the cooperative

company JLP	Under contract with a trader (2021)	Under contract with a trader (2022)	Under contract with the cooperative
price of own electricity PV, BGN/MWh	344	344	344
network price, BGN/MWh	226	235	197
selling price of own electricity PV, BGN/MWh	-183	-246	-188
final price, BGN/MWh	388	333	354

The evaluation shows that JLP can negotiate more favorable terms when working as a partner with the cooperative due to the higher costs of grid services and balancing from a merchant. The possibility of obtaining a high price for the renewable energy produced is very conditional. Of course, the inclusion of the company in the cooperative should not be excluded as an option either.

7. Conclusions and recommendations

- The proposed model is indicative and should be developed in detail after a decision in principle on the establishment of a cooperative.
- The existence of the possibility of balancing from another RES source, such as the anaerobic plant of the Municipality of Burgas, allows to develop a concept for maximum satisfaction of the needs of a large part of the sites in the ILPB, based on own production.
- Achieving high investment efficiency for PV installations is linked to maximizing the use of the energy they produce on site, which requires the implementation of "smart" solutions to manage the consumption of individual units and groups of units.
- The price levels achieved are competitive with the current prices for active electricity, taking into account that the offers for long-term contracts (for 12 months ahead) are now between BGN 300 and BGN 450 per MWh.
- Additional opportunities for electrification and new technology development are associated with the introduction of electromobility, but these involve additional investment and are therefore not discussed in the model considered.