SOLAR CITIES

Cities powered by sun. Unlock the solar potential of Burgas and Sofia

09.2023

GUIDELINES

For the construction of small photovoltaic installations by citizens and companies (from the idea to the commissioning)

БСА БЪЛГАРСКА СОЛАРНА АСОЦИАЦИЯ

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Federal Ministry for Economic Affairs and Climate Action

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European Climate Initiative EUKI

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1. INTRODUCTION

The project "Cities Powered by Sun. Unlocking the Solar Potential of Burgas and Sofia (Solar Cities)" is funded by the European Climate Initiative (EUKI). The main objective is to support the energy transition of the participating cities by implementing a basic set of measures to promote the process of implementation of projects in the field of renewable energy sources (RES). By assessing the potential of the participating cities for solar energy production and creating administrative conditions to support the implementation of photovoltaic projects in the private sector, local communities and authorities are supported in the implementation of their climate and energy goals.

Effective measures and tools have been created to facilitate citizens, institutions and businesses in Burgas and Sofia when investing in photovoltaic plants on the roofs of buildings, regardless whether they are residential, administrative, or industrial.

The main activities are related to the preparation of an assessment of the total potential of Sofia and Burgas regarding the production of solar energy. As part of the project, large-scale aerial photography of urban areas have been carried out and the possible number of solar panels that could be placed on a specific building have been calculated.

The data is also used to update the energy strategies of Sofia Municipality and Burgas Municipality and a public digital platform has been developed in which the collected information is placed. There every citizen can get familiar with the data for the building in which they live or work — number of panels that can be installed, amount of energy that could be generated, estimated deadlines for the completion of the project, trainings, etc.

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2. RENEWABLE ENERGY CONCEPT

Renewable energy sources cover resources at local level, available for use and providing a number of advantages for the sustainable development of the municipality and the region as a whole. These energy sources are renewable and serve as substitutes for fossil fuels, which contribute to the reduction of greenhouse gas emissions in the atmosphere. In terms of the local economy, they ensure the stability of energy supplies, since their use does not depend on global events and conflicts, as well as on the exhaustion of resources. They also provide new jobs for the production and development of technologies, the construction and operation of the installations, and their service infrastructure.

The Energy from Renewable Sources Act (effective from 03.05.2011 and last amended in SG issue 54 of 23 June 2023) defines the term "Energy from renewable sources", which is "energy from renewable non-fossil sources: wind, solar energy, energy stored as heat in the atmospheric air (aerothermal energy), geothermal energy, ocean energy, hydroelectric energy, biomass, gas from renewable sources, landfill gas and gas from wastewater treatment plants." Mostly solar energy, aerothermal energy, and biomass are suitable for households and energy communities in urban areas, as well as the energy of the earth's layers and water, which are utilized through heat pumps.

ORDER No. РД-02-20-3 of 9 November 2022 on the technical requirements for the energy characteristics of buildings includes a requirement for the design of buildings with close to zero energy consumption from 1 January 2024. According to the national definition for this type buildings, they need to be in energy class A and not less than 55% of the required (supplied) energy for heating, cooling, ventilation, domestic hot water, and lighting should come from renewable sources located on site at building level or near the building. When existing buildings are being renovated, the possibilities of utilizing renewable sources should also be considered as per the Order.

- **Use of solar energy**

The main technologies for solar energy conversion are the following:

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- photothermal conversion — solar energy is converted into heat through solar collectors or concentrators.

Solar thermal collectors are mainly used for domestic hot water and pool heating. The percentage of solar energy converted into heat when using collectors depends on their type (flat plate without cover, flat plate with glass or other cover or evacuated tube), the quality of the absorber and other characteristics, which are summarized by the so-called efficiency ratio. High-efficiency evacuated tube solar collectors can operate year-round and convert about 70% of the total solar radiation, i.e. for one year 830 kWh of thermal energy are obtained from 1 m^2 collector area for the conditions in Bulgaria. The most favorable conditions are southern orientation and inclination of about 42^o for year-round use.

- photovoltaic conversion – solar energy is converted directly into electricity using the photovoltaic effect. Modern semiconductor materials provide over 20% efficiency and their price in recent years has been economically advantageous taking into account the increasing price of electricity.

The possibilities of passive use of solar energy should also be considered, such as construction of buildings with the right orientation and using materials for maximum utilization of solar energy and respective reduction of energy losses. These so-called “passive buildings” have heating energy consumption of no more than 15 kWh/m2y, which is several times lower than the heating cost of buildings built in the last century. To reduce cooling costs in summer, it is also important to take passive measures such as shading, night cooling, etc.

- **Use of biomass**

Wood and agricultural biomass is utilized according to the following technologies:

- wood-burning stoves and fireplaces — the technology can be improved with the addition of water jackets and air ducts to improve efficiency;
- charcoal production and subsequent combustion;
- briquette stoves and fireplaces — briquettes are fuel made of high-density wood particles, but manual loading and cleaning of the ash is required (similar to the first two technologies);

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- pellet or wood-particle boilers — pellets are fuel made of high-density wood particles and are small in size. Pellets and wood chips are fed automatically, which means that the boilers are operated easily. Combustion is controlled and efficient, producing less ash.

In order to improve the quality of the atmospheric air (Air Priority) under the Operational Environment Program (2014-2020) and the Environment Program (2021-2027), replacing existing inefficient solid fuel appliances with ecological alternatives, such as pellet stoves and boilers, air conditioners, heat pumps, is planned for the new period.

- **Use of geothermal and aerothermal energy**

Using heat pumps provides an opportunity to utilize the energy in the ground, water and air, in which the energy of the low-temperature source is increased using mechanical energy (compressor).

- *Geothermal heat pumps*

These heat pumps utilize the heat of the earth's layers through heat exchangers in the earth's layers or deep boreholes. With these heat pumps, a very high seasonal coefficient of conversion is achieved which can reach 8 (on average during the heating season, from 1 kWh of electrical energy consumed 8 kWh of thermal energy are obtained). Terrain is required for placing the coil or for drilling. The initial investment is high, but the operating costs are small, and in most cases the systems can also work in reverse, i.e. to be used for cooling in the summer with minimal costs for circulating the fluid, i.e. the so-called passive cooling.

- *Water-to-water heat pumps*

There are many areas with shallow groundwater in Burgas and Sofia and their surroundings. For Sofia, these are Obelya, Trebich, Benkovski Negovan, Chepintsi, part of Darvenitsa, etc. There are also high groundwater levels in other heavily populated areas — Druzhba, Hadzhi Dimitar, Lyulin. In Burgas, most neighborhoods also have access to groundwater. The potential of this low-enthalpy energy is difficult to estimate, but in practice it is possible for a large part of the private and municipal buildings in these areas and those near reservoirs and rivers to be heated with water-

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to-water heat pumps. With this solution, the passive cooling mode can also be used when it is embedded in the system.

- *Air-to-air and air-to-water heat pumps*

Manufacturers of modern air-to-air (also called air conditioners) and air-to-water heat pumps are achieving increasingly better performance in terms of efficiency, with those with a higher energy efficiency class having a seasonal conversion factor of over 4 for the climate zone of Bulgaria. The devices are becoming increasingly popular also due to their cooling capabilities.

In addition to heating and cooling premises, heat pumps can also be used to provide domestic hot water for households or energy cooperatives.

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3. GENERAL FUNDAMENTALS AND TECHNOLOGIES FOR PHOTOVOLTAIC INSTALLATIONS

The technological solution has several aspects: location, choosing photovoltaic panels, choosing a storage system (if a decision is made for one), monitoring system, ensuring safe operation, etc.

- **Choosing photovoltaic panels and system sizing**

The main types of photovoltaic panels on the market are silicon panels, which can be:

- monocrystalline — these are the most efficient, and their price has decreased in recent years due to the development of the silicon extraction technology. Their efficiency usually reaches 23%
- polycrystalline — these have lower efficiency of usually up to 18%
- thin-layer panels — with low efficiency, but can be used in facades and similiar building structures.

The life cycle of solar panels extends to 25-30 years, and after 25 years, according to the manufacturers, their efficiency will be about 80%, i.e. decreases by 20%.

Determining the appropriate installed power of the photovoltaic installations is related to determining the installed power and operating hours of household appliances. The time range in which the appliances are switched on and whether the usage of a storage system is necessary should also be taken into account. If there is a load profile from an electricity consumption monitoring system, the hourly load range will be visible, as well as the weekly profile for each day of the week. For households, the load profile varies depending on whether they consist of elderly people and whether there are children. It also varies between seasons, especially when power is used for heating and cooling purposes. Power distribution companies use the so-called standardized load profiles, as an example for Friday, 20.01.2023, is presented in **Fig. 3.1**. There is a higher energy consumption from 7 to 10 am and a pronounced evening peak from 6 to 8-9 pm, which does not coincide with the peak electricity output from PV plants, which is in the midday hours. **Fig. 3.2.** presents actual energy consumption for one electric circuit – a floor of an office building. In this

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profile, energy use is characterized by a morning peak and a comparable consumption during the rest of the working hours.

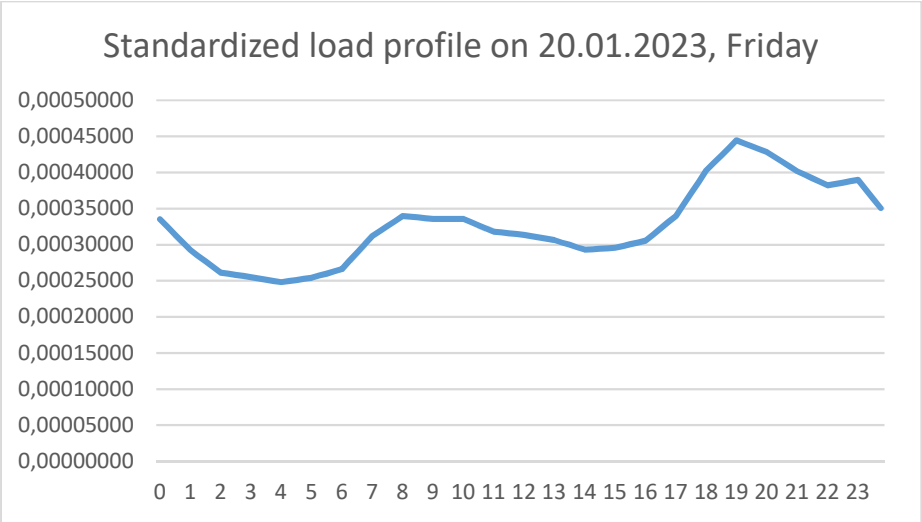

Fig. 3.1. Standardized load profile for households on 20.01.2023.

The supplier companies provide additional consultations and in some cases there are also free internet-based calculators for estimating the average electricity yield for Bulgaria and the redemption period.

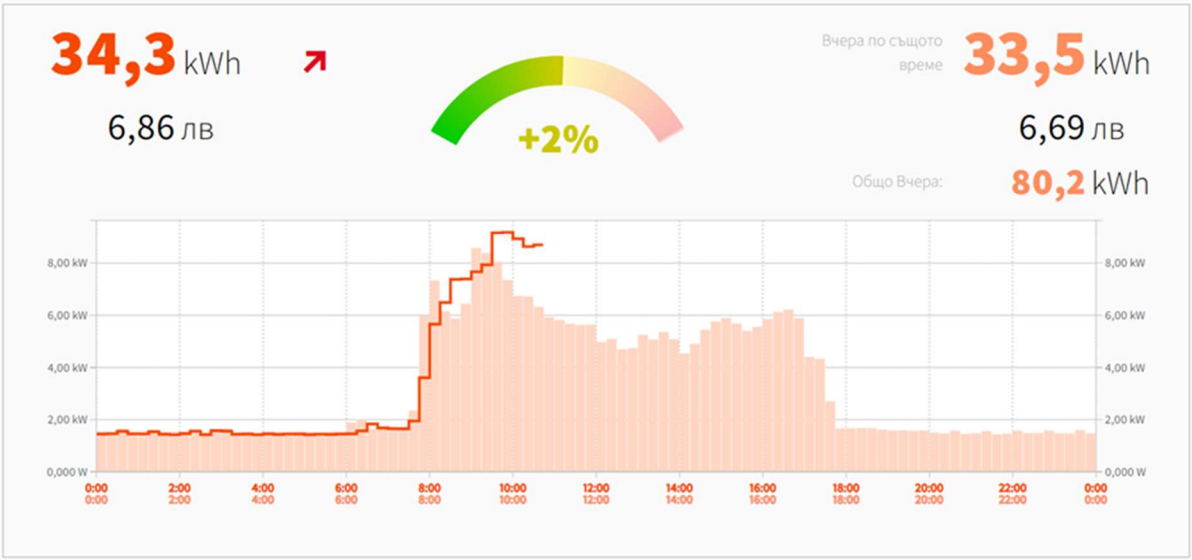

Fig. 3.2. Sample daily load profile of one electricity circuit of an office building

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As a benchmark for households, the power provided by the power distribution companies, which is usually 8 kW, can be used. It reflects the type of installed power of household appliances and the coefficient of simultaneous use. For households with a larger than average number of inhabitants, for example more than 3, a higher power can be installed, and the use of batteries should also be considered for better utilization of the converted energy.

- **Location of the photovoltaic generator**

Theoretically, the possible locations for the installation of photovoltaic modules are:

- on the roof structures of the buildings;
- on the facades;
- on vacant areas.

When the modules are to be placed on any available areas, the detailed layout plan must be complied with, because if the areas are intended for landscaping, construction or installation is not allowed.

Placement on building facades in most cases is not economically justified due to the expensive supporting structure and low efficiency. For example, the theoretical specific power production calculated with the application of the Joint Research Center (JRC) PVGIS for modules installed on the southern facade of a building in the central part of Sofia is 813 kWh/kWp. When being placed on a south-facing roof with an 8-degree slope, the theoretical power production, again calculated with PVGIS, is 1092 kWh/kWp or 34% higher.

There are basically 2 ways to place the photovoltaic modules on the roof structure of a building — parallel to the roof structure or on a structure with an additional slope. The assessment of the method of placement is made on the basis of the following conditions:

- **Load on the roof structure of the building.**

The parallel photovoltaic modules weigh on the roof of the building only with their own weight and the weight of the fasteners, which is minimal. Snow and wind loads remain the same as the building was designed for. When installing a structure with an additional slope, the load on the roof increases, due to several components:

- Load from the additional supporting structure.
- Possible load due to a “snow bag” between the individual rows of the photovoltaic modules

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- Additional wind load caused by the profile of the structures with the photovoltaic modules.

- **Solar radiation**

PVGIS 5.2 Beta version online software with solar radiation data up to 2020 can be used to calculate the energy yield: https://re.jrc.ec.europa.eu/pvg_tools/en/ This is a free web-portal which also contains a meteorological database and which allows the generation of monthly, hourly and other values for solar radiation, air temperature and wind speed. This data is intended for sizing and simulating installations using solar energy.

The roof inclination or the planned slope of the photovoltaic panels relative to the horizon, as well as the orientation relative to the south, need to be entered.

If structurally possible, when designing the installation, an orientation to the south or southeast can be chosen, which will correspond better to the mode of use of the building.

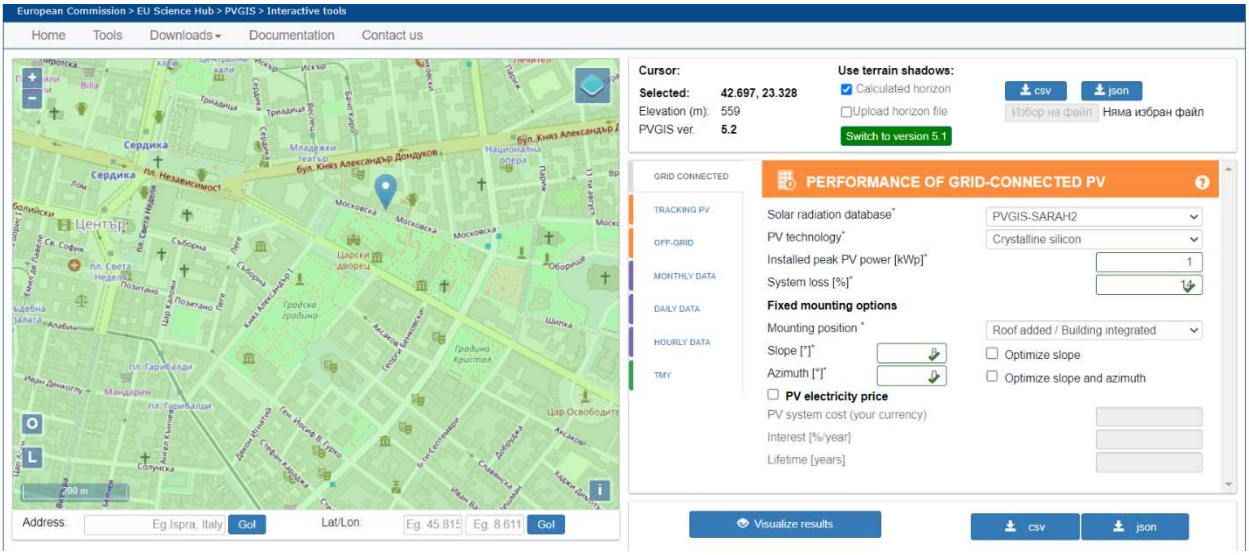

Fig. 3.3 Input Data about the Model

To produce the maximum amount of electricity, the photovoltaic modules must be oriented at the smallest possible angle to the sun. The optimal inclination of the photovoltaic surface to the horizon for the region of Bulgaria is about 32°. However, in order not to shade the individual rows of photovoltaic modules, a distance of about 2 times greater than that occupied by the modules must be left between the rows, which means only 33% utilization of the free area. Therefore, in

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practice, it is necessary to install the photovoltaic modules at a smaller angle, in order to utilize a larger part of the free area.

- **Self-cleaning option**

Contamination is continuously deposited on the surface of the photovoltaic modules. In order for them to be cleaned by the rain and not have to be cleaned manually, the photovoltaic modules must be tilted at a minimum angle of 5 to 8° so that the rainwater can pass the frame of the module.

Dust monitoring can be carried out for the specific location — near a busy road or muddy area. .

According to a study conducted on the effect on power generation of module dusting, it depends to a large extent on the amount and type of pollutants. The finer the dust particles, the more densely they cover the active surface of the solar cells and block more of the sunlight reaching it. According to the same study, the effect of the accumulation of various types of pollutants on photovoltaic modules varies from insignificant, in the range of 3-5%, to severe — about 60% in prolonged dry periods.

- **Energy storage**

The storage of energy from photovoltaic systems gives us the opportunity to use the energy from the sun outside the time of production itself. An economically viable solution for storing energy from photovoltaic plants for households is the use of electrochemical storage systems — batteries, accumulators.

One of the main features of batteries is their useful life, i.e. their charge and discharge cycles. Lead-acid batteries have the lowest number of cycles, which is between 1000 and 1500 cycles, while manufacturers of lithium-ion batteries declare between 2000 and 6000 cycles. There are also new technologies reaching 15,000 – 20,000 cycles.

The batteries can be connected through the AC part — the photovoltaic system and the energy storage system are connected to separate inverters and can work simultaneously or separately. When connecting the DC side, one inverter is used and the two systems can only work

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together as one system. In addition, if a bidirectional inverter is used, the battery can be charged both from the photovoltaic system and from the grid.

Fig. 3.3. Modular batteries for photovoltaic systems

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4. STEP BY STEP CONSTRUCTION OF PHOTOVOLTAIC INSTALLATIONS

The steps involved in the construction of photovoltaic installations slightly differ depending on whether the installations are placed in a single- or multi-family residential building. There are also differences at the preliminary decision-making stage when establishing an energy cooperative.

4.1. Preliminary stage

The preliminary stage is related to making a decision and researching a specific technological solution.

A. Single-family residential building — the owner of the property decides to place a photovoltaic plant on the roof of an existing building or in the immediate vicinity in the area of the property.

B. Multi-family residential building — individual usage for a separate household

In the case of a household with ownership of a home in a multi-family building, the consent of the condominium should be obtained and it should be approved with a Decision of the General Meeting of the Owners as per Art. 17 (2.5) of the Condominium Management Act (with a majority of not less than 67 percent of the ideal parts of the common parts).

C. Multi-family residential building — collective use for common needs and/or for sale

A Decision of the General Meeting of the Owners is required as per Art. 17 (2.5) of the Condominium Management Act (with a majority of not less than 67 percent of the ideal parts of the common parts).

4.2. Design stage

The construction of photovoltaic systems for the production of electrical power from the sun is treated as construction in the sense of the Spatial Planning Act (SPA) and special regulations have been established to regulate the PV systems, namely Art. 147 (1.14) and Art. 147 (2) of the SPA.

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Photovoltaic installations with an installed capacity of up to 1 MW (1000 kW) are classified as 6th category construction and are processed according to the so-called simplified procedure specifically designed to stimulate the construction of such installations.

The procedure applies to urbanized areas, i.e. in regulated land properties (RLP) where construction is permitted. If the plots are outside of populated areas, their designation must changed. Construction in agricultural lands, forests, and other specific terrains requires a procedure for changing the designation. Also, the procedure under Art. 147 (1.14) of the SPA is applied in the case of construction "to the existing buildings in the urbanized territories, incl. on their roof and facade structures and in their adjacent land properties."

4.2.1. Request for preparing a sketch with a design visa.

It is submitted to the respective municipality in which the property is located. If fees are paid, which may vary between the municipalities, the visa is issued within 7 weeks. Whether the property meets the requirements of the SPA for construction is assessed, as well as whether Art. 147 for the simplified procedure should be applied.

4.2.2. Request to research the connecting conditions.

With the issued sketch/design visa, a request is submitted for researching the conditions for connection by the distribution company to whose network the site will be connected (Electrodistribution Grid West EAD (EGW West), Electrodistribution South EAD (ED South), Electrodistribution North AD).

An opinion on the connection of the power plant follows, and for sites up to 30 kW the opinion is issued within 30 days of receiving the request. If the place of connection of the energy sites coincides with the place where a device for commercial measurement of the consumed power is installed and if the installed power does not exceed the power provided for connecting the building as a site of a user — within 15 days of receiving the request.

There is no need to conclude a preliminary connection contract for sites up to 30 kWp, but only a connection contract under the conditions defined in the opinion of the electricity network operator and when a building permit is issued.

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Indicating in the request that you wish the connection point to be the main switchboard is advisable. In the event that the power requested for connection is lower than the provided one, the power distribution company has no reason to refuse connection (for example, a household with 8 kW of connection power declares that it will install a photovoltaic plant of up to 8 kW). In the case of a higher power of the photovoltaic plant, the power distribution company may give instructions for the construction of a route and a connection point to the nearest substation.

4.2.3. Preparation of an investment project

With the sketch/visa and opinion, design is commissioned in the scope of: opinion by a design engineer; projects for the electrical part with drawings, diagrams, incl. single-line diagram, calculations and instructions for their implementation and an opinion, which determines the conditions for connecting to the distribution network.

4.2.3. Obtaining a construction permit

The prepared investment project and the opinion on the connection are submitted to the municipality for the issuance of a construction permit for a category VI site. In this case, approval of the investment project is not required.

In the case of a specified connection point to an existing substation, a category III construction permit is issued. These projects include the construction of cable routes and are also coordinated with communication companies and water supply and sewerage companies, fire departments, etc.

4.2.4. Connection Agreement

With the issued construction permit, a connection agreement is concluded with the distribution company.

4.2.5. Peculiarities when building photovoltaic installations only for own consumption on real estate in urbanized areas

In this case, Art. 25a of the Energy from Renewable Sources Act (ERSA) is applied, according to which an end customer can build energy sites for the production of electric power from renewable energy sources on roof and facade structures of buildings connected to an electricity distribution network and on real estate attached to them in urbanized areas, the energy

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from which will be used only for own consumption. The end customer must notify the operator of the network to which the facility is connected. Within 14 days of receiving the notification, the operator provides an additional agreement to the contract for access and transmission to the end customer, which specifies the technical requirements to the connection scheme of the energy site to the electrical system of the end customer and regulates the rights and obligations of the parties, with the purpose of guaranteeing the security of the electric power system and preventing any disturbances in the network. The additional agreement is concluded before the issuance of a permit for the construction of the energy site as in this case an opinion on the connection is not issued.

For the construction of an energy site under Art. 25A (1) of ERSA with a total installed capacity of up to 5 MW in accordance with Art. 147 (1.14a) of SPA, an investment project approval for the issuance of a building permit for their installation is not required.

With amendments in Art. 151 (1.19) of SPA (effective from 20 January 2023), a building permit is not required for the construction of installations for the production of electric power from RES in existing single-family residential buildings and in their adjacent land properties, the energy from which will be used only for own consumption if the total installed power is up to 20 kW.

For these installations, preparing project solutions is required for constructions and/or electrical parts with drawings, diagrams, calculations, technical specifications, and instructions for the implementation of the installation, guaranteeing safe operation and protection against the return of electrical power to the electrical distribution network when the building is attached to such.

A building permit is issued for the connection of installations for the production of electrical power from RES in single-family residential buildings in the event that the total installed power of the installation is over 20 kW, as well as in multi-family residential buildings in all cases.

4.3. Construction and commissioning stage

The photovoltaic plant should be built by technical persons possessing the necessary qualifications according to the requirements of Art. 21 of ERSA (or another similar national accreditation program) and in compliance with all applicable safety standards for the installation, as well as a high standard of quality of the materials used.

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The network operator establishes the suitability of the electrical plant by carrying out an on-site inspection of the degree of completion of the installation and prepares, along with the manufacturer and the person performing the installation, a protocol of findings on the compliance with the building permit, the connection contract, and the agreed project in its Electric part.

If energy is supplied to the network, an access and transmission contract is concluded with the power distribution company.

The plant is connected to the network.

4.4. Operation Stage

During the operation of the photovoltaic plant, the following must be observed:

- Power production
- Monthly and annual energy yield
- Normal operation of the equipment — photovoltaic panels, connectors, inverters, batteries, etc.

4.5. Decommissioning and recycling stage

The recycling of the components of photovoltaic plants is a frequent problem given their mass market entry. Photovoltaics fall under the requirements of Directive 2012/19/EC of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (revised text).

One of the silicon module recycling plants was built in Rousset, Bouches-du-Rhône, France. The recycled raw materials are: glass (between 65% and 75%), aluminum, plastic (10%), silicon and copper, all of which are recycled into the production of raw materials or incinerated (the plastic). In this way, the principles of the circular economy are respected. A brief presentation of the plant with a description in Bulgarian can be found at the following link:

https://www.veolia.bg/bg/reciklirane-na-fotovoltaichni-paneli-edna-unikalna-tekhnologiya

Regarding the recycling of batteries, the applicable legislation must also be complied with and there are many facilities that specialize in this activity.

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5. QUALITY IN CONSTRUCTION AND OPERATION OF PHOTOVOLTAIC INSTALLATIONS

The quality in the implementation of projects for the use of photovoltaic installations is of key importance to obtain the expected result and guarantee the sustainable operation of the systems. Quality must be ensured at each stage of the life cycle of photovoltaic plants.

5.1. Engineering

The engineering of photovoltaic installations includes the stages of design, construction and commissioning.

5.1.1. Design

At this stage, a model of the photovoltaic installation is prepared as well as a conceptual, technical, and working project.

The modeling of photovoltaic systems is required due to the need of preliminary analyzes and assessments of the potential of solar energy and the expected energy yield. Software products are used — these are used to simulate the operation of the installations for a certain period of time (most often a year) in order to determine their behavior and the amount of energy produced.

There is a wide variety of software products that differ from each other in their computing models used, user interface, range of activities that can be performed, their ability to exchange data with other software applications. The source data for the software are:

- site location – building or terrain;
- inclination at installation;
- roof orientation;
- power of the installed panels;
- planned installed panels and inverter/inverters, etc.

If there is shading, its effect should also be reflected in the software if possible.

The main software products used are:

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- PV GIS - free Internet-based software of the Joint Research Center of the European Commission:
  https://re.jrc.ec.europa.eu/pvg_tools/en/
- PV*SOL online - free internet-based software by Valentin Software GmbH
  https://pvsol-online.valentin-software.com/#/

The paid version of the program has a number of additional options for preparing projects with the placement of the panels on a specific building or terrain.

- PVsyst - paid software for modeling photovoltaic systems -https://www.pvsyst.com/

- HelioScope – paid software for modeling photovoltaic systems https://helioscope.aurorasolar.com/

There are many other softwares that are used for modeling and simulating photovoltaic systems. Usually the paid versions have a trial period, but it is possible that the full functionalities are not available in the trial period.

Following the instructions of the company or organization that developed the software, as well as accurately entering the system parameters, is necessary when preparing the model. The accuracy of the simulations is greater when specific brands and models of panels and inverters are introduced, which can be selected from the libraries of the respective software. More than one product may be used to compare results. Modeling also allows rapid simulation and comparison of alternatives, including with and without storage systems. Professional programs also allow entering a load profile of energy consumption, for example for a period of 1 year, and when simulating the results, you can see for specific days and months what the expected production is and what part of the own consumption it will cover.

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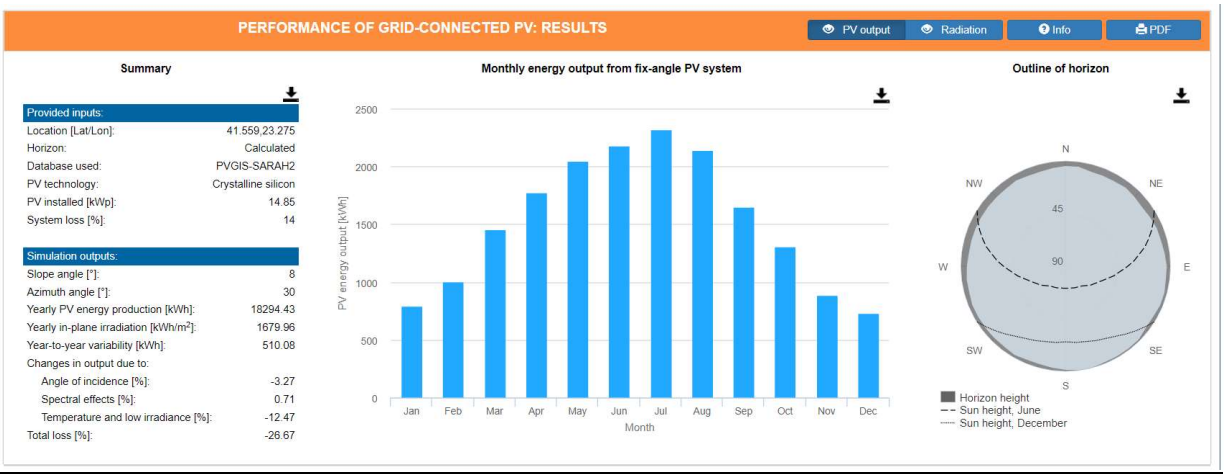

Fig. 5.1. An overview of the results for a sample photovoltaic system

At the design stage, a conceptual design can be prepared first, which includes:

- preliminary drawing of the layout of the power plant, simulation of power production,
- grid connection assessment and approximate bill of quantities for the key components only: PV modules and inverters — manufacturer and model;
- assembly construction and preliminary single-line diagram of the electrical installations;
- Simulations of electricity production with assumptions about possible losses from availability, pollution, wiring

The working/technical project contains specific project decisions and details, as well as a bill of quantities.

A number of maintenance requirements must be considered at the design stage:

- The supporting structure must allow maintenance and cleaning of the panels and grass mowing (if it is on undeveloped terrain);
- The string cables should be fixed in a way that keeps the connectors away from rain and flooding should be prevented;
- Lightning protection must be provided;
- A monitoring system should be in place to allow quick detection of problems.

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The necessary parts of the project, at least ELECTRICAL and CONSTRUCTIVE (or constructive opinion), must be prepared by designers with the respective licenses that are members of the Chamber of Engineers in Investment Design (CEID). Insurance "Professional liability of the participants in the design and construction" should also be required, which is mandatory (as per Article 171 of the Spatial Planning Act (SPA)). The insurance is intended to compensate for damages caused by the Insured person to other participants in the construction and/or to third parties in the exercise of his/her professional activity.

The proposed suppliers of key components should be inspected for satisfactory experience and appropriate warranties. Consultations can be held with importers of equipment and companies with experience in the installation of such systems, including members of the Bulgarian Solar Association, the Chamber of Installers in Bulgaria, representatives of equipment suppliers, etc.

5.2. Installation of photovoltaic systems

According to the Energy from Renewable Sources Act, "Art. 21. (1) (effective from 31.12.2012) Installation and maintenance activities of biomass facilities, solar photovoltaic converters, solar thermal installations, heat pumps and surface geothermal systems shall be carried out by persons possessing the necessary professional qualifications." Pursuant to paragraph 2 of the same article, "The acquisition of a qualification for carrying out the activities under paragraph 1 is carried out under the conditions and according to the procedure of the Vocational Education and Training Act." The Recognition of Professional Qualifications Act for ensuring access to and exercise of regulated professions in the Republic of Bulgaria also settles the recognition of professional qualifications acquired in other member states of the European Union and in third countries for carrying out the activities under para. 1.

Lists of persons who have acquired qualifications for carrying out the activities under Art. 21 (1) of ERSA — installers of biomass facilities, solar photovoltaic converters, solar thermal installations, heat pumps, and surface geothermal systems, are published online on the page of the Sustainable Energy Development Agency: https://www.seea.government.bg/bg/spisaci/spisak-21-bg.

The guarantees for high-quality performance are assumed by the installation companies, which have in their teams competent people who carry out the installations.

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Upon acceptance of the photovoltaic system, the engineering company (the designer) must hand over to the contracting authority an executive version of the design documentation, which fully reflects the actual implementation of the installation and the construction activities performed. In the event of larger systems or a higher category of construction, this is done after 73-hour tests and by an acceptance committee. Also, considering the growing digitization in construction, the documentation should be applied to the building information model, including an accurate geospatial model (3D model) based on the data from drone photography of the construction process or after installation. This allows for easier monitoring results and maintenance.

In addition to the executive documentation, other documents such as operation and maintenance manuals, warranty conditions, etc. are also submitted. Instruction and training of a representative of the owner is implemented — preferably a person with technical knowledge.

Insuring the asset is recommended, as this is a mandatory requirement when receiving grant or a targeted bank loan.

5.3. Operation of photovoltaic systems

When operating photovoltaic plants, the manufacturer instructions and the good practices related to their operation should be followed. This includes:

- **Monitoring key performance indicators** – the monitoring of power production in modern systems is performed via meters and communication systems embedded in the inverters. To improve the quality and safety of the systems, using panel optimizers is recommended, which reduce losses from production tolerances (differences in the production among individual panels from one batch) to partial shading of the panel, which under normal conditions and in the absence of optimization will affect the entire string of panels. In addition, there may be an indication of the temperature rise of the connectors, etc., as well as a quick shutdown at the module level. Inverters must also be disconnected in the event of a problem, including fire.
- **Battery maintenance**

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Batteries must be regularly checked for corrosion and always maintained at optimal charge levels to function properly. If the charge is too low, that can lead to permanent damage, and if it is too high, it can lead to overheating.

- **Visual checks and technical inspections**

Visual checks and/or technical inspections of the condition of the facilities are carried out at certain time intervals or when problems are detected by the monitoring system. The purpose is to detect faulty modules and inverters, breaks or poor connections at the connectors, etc. The inspections can be aided by thermal cameras, measuring devices, and other devices for detecting damage in all components of the system. Attention should also be paid to the fastening of the panels and the condition of the assembly structure.

Good practice, especially for larger installations, is to enter into a contract for the monitoring and subscription maintenance with a company that provides this type of professional services. Thus, losses in case of possible damage to the facility can be reduced.

- **Cleaning**

Cleaning can be done once or twice a year or as needed. In most cases, self-cleaning of the systems is sufficient for their proper operation. The constructions must also be adapted to the possibility of snow accumulation and its effect should also be taken into account.

Modernization of photovoltaic systems is usually not required during their operation. It may be necessary to change some pieces of equipment and modules to meet the latest requirements or to reach higher efficiency, achieving better energy yields from the available area.

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6. FUNDING OPPORTUNITIES

6.1. National Recovery and Resilience Plan of the Republic of Bulgaria

The main objectives of the National Recovery and Resilience Plan are to facilitate the economic and social recovery from the crisis caused by the COVID-19 pandemic and to create a more sustainable, fair, and successful economy.

6.1.1. Under procedure BG-RRP-4.026 - Support for renewable energy for household — Call 1 Component 2: Purchasing photovoltaic systems up to 10 kWp, including electrical energy storage systems, is funded, which includes activities for delivery and installation of a photovoltaic system up to 10 kWp, which may include an electrical energy storage system, including technical commissioning of the photovoltaics systems — purchasing fittings, cables, structure for installation of the facility, inverters, etc.

The purpose is to support at least 10,000 households with a total budget of BGN 240 million, and the implementation of the contracts is until the end of 2025. The resources will be distributed in stages. As per Call 1, the planned amount of the investment has been determined to be a total of BGN 80 million and the remaining financial resource will be further distributed in 2023.

There are two funding options:

- Option 1: The proposal is for funding an investment for which the commissioning activities have been completed in the period from 7 June 2022 until the submission of the proposal by the Applicant under this procedure.

or

- Option 2: The proposal is for funding an investment for which the delivery, installation and commissioning activities are in progress at the time of the conclusion of the funding contract with the final recipient or will be performed after the conclusion of the contract.

The maximum amount of funding of a proposal under:

- Component 1: Purchase of solar installations for domestic hot water — up to 100% of the value of the installation, but not more than BGN 1,960.83;

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- Component 2: Purchase of photovoltaic systems up to 10 kWp, including the electrical power storage systems — up to 70% of the value of the system, but not more than BGN 15,000.

The sale of the produced and/or stored electric power is not allowed, and for this purpose Art. 25a of the Energy from Renewable Sources Act (ERSA) will be applied, according to which an end customer can build energy sites for the production of electric power from renewable energy sources on roof and facade structures of buildings connected to an electricity distribution network and on real estate attached to them in urbanized areas, the energy from which will be used only for own consumption.

The eligibility conditions for applicants are specified in 12 points of the Application Conditions, the main ones being that the applicant is a natural person; is the owner or co-owner of the home the applicant is applying for; his/her permanent address is at the residence for which the applicant applies; the home is regulated and used only for residential purposes; - there is no registered legal entity or non-profit legal entity; consent of the condominium, in the case of housing in a multi-family building, is present; the home is heated with inefficient source of heating energy; the due local taxes and fees and others have been paid.

The published clarifications of questions on the program also include the condition for using inefficient source of heating energy: "In item 8) of item 9.1 of the Conditions for Applying under the Procedure, a requirement is included for using inefficient heating source (stove, boiler, fireplace, etc.) using solid fuel (wood, coal, etc.) in the home. The solid fuels listed in parentheses do not represent all possible solid fuels that are used. Therefore, under this procedure, pellets are considered to be inefficient source of heating energy."

The submission of a proposal for the implementation of an investment under this procedure is carried out entirely electronically by filling in a web-based application form and submitting the form and accompanying documents through ISM-UMIS 2020, through the e-application module at the following web address: https://eumis2020.government.bg/bg/s/800c457d-e8be-4421-8ed9-9e78d0a75c39/Procedure/Info/10b9787c-b382-40f2-94b9-1bd8b31f8799

The deadline for submission of proposals is 5 pm on 10 November 2023.

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The application documents and conditions, as well as the clarifications, are published at the following address:

https://eumis2020.government.bg/bg/s/800c457d-e8be-4421-8ed9-9e78d0a75c39/Procedure/Info/d5358ff6-70f3-49ba-96f1-ce8790300fb2

6.1.2. Under procedure BG-RRP-4.024 "Support for sustainable energy renovation of the residential building stock - Stage II, also within the framework of secured funding from the National Recovery and Sustainability Plan, the following are financed: "Placement/installation of systems for the utilization of energy from renewable energy sources for the energy needs of the building, as well as energy storage batteries, hot water boilers to the common parts of the system (not for individual use of SU), if prescribed in the energy research;"

The owners' association should ensure its own participation in this procedure through its own financial resources in the amount of 20% of the value of the eligible costs of the project.

The full application conditions are published on the application portal:

https://eumis2020.government.bg/bg/s/Procedure/Info/fbf34c6a-8f67-4d16-9019-3bd43c71b70f

6.2. Investment of own or borrowed funds

In Bulgaria, there is a good practice for building a photovoltaic installation with the remaining funds from the construction of a residential block in area Geo Milev, Sofia. By decision of the general assembly, a decision was made to build a plant on the roof of the block, and the energy produced to be fully sold. Funds collected from advertising or renting common areas, funds from residents and others can also be used to build such plants on the common areas of the roofs of buildings. There is also a practice of building photovoltaic plants for individual households in single-family residential buildings, which are financed with the residents' own funds.

Banks and other financial institutions, such as the Energy Efficiency and Renewable Sources Fund, offer loans to finance photovoltaic installations both for self-consumption and for sale or combined for self-consumption and the surplus for sale. Loans are primarily aimed at small

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and medium-sized enterprises and farmers, but funding for plants owned by multi-family residential buildings is also allowed. The terms of the loans are specific to each of the institutions.

The Council of Ministers adopted a bill to amend and supplement the Condominium Management Act (CMA), which will facilitate access to funds for energy renovation in multi-family residential buildings. To facilitate the energy efficiency investments in multi-family residential buildings, each condominium will be able to open a special-purpose bank account to collect funds for the management and maintenance of the condominium's common areas. This will also facilitate the application for collective loans before various financial institutions. The disposal of this resource will be carried out by the chairperson of the management board (the manager) based on a decision adopted by the general meeting.

The bill has been submitted to the National Assembly and its adoption is pending.

6.3. Crowdfunding

Collective finance, or Crowdfunding, is the natural extension of the cooperative idea to even larger communities with the help of the internet, drawing support from people across entire countries in order to support specific projects that can create change on a local level, raise awareness of social challenges or inspire communities to participate and engage with local projects and get involved.

With this type of financing, the resources of many citizens and organizations are mobilized for the construction of RES capacities.

More information, advice and ideas about crowdfunding can be found at the following address:

https://www.powerfund.eu/bg/kolektivno-finansirane

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7. SOURCES OF INFORMATION

1. SolarPower Europe Best Practice Guidelines for the Design, Procurement and Construction of Photovoltaic Power Plants — https://apste.eu/wp-content/uploads/2022/06/EPC_Best_Practice_Guidelines_BG_web_low-res.pdf
2. Project POWERPOOR – crowdfunding https://www.powerfund.eu/bg/kolektivno-finansirane
3. Open calls BG-RRP-4.024 – SUPPORT FOR SUSTAINABLE ENERGY RENOVATION OF THE RESIDENTIAL BUILDING FUND - STAGE II https://eumis2020.government.bg/bg/s/Procedure/Info/fbf34c6a-8f67-4d16-9019-3bd43c71b70f
4. Open calls BG-RRP-4.026 - Support for renewable energy for household - Call 1 https://eumis2020.government.bg/bg/s/800c457d-e8be-4421-8ed9-9e78d0a75c39/Procedure/Info/d5358ff6 -70f3-49ba-96f1-ce8790300fb2
5. Lists of persons who have acquired qualifications for carrying out the activities under Art. 21 (1) of ERSA — installers of biomass facilities, solar photovoltaic converters, solar thermal installations, heat pumps, and surface geothermal systems: https://www.seea.government.bg/bg/spisaci/spisak-21-bg
6. Information on crowdfunding within the POWERPOOR project: https://www.powerfund.eu/bg/kolektivno-finansirane

www.euki.de

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