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How To bring solar energy into your city

SOLAR ADRIA

Solar Adria Project

How to promote integration of PV solar system through urban spatial planning

This ***How To*** document was developed under the SOLAR ADRIA project within the European Climate Initiative (EUKI), financed by the Federal Ministry Economic Affairs and Climate Action of the Federal Republic of Germany. With the project, the international team under the lead of Hrvoje Požar Energy Institute (Croatia), aims to accelerate solar power development in the coastal Adriatic municipalities. The objectives of the project are to explore on a municipal level how stakeholders perceive and contribute to energy transition through solar development, to provide solar potential maps for target municipalities and create a matchmaking platform to connect any interested investors with the municipality administration and other stakeholders. The project was carried out in Croatia, Slovenia and Montenegro.

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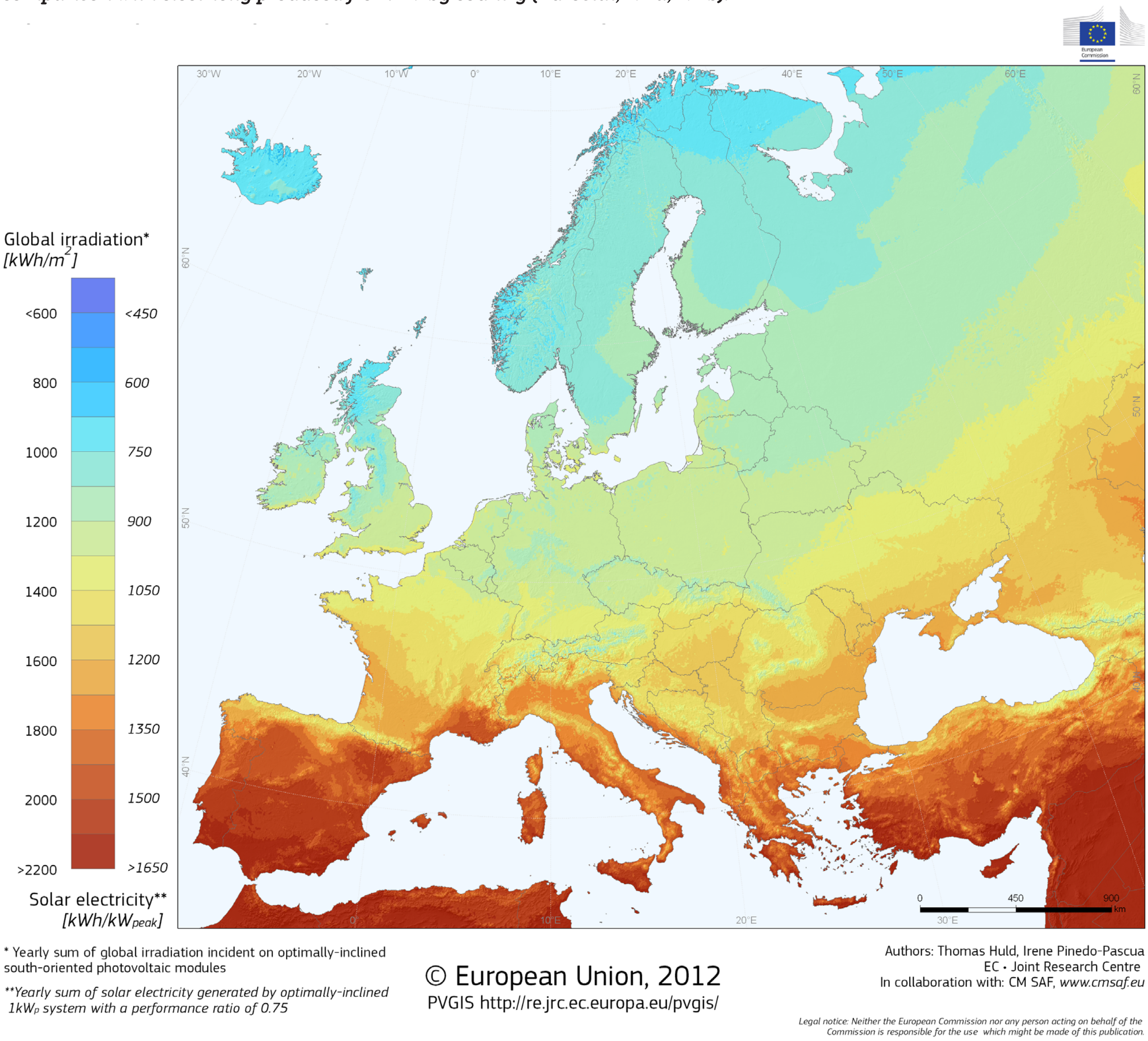
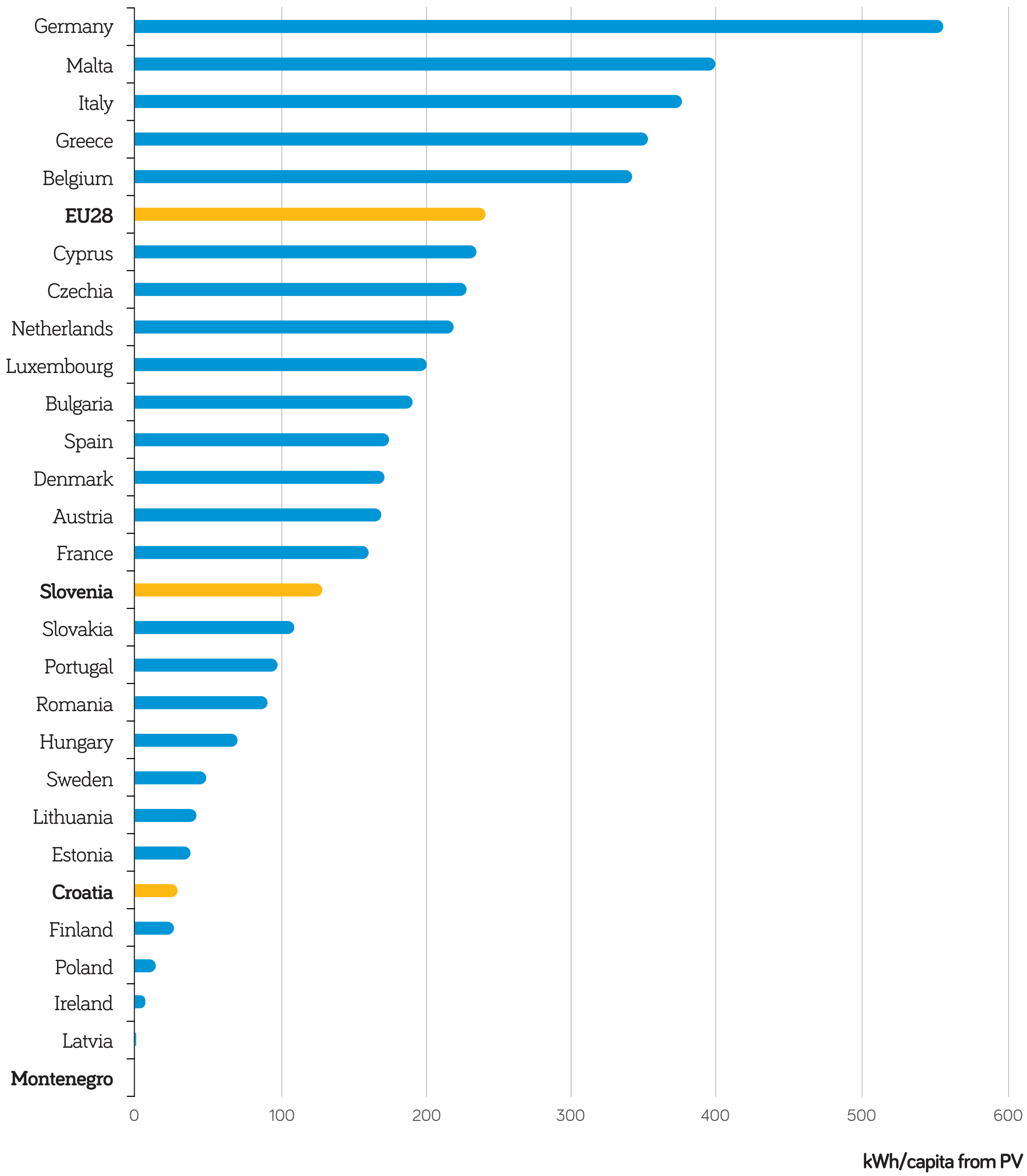
Introduction

Why this “*How To*” guide?

Adriatic region is endorsed with a high solar energy potential but still the utilisation of that potential for electricity generation in urban areas is still limited compared to the other European regions, which often have far lower solar potential. It is noticeable in the Figure 1 below that Slovenia, Croatia and Montenegro leg behind the norther European counties (right), although their PV solar electricity potential is considerably higher. The fact that PV technology is easily accessible on the international markets, and moreover the respective costs have plunged over the past decade, leads to a conclusion that the problem does not lay in the solar potential but in mobilising people to use it. Stakeholder surveys conducted in the Solar Adria project suggest that key problems are lack of awareness and knowledge about solar power utilisation and lack of efforts on local scales to promote development. This guide points out approaches and methods which can be used to remedy these difficulties.

Figure 1. Map of photovoltaic solar electricity potential in European countries (European Commission, 2020) and comparison with electricity produced from PV by country (Eurostat, NDa; NDb).





For whom is this "*How To*" guide?

This document primarily aims to address the leaders of local communities, including decision makers and technical staff of municipalities, in the Adriatic region. But not only them, because a common citizen, a representative of a civil society organisation, an entrepreneur or a teacher, or anybody else interested in how to facilitate higher utilisation of solar energy in urban areas may find the "*How To*" guide interesting.

This document was built on the experience and lessons learnt during the implementation of SOLAR ADRIA project. Over the past two years (from 2020 until 2022) the project collected and analysed information about state-of-affairs in solar energy utilisation in Croatia, Slovenia and Montenegro; collected and assessed views and opinions from the solar energy stakeholders in Koper (Slovenia) and Starigrad Paklenica (Croatia); and, in close collaboration with local authorities, initiated actions through provision of technical tools, guidelines and exemplary feasibility studies.

Lessons learnt during SOLAR ADRIA

In SOLAR ADRIA project we had seen that there are different stages of solar energy market development, each with distinct problems. At the very beginning, in the early stages of the market development, the key problem is to inform citizens about solar energy, PV technology and raise their interest in harvesting the potential benefits from its utilisation. This should be coupled with providing information how to develop a PV project, how to implement a project and what are the existing funding options. Secondly, the regulatory environment should be designed in a way to ensure easy and fast deployment of PV technology. This is especially important once the number of interested people raises. In order to ensure a just "transition" to this new technology, regulations and rules should be clearly set and communicated with potential users. This may include information about the capacity of the distribution grid to uptake new systems, restrictions of PV installations in the urban areas designated as cultural heritage, or what are the options for installation of PV systems in multi-apartment buildings.

State-of-Affairs in Montenegro, Croatia and Slovenia

Montenegro, Croatia and Slovenia, have a different degree of alignment with the EU legislative renewable energy framework, as well as different regulations and support measures for utilisation of small-scale renewable energy technologies. This is also reflected in the level of PV deployment.

Montenegro is still in the initial phase of using renewable sources and at this stage it is crucial to inform citizens about the potential benefits of, and raise interest in, developing solar energy projects. Information about the regulatory procedures and financing options will increase their trust in both the technology and the governance and prone the "champions" initiate projects.

In **Croatia**, the citizens' awareness about solar energy and PV technology is already at a high level, but they often do not know how to install a PV system on their roof and what does it entail to become an electricity "producer" or "prosumer". In other words, there is insufficient information and lack of understanding about administrative procedures, responsible authorities and service providers. This often results with a dose of mistrust in the technical soundness of the equipment and administrative bodies. Such challenges can be addressed though targeted education and discussions, promotion (advertisement) of successful examples and common space for networking.

Finally, **Slovenia** has the most developed integrated PV market among the mentioned countries. Citizens are very interested in installing PV systems on their roofs. The communities are now facing issues related to high density of the PV systems with can affect the stability of the electricity grid network or visual identity of urban areas or cultural heritage.

Therefore, in Slovenia the municipalities should focus on developing tools for more advanced planning of energy communities and the optimal use of available roof surfaces to increase the well-being of the community.

Although part of these problems is commonly addressed on the national level, municipalities can have a vital role in facilitating their practical implementation, and consequently deployment of PV systems. Certainly, different problems will require different methods and approaches. Therefore, on the one hand, one needs to be aware of the national policies and regulation, and on the other, the stage of market development and the prevailing urban, social and environmental conditions in their community. When drafting development strategies and plans, municipalities should set their climate and renewable energy goals based on evidence. Solar maps can be used to estimate the potential of utilizing rooftop spaces for installation of PV systems and thus help define realistic goals.

Municipalities should review their spatial plan, to identify, and revise, the rules that might hinder solar development. Spatial plans can also encourage (or demand) use of solar on new buildings. In order to ensure good governance and provide citizens with high quality services, the municipality staff should be well educated and the whole administration should understand and share common goals related to energy. This will then reduce the likelihood of foregone opportunities (e.g. installation of PV systems as part of public buildings refurbishment). Furthermore, municipalities can act as mediator and promotor of energy communities by bringing its citizens together and facilitating discussions and procedures needed to establish a solar community.

Municipalities can also leverage early adopters or "local champions" to share their experience or help develop new projects. For example, people who have installed solar on their buildings can share their experience though a dedicated website, workshops or networking platforms. Municipalities can also earn from each other through collaboration as well as through collaboration with other organisations, e.g. existing energy cooperatives.

How to read this "*How To*" guide?

The "*How To*" guide is divided into four sections. Each section addresses a specific feature relevant to promotion of PV systems in urban areas.

Section I - *Integrated roof-top PV systems* include a description of PV technology and the elements that should be considered when installing such a system. To read this section, go to page 9.

Section II – *PV project development* identifies the key steps in development of a PV project, describes the elements of project design and feasibility study. Furthermore, in this section you can find description and characteristics of the most common business models applied in the Adriatic region. To read this section, go to page 15.

Section III – *Participatory planning* gives a background information about the participatory urban planning and what methods can municipalities use to involve stakeholders in development of municipality spatial plans and actions related to solar energy. To read this section, go to page 22.

Section IV – *Deployment of PV systems in local communities* includes a set of examples of project initiated by local communities in the Adriatic region and other EU countries aiming to promote the utilisation of solar energy in their areas. This section starts on page 27.

Furthermore, along the document you will find references and links to additional materials which provide more detailed information about the respective topics.

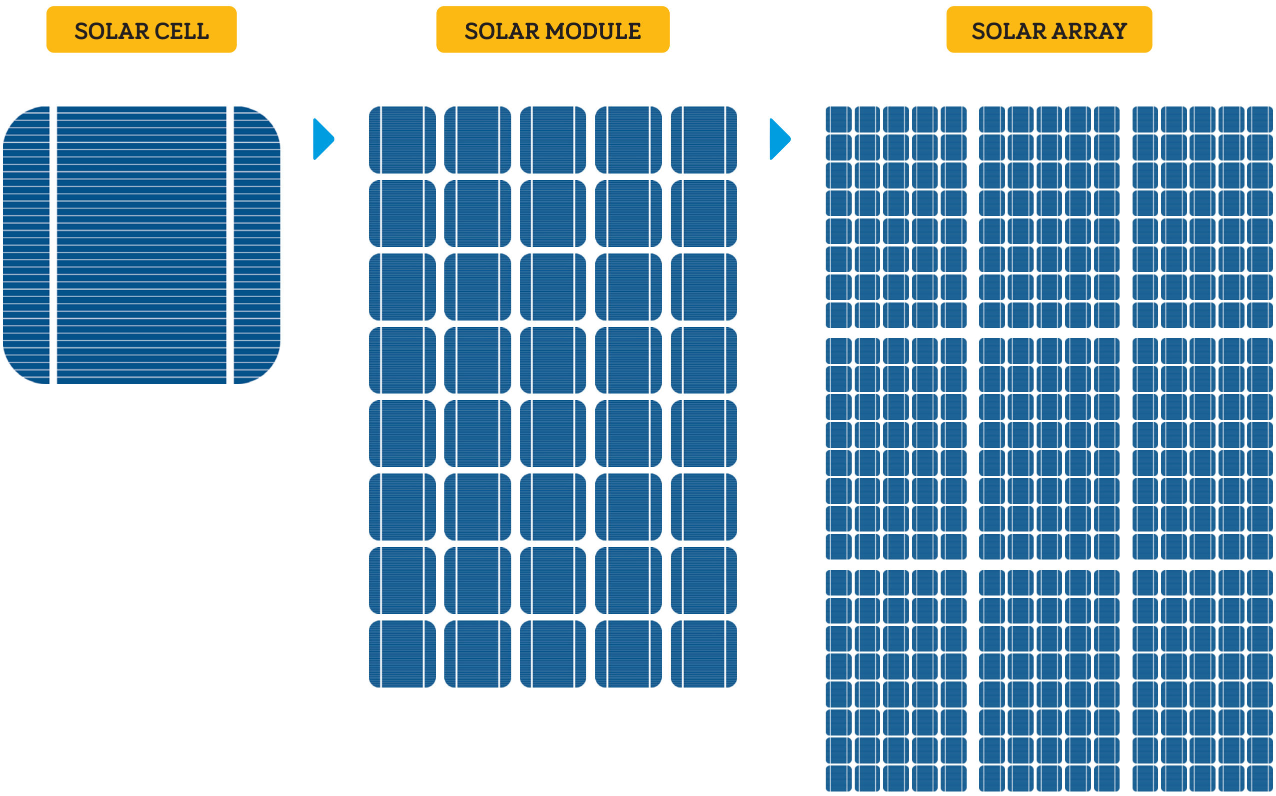
Integrated roof-top PV systems

What are PV panels and how do they work?

Photovoltaics (PV), or solar cells, are devices that can convert sunlight directly into electricity. Their output is optimal when the sun is shining, while production is minimized during cloudy days and during the night.

The individual solar cells are typically small (1-2 Watts) and as to achieve higher electricity outputs, they are connected to form larger units, which are called **PV panels or modules**. The overall power generating equipment is called **photovoltaic array** and it consists of a number of PV panels.

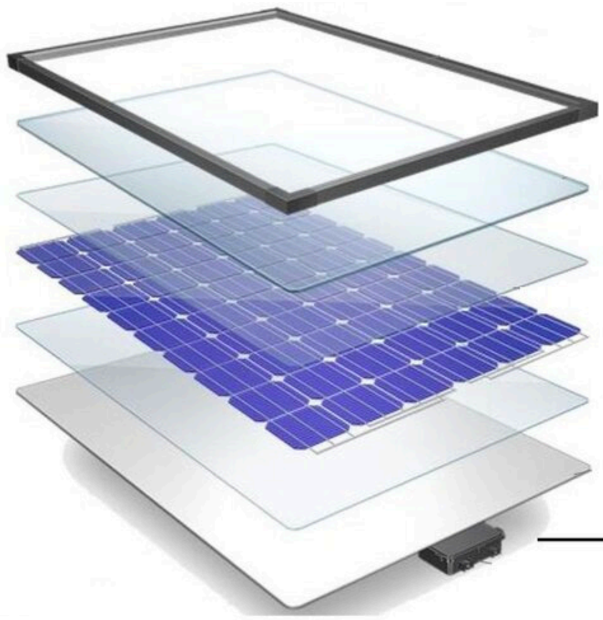
Figure 2. Solar cell, module and array [1]



[1] https://www.energy.gov/eere/solar/articles/pv-cells-101-primer-solar-photovoltaic-cell

PV cells are made of different **semiconductor** materials and currently the major part of the market (approx. 95 %) is using **crystalline silicon**. For a silicon panel, very thin silicon wafers, one positive and one negative, are processed on both sides to separate the electrical charges and thus form a diode, which allows the current to flow in only one direction. Metal contacts are used to surround the diode, in order to ensure that electricity can flow out of the cell. Solar cells are then placed between a **highly transparent, anti-reflective coating**, which is responsible for withstanding high temperatures and humidity and thus ensuring the long-term performance of the equipment. The **front glass sheet** protects the PV cells from the weather and impact from hail or airborne debris. The **back sheet of the panels** is made of a highly durable material that is used to protect the panel from moisture damaging, while also providing mechanical protection and electrical insulation. Subsequently, the **junction box** is added, in order to enable connections inside the module.

Figure 3. Main parts of a PV panel [2]



Typically, PV panels have a **lifespan of approximately 25 to 30 years**, without requiring very frequent maintenance. The efficiency[3] of crystalline silicon panels ranges between **18% and 22%**, with a maximum theoretical value of 32%. However, module performance deteriorates over time at a rate of approximately 0.3% to 1% per year, depending on the module type and local conditions.

Apart from crystalline silicon panels, one other PV technology has been gathering increasing attention in recent years. **Thin film solar panels** do not require a frame backing and are lighter and easier to produce. It should however be noted that despite their flexibility and lower cost, their efficiency typically ranges from 7% to 18% and is lower compared to crystalline silicon panels. There are three types of thin film solar panels, namely cadmium telluride (CdTe), amorphous silicon (a-Si) or copper indium gallium selenide (CIGS).

Solar panels that reach the end of their lifespan can become sources of hazardous waste and cause environmental concerns, if not treated properly. Considering the increasing number of PV installations globally, the end-of-life management of PV is already an important topic. **End-of-life management of PV panels** refers to the treatment of PV panels and other system components after they are retired from operation.

[2] https://www.cleanenergyreviews.info/blog/solar-panel-components-construction

[3] Učinkovitost pretvorbe energije: omjer između izlazne električne energije sustava i stvarne ulazne energije

It allows for the recovery of valuable materials, thus reducing the environmental impacts and promoting resource efficiency. The recovered materials can be re-utilized to produce new PV panels or be sold as raw material on the market. Recycling is also vital for the long-term management of resource-constrained metals, which are used in the production of PV panels.

The specific processes that are required for the recycling of silicon and thin-film PV panels differ. The recycling process of silicon-based PV panels includes the disassembling of panels as to separate the aluminium and glass components. Nearly 95% of the glass can be recovered, while the external metal parts are used for re-moulding frames for new panels. Further thermal and chemical treatment is used to recover silicon cells, with an 85% recycling rate for the silicon material. Thin film-based PV panel recycling allows for approximately 95% of the semi-conductor material to be reused, while 90% of glass elements are also reclaimed for re-manufacturing.

How flexible are PV systems?

PV electricity generation is **a very flexible technology**; the size and specifications of an installation can vary greatly based on the energy requirements and the application.

The systems can be differentiated according to several criteria:

"On-grid" and "Off-grid" PV systems

An on-grid system is connected to and supplies the generated electricity into the utility grid (distribution or transmission grid). On the other hand, an **off-grid or stand-alone system** is not connected to the utility grid, but operates autonomously and is connected only to the energy consumers and/or storage systems (e.g. batteries).

Why is energy storage needed for "off-grid" systems?

Electricity generation from PV panels varies greatly, as sun availability changes throughout the day and the year. This means that at certain time periods it is not possible to generate enough electricity to meet the demand. Additionally, during the day, PV panels can potentially produce more electricity than required, which is then wasted. To combat this issue, **energy storage** i.e., batteries, is usually essential. In this case, the excess electricity produced during the day is stored and is utilized when the production is not possible for example during the night or on a cloudy day. Especially in off-grid systems, energy storage is **vital for reliable electricity supply**.

An innovative emerging solution of energy storage coupled with PV panels is the **vehicle-to-grid** technology, where **electric vehicles (EV)** are used as storage systems. In such a configuration, when the EVs are parked and plugged to a charging station, they can store electricity during hours of peak production (i.e. during the day when the sun is shining and there is a surplus). Then this electricity can be sold and discharged back to the grid when PV outputs are low, thus helping in balancing the grid, while also generating profit for the vehicle owners.

"Ground-mounted" and "Integrated" PV systems

In **ground-mounted systems** PV panels are secured to a rack structure, which is connected to the ground with steel beams. On the other hand, in **integrated systems** the solar rack is installed on a building or another constructive structure which serves another purpose. Such systems are commonly called rooftop systems, since most fervently they are installed on roofs of residential, commercial or public buildings.

Similarly, PV panels can be mounted on any other structure where sun is available. For example, they can be placed on the covers of parking lots and thus generate electricity which can either be fed to the grid or used to power nearby buildings. Additionally, this electricity could also be used to power electric vehicle charging stations located in the parking lot. The latest innovation are the building-integrated PVs, where solar panels are incorporated directly into the building envelope, serving as both a design element and for electricity production.

Size of the PV system: “Rooftop” and “Utility level” systems

PV panels are categorized according to their power output i.e. wattage, which usually ranges from 150 W to 400 W, depending on their size and efficiency. The size of a PV system depends on the energy demand and the application. A typical **residential rooftop** solar system is usually 5-10 kW and has about 30 panels. Solar energy installations can range from hundreds of kW in **commercial applications**, up to hundreds of MW in the case of **utility scale power plants** (solar farms). The typical dimensions of a residential 250 W PV panel are 165x100 cm, while for a 330 W commercial panel they are 196x100 cm.

What are the elements of a rooftop PV system?

A rooftop PV system consists of many different parts and its complexity depends on its size and the specific application. A typical rooftop PV system is presented below, along with its main components and their basic operational principles.

Figure 4. Integrated PV system [4]

[4] https://solargyaan.com/expected-life-of-rooftop-pv-plant-components/

Components of rooftop PV instalation

1. PV panels	PV panels generate electricity by absorbing sunlight. The output of a PV panel is Direct Current (DC).
2. Inverters	A solar inverter is used to **convert the variable direct current (DC)** of the PV panels into utility frequency **alternating current (AC)**, which can either be fed into the commercial grid or used directly to power a household or commercial building. PV systems either have one inverter for all the panels, or microinverters that are attached to each individual module. Usually, it is likely that inverters will have to be replaced at least once in the lifespan of a PV system.
3. Mounting structures	An array of PV panels is mounted on a structure that should be **stable and durable**, in order to be able to support the weight of the equipment and withstand wind, rain, snow, hail and corrosion. Currently **rack mounting** is the most common method, due to its robustness, versatility and easy construction and installation. The specific characteristics of the mounting structure for rooftop PV installations are defined by the type of the roof and the structural characteristics of the building. In the case of a **flat roof configuration**, usually a ballasted racking system is used, which typically does not require roof penetration. The system consists of a pre-assembled structure that uses a set of ballasted blocks as a support for the installation, while the PV panels are attached to the mounting structure using clamps or clips. For **sloped roof systems**, which are most common in residential applications, there are three configurations, for which roof penetration and anchoring to the roof is required. The most typical residential system (i.e. **railed system**) uses rails that are attached to the roof. Panels are placed on the rails, which are secured to the roof by bolts or screws. **Rail-less systems** do not require rails and the PV panels are directly attached to the roof with bolts or screws. This type of configuration presents lower costs and easier installation. Lastly, **shared-rail mounting systems** display the same working principle as railed systems. However, while railed systems use four rails to support two rows of PV panels, in shared-rail systems, only three rails are used, as one is shared by the two rows. **Appropriate design** of the mounting structure can **optimize the electricity production** and minimize shading losses of the system, as it is ensured that panels are placed at appropriate places and with the optimal orientation and tilt angles.
4. Cables	Cables are used to **transmit the electricity produced from the modules** to the inverters and then to the building or the transmission grid. PV cables have to be very durable, as they are constantly exposed to the environment and thus have to withstand UV light, heat and rain without degrading. Cable length also affects the operation and profitability of the system. Minimizing the overall length results in lower losses and reduced capital costs.
5. Storage system - batteries	As mentioned, batteries are used to **store solar energy** when excess production occurs, so it can be used to provide power at night or when weather elements keep sunlight from reaching PV panels. In the case of off-grid systems, a storage system is required for a reliable supply of electricity. A **battery charge controller (BCC)** is required to regulate the voltage and current of the electricity flowing from the PV system to the batteries. This is necessary to prevent damage to the energy storage system by over-charging and over-discharging.
6. Energy meter	Energy meters are used to measure the electricity generated by the PV system, as well as the electricity supplied to or from the grid (for on-grid installations).

What to consider when installing a rooftop solar PV system?

When deciding about installing a rooftop PV system, several parameters need to be taken into account and careful planning is required to ensure optimal and safe operation. These include:

Insolation

Locations with **abundant sunlight** throughout the year are preferrable because they display higher potential for electricity generation. Insolation changes during the day and throughout the seasons and is also affected by the **characteristics of the chosen location**, such as the latitude, terrain elevation, local landscape and weather.

Shading

Neighbouring buildings, trees or natural features, as well as the frequent occurrence of clouds can result in **extensive shading** of the panels and thus drastically **reduce the electricity production** of the system. Additionally, on flat roofs it is possible that shading from other PV panel rows occurs, which again reduces the output and is called **inter-row shading**. Rooftop mounted systems present an important advantage compared to ground-mounted configurations, as it is possible to completely avoid shading with the proper system design.

Orientation and tilt

The orientation and tilt angle of a PV panel is another important variable that has to be taken into account, as optimal performance can be achieved when the sun's rays are **perpendicular to the module surface**.

Building characteristics and safety

Before installing a rooftop PV system, the building's **structural integrity** must be assessed, in order to make sure that the equipment will not cause damages by exceeding the building's allowable loading limits. This is a major issue especially in older buildings. During the design and installation phase of the PV system, its **accessibility** must be taken into account, ensuring that maintenance can be carried out easily, while also not preventing access during emergencies (i.e. in the case of a fire).

On-grid configuration

The excess production of on-grid rooftop PV systems is supplied to the grid, while when PV outputs are not sufficient (i.e. during the night), then it is possible to cover the household energy demands using electricity from the grid. Through a mechanism called **net metering**, rooftop PV owners can get credit for supplying their excess electricity to the grid and offset electricity that they take from it.

Off-grid/Self consumption

It is also possible for rooftop PV systems to be autonomous and only provide electricity to the building. In this case, it is necessary to couple the PV system with batteries, to ensure reliable and constant electricity supply.

PV project development

What are the key steps in PV project development?

The actions required for the development of an integrated PV system are divided into five main steps, which are comprised of several sub-activities:

STEP 1: Preliminary decions about the project

1. Decision who will be developing the project:

- Building owner/Investor, or
- Dedicated solar energy expert (consulting/engineering company).

2. Preliminary assessment of the rooftop area, which should address the following questions:

- What is the roof orientation (south orientation is optimal, north not favourable)?
- Is there *sufficient sunlight* throughout the day to ensure good performance of the system?
- Is the roof in suitable for the installation, or replacement/refurbishment is needed (stability and materials of the roof)?

3. Gathering of legal and technical documentation:

- Building permit, use permit and other legal documents of the building
- Technical documentation about the electricity grid connection and electricity consumption for at least one year (i.e. monthly electricity bills)
- For multi-apartment budlings - a consent of co-owners about the project development.

4. Gathering other relevant information, such as:

- Status of the building regarding special provision, e.g. status of a cultural heritage
- Other legal obligations, contracts and/or ownership rights that may limit or prolong project development

STEP 2: Project design

1. Development of technical project concept and pre-feasibility study, that will be a bases for:

- Deciding on the optimal business model
- Assessment of the grid connection possibility
- Securing funding from third parties (e.g. a bank loan)

2. Initiating discussion with, and obtaining an opinion about and technical precondition for the grid connection possibly from the electricity distribution operator.

3. Development of the project design, that will:

- define the size, mounting structures, electrical and other installations of the system, etc.,
- serve as a technical baseline for obtaining the permits and later purchase the equipment and/or develop a tender for PV system installation services.

STEP 3: Obtaining the necessary permits to install the PV system

A set permits needed for building and operating an integrated PV system and the authorities that issue such permits may be different from one country to another. However, in general they usually include:

1. Permit for energy production (if the system will be connected to the electricity grid) issued by an authority responsible for energy sector on the country/regional/local level (e.g. ministry of energy),

2. Building consent or a building permit issued by the local/regional/national authority (this may include opinion of an authority responsible for cultural heritage, if applicable). For small PV system, such consents are often issued on the local level,

3. Grid connection consent issued by the electricity distribution operator, which confirms that the projects is in line with the required technical standards and provides information now will the production affect the grid.

4. Other permits or contracts, such as:

- Contract with the building owner that confirms access to the roof/location of the PV installation – if the owner is not the project developer.

STEP 4: Building the power plant and connection to the grid

1. Development of a detailed project design which contains detailed plan for installation of the system.

2. Installation of PV system and connection to the electricity grid, which encompasses building the PV system and all electrical works on the building.

3. Closure of electricity sale/purchase contracts as per applied business model (e.g. self-consumption (prosumer) contract with the electricity supplier/distribution system operator; power purchase agreement with the electricity consumer).

4. Closure of the grid connection contract with the distribution system operator

5. Technical inspection and test drive

6. Connection to the distribution network: physical connection to the grid

STEP 5: Monitoring and operation

1. Performance monitoring

2. System maintenance – cleaning

3. System inspection

4. System inspection

5. Improvement of the system for better performance

What is included in the project design and the feasibility study?

In order to ensure that an integrated PV installation is technically feasible and financially viable, it is necessary to conduct a feasibility study for the system. A complete, well drafted feasibility study should include the following parts:

1. Conceptual design of the solar power plant

In this part of the feasibility study the main elements of the system, their characteristics and configuration are defined and described.

Selection and dimensioning of basic elements: The choice of specific equipment for the construction of a rooftop PV system depends on several factors. The most important factors are the price of the equipment itself and the expected production of electricity, but other factors in some cases decisively influence the choice, such as the suitability of the technical solution, market availability, reliability and experience of equipment manufacturers and suppliers. Considering the relatively large number of PV equipment manufacturers, the different available models of PV panels, as well as the constant advancement of technology, it is clear that the conceptual design can provide only one of the possible final solutions. In the early phase of the project, it is important to outline a possible technical solution, potential electricity production and size of investment. The experience shows that prices for similar configurations of different manufacturers and / or equipment suppliers can vary by up to 20%. The concrete selection of equipment for the construction of the power plant takes place in the later stages of the project, shortly before the start of construction of the power plant.

Layout of the system on the roof: It is vital to determine the required area of the system, in order to achieve the desired electricity outputs. A specific arrangement of the system elements is very important, especially in the case of a smaller roof with objects that take up portion of the available area.

Electric system configuration: During this step it is important to determine the connections of the electrical components of the system, such as inverters and PV modules.

2. Estimation of electricity production

The basic parameter that describes the **solar radiation potential** of a certain location is solar radiation on a horizontal surface, while the radiated energy on a sloping surface is more important parameter for the energy use of solar radiation. The estimation of the energy potential of solar radiation should be based on long-term measurements of solar radiation and application of well recognized methods. Data on solar radiation are available in various publications, databases, and publicly available online tools. These data are mostly obtained by measurement, satellite tracking or estimation.

Some of the data sources on solar radiation are explained below:

- **Meteonorm database:** Contains labelling data based on measurements from over 8,000 meteorological stations, five geostationary satellites, and globally calibrated aerosol climatology. Averaged data, as well as multi-year data sets are also available. A site-specific data interpolation tool is available, based on available data from sites for which the data is available.
- **VGIS (Photovoltaic Geographical Information System):** is a publicly available tool for estimating the value of solar radiation and the productivity of the photovoltaic system for Europe, Africa and Southwest Asia. The tool is based on international databases and provides open data and software architecture and high-resolution climate and geographic data integrated into a geographic information system (GIS).

The calculation of **electricity production** from a photovoltaic power plant is based on the **simulation** of the behaviour of the selected photovoltaic system in a simulation computer tool specializing in sizing, calculation of production and cost-effectiveness of photovoltaic systems, based on average climatological data. The computer tool contains a database of photovoltaic system components (photovoltaic modules and inverters), with the characteristics of individual components, in order to properly simulate the operation of the system. An example of this type of simulation software is the **PV* Sol 2022 tool**.

In addition to the estimation of electricity production, the output from the simulation can include a whole range of **various climatological and technical data**, such as the radiation values of the surface of photovoltaic modules, module temperature, exchanger efficiency, overall system efficiency, etc. Furthermore, in the long-term assessment of electricity production during the life of the power plant, it is necessary to take into account the **aging (degradation) of PV modules**, which is manifested by a decrease in rated power of PV modules, and consequently a decline in electricity production.

3. Economic and Financial analysis of the project

The profitability of a rooftop PV system has to be determined by examining the overall investment and operating costs, the PV production and consumption of the building, as well as by calculation some financial indicators.

Estimation of investment

Investment in small scale PV plant is mostly focused towards equipment, i.e. PV modules, inverters, cables, mounting structure and other parts of PV systems, but cost of grid connection, works, project documentation and other cost are also part of the investment costs.

Estimation of operating costs

Typically, operating costs can be estimated to be around 1% of the total investment costs.

Financial analysis

Based on the data on PV production, electrical energy consumption of the building, selected business model, the investment and operating costs, as well as the cost of associated energy, it is possible to conduct a financial analysis to determine the feasibility of the system.

For the lifetime of PV power plant all generated income and operating cost are estimated over this period. The following indicators are calculated in the cost-effectiveness calculation:

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Pay-back Period (PBP)

The cost-effectiveness analysis does not evaluate the financial and accounting aspects of the project (such as financing costs, depreciation costs and tax liabilities) because they are subject to legal regulations and company policies. The aim of the cost-effectiveness budget is to determine whether the project achieves sufficient accumulation of funds to justify the invested funds.

Exemplary feasibility studies for PV power plants on four public buildings in Starigrad and Koper are available on SOLAR ADRIA web site, and you can download them at: https://solaradria.eu/dokumenti-1

Which business models are common in the Adriatic region?

There are different business models for integrated PV systems and their applicability varies on several factors, such as the type and characteristics of the user and investor, the project size and the funding options. The exact parameters of each business model change depending on the country of the application. Below, a simple overview of the main business models, their respective applicability and financing choices are presented.

1. Prosumer (producer-consumer)

Under this business model, the electricity generated from the integrated PV system is **consumed on the spot** to cover the energy requirements of the building and then the **excess electricity is fed into the grid**. Similarly, electricity from the grid is given to the building when the production of the integrated system is lower than the demand. Correct sizing of the PV system is vital for the financial viability and efficient operation of a system, as it avoids overproduction and achieves a maximum coverage of the users' energy needs with minimum excess generation and impact on the grid. Through **net metering** mechanism, the rooftop PV owners can get credit for supplying their excess electricity to the grid and offset electricity that they take from it, thus reducing their electricity bills significantly. Net-metering is commonly defined with a contract between the prosumer and the electricity supplier (grid electricity distributor). This model is profitable for prosumers if the production costs of the integrated PV system are lower than the electricity price offered by the grid electricity supplier.

Rooftop PV systems in the self-consumption model is, in general, financed by the user, but in many countries the public financial support in the form of subsidies and/or grants is available for such investments. This type of financial support is designed to accelerate PV technology deployment and to improve energy performance of buildings and households.

The prosumer model **is applicable** for both private and public buildings and it is fairly easy to implement. But its feasibility depends on the user "size" since the accounting period is not the same for households and larger private/public building owners. For **commercial** applications systems usually range between 30 kW and 1 MW, but most are below 300 kW and in the lower range (i.e. below 50 kW). Integrated systems on **public** buildings typically have an installed capacity of 50 kW – 500 kW, which can also be higher depending on the roof size and consumption. In **households**, PV systems are larger than 3 kW, as smaller systems are not very profitable.

2. Roof rental with/without power purchase agreement

This model includes a financial **contract between a building owner and the investor/developer**, where the latter is responsible for the design, permitting, financing, installation and operation on the customer's property. **The developer** is the owner of the PV system and typically **sells the electricity** that is generated **to the building owner** at a pre-defined price that is usually lower than the utility's retail price. In this instance, the building owner is able to reduce their electricity bills. However, there are also other options, such as having **a roof lease contract** with a fixed annual rental fee or a fee for the lease period. Therefore, the developer pays rent to the customer and can then **sell the electricity** generated from the PV system **to the grid**.

The duration of a power purchase agreement usually ranges from 10 to 25 years, and for this timeframe the developer is responsible for the operation, monitoring and maintenance of the system. After the contract ends, the building owner has the option to extend the agreement, remove the PV system or choose to purchase the system from the developer. The exact conditions of the PPA, including the duration, electricity selling price etc., are defined in detail in the contract.

In principle, this business model is applicable to both commercial, private and public building, but the model is relatively new and thus more common in **commercial buildings**. The examples of this model in public buildings are still very limited in Croatia and Slovenia because public administration often lacks experience in designing public tenders and/or finds the procedure too complex to implement. On the other hand, in the multi-family buildings the ensuring an agreement among all co-owners to engage in such a project can be a challenge, while in the case of single family houses the roof size can be a limiting factor.

Typical systems in this business model are usually larger than 500 kW. This model is applicable for large commercial as well as public buildings, such as hospitals, research centres etc. Lastly, in households this model can be applied if large roof area is available.

3. Premium model/feed-in tariff

The feed-in tariff model (FIT) is an energy supply policy that aims to support the development of new renewable energy projects by providing guaranteed, above-market prices for electricity that is offered to the grid by producers, including homeowners, business owners, private investors etc. This scheme offers long-term purchase agreements for the sale of renewable electricity, which usually range from 10 to 25 years and are extended for every kWh of electricity that is generated. The specific payment level per kWh varies depending on the type of technology, the size of the installation and the project location and is independent of the fluctuations of the market price. The long-term contracts and guaranteed prices protect the producers from some of the risks connected to renewable energy production, thus encouraging investments and the development of the sector. It is possible that the price of the FIT will decrease gradually, in order to follow and encourage technology cost reductions. Feed-in tariffs are now in the transition to a feed-in premium model that is more market-oriented.

In the **feed-in-premium (FIP)** model, the payment level to eligible electricity producers is based on a premium offered above the market price for electricity. This premium can either be constant or it can vary based on a sliding scale. Through this scheme producers can benefit significantly when market prices increase, but also have a corresponding risk when they decrease. Typically, a public tender is conducted for the award of a premium, which defines the electricity quota and reference price for different types of production installations. The reference price is the maximum price for the purchase of electricity and the tenderer(s) with the lowest production price, are to be selected from the bids that are due. The eligible electricity producers then enter into a contract for the sale of electricity on the market with authorised market participants.

In Croatia, the investors in PV plants with a capacity between 50 kW and 500 kW can compete for the guaranteed purchase price by tendering for the most favourable offers of privileged electricity producers (more similar to feed in tariffs). On the other hand, large-scale/commercial PV plant, with capacities larger than 500 kW, compete for premiums by tendering the most favourable offers of privileged electricity producers.

4. Other business models and funding options

Cooperative model & crowdfunding. The **energy cooperative** model offers an alternative to large energy companies, as it allows **citizens to jointly own and participate** in renewable energy projects. Members of the cooperative can acquire a share, actively participate in the market and benefit equally form the profits of the project.

For example, owners of integrated solar systems that are members of a cooperative could potentially achieve a higher electricity selling price, compared to individual producers.

Another option is **crowdfunding**, which is a **public call for investments** via the internet to support the installation of an energy system (i.e. PV system). For instance, even if a citizen does not have the required space to install a solar energy system, they can still invest in the installation on other buildings and benefit from its operation.

Energy Community model. Energy community schemes aim to accelerate the investments in renewable energy, by involving the **wider public** and allowing them to **invest as stakeholders** in the project and also **benefit** from the income generated. Through this concept, natural persons, public bodies and companies are invited to participate in the energy sector and through collective energy actions.

ESCO (Energy Service Company) model, where the ESCO company is the **investor** in the power plant, and they **maintain, insure and operate** the power plant during the project period. Thereby, the ESCO company "guarantees" that the user of the energy service will reduce their expenditure for energy by using solar PV. The ESCO has the obligation to **report the savings** that occurred and if the goals are not reached, they **lower the price** of the energy service. These are long term contracts made for **large scale consumers** (usually large companies) where energy is self-consumed on the spot.

Further information can be found in the SOLAR ADRIA Reports:
Business models, administrative requirements and financing sources for the development of integrated solar systems and Templates of contracts for the lease of building surface for the installation of small solar power plants

The reports are available at:
https://solaradria.azurewebsites.net/media/Business_models.pdf.pdf
https://solaradria.azurewebsites.net/media/Business_models_contract_templates.pdf.pdf

Participatory planning

What is participatory urban planning?

"Participation" presumes active involvement and some degree of influence of interested parties in a decision-making process. This implies that each participant becomes a contributor by expressing their opinions and concerns, which are then analysed and incorporated into the planning process.

Urban planning is led by local governments, while citizens, civil society groups, entrepreneurs and other stakeholders on the local and national level are affected by the development – and thus can be interested parties in the planning process. When involved in the process, interested parties can contribute to sustainable and socially acceptable urban development by voicing their expectations, as well as by sharing their knowledge and experience. This is particularly important for building consensus when disagreements and conflicts between different stakeholders may arise, and consequently for building citizens' trust in, straightening the legitimacy, local governments.

The participatory planning requires time and effort dedicated to informing interested parties about new initiatives and engaging them in the planning process. Although this may result with a somewhat longer and more costly planning process on the short-term compared to the traditional, top-down approach, there are several long-term **benefits which make the participatory planning worth applying**:

- Timely identification of potential issues and barriers for plan development and implementation,
- Acknowledgement of views and values held by different stakeholders,
- Identification and meeting the needs of the affected local community
- Possibility to address disagreements and avoid/mitigate potential conflicts during planning and implementation phases,
- Long-term efficiency of the planning and implementation processes.

In order to make the process efficient and define the model of participation, it is important to identify **the needs and goals of the participatory urban planning, which can include**:

- Efficient development and implementation of new initiatives and plans,
- Transparent planning process without ambiguities,
- Bringing together different perspectives and achieving consensus through collaboration,
- Increase of mutual learning by sharing information, experiences and data,
- Strengthening of civil capacity and inclusion of all relevant actors,
- Improvement of social cohesion,
- Building public support and trust in local institutions,
- Ensuring quality and democratic governance.

Local governments can facilitate PV deployment in the Adriatic region!

Adriatic region is endorsed with a high solar energy potential but still the utilisation of that potential for electricity generation in urban areas is very limited compared to the other European regions, which often have far lower solar potential. The deployment of integrated roof-top PV systems can result with multiple benefits: households and companies can produce electricity for their needs and thus reduce their electricity bills, increased renewable electricity production can reduce the dependence on fossil fuels and therefore contribute to local, national and international GHG emission reduction goals.

A successful integration of PV technology in urban areas is complex and requires consideration technical, urban and socio-economic aspects which are often site- and location specific. For example, this can include the capacity of electricity distribution to integrate newly installed PV systems, architectural and urban attributes of the area, such as cultural heritage, to integrate new elements into the scenery, the ownership structure of the residential, commercial and public buildings, etc. In addition, it is also important to consider people's attitudes towards novelties and changes in their surroundings.

So, to identify **"What can and should be done to increase the PV deployment in my community?"**, the local governments should start with a few key questions:

- *What is the state-of-affairs in roof-top PV deployment in our country? What is the situation in our municipality?*
- *What are the necessary steps to install and deploy an integrated roof-top PV system?*
- *How can we inspire and encourage our citizens, companies and entrepreneurs to get engaged in deployment of roof-top PV systems?*
- *What are the key barriers people face when developing a roof-top PV project? What can we do to overcome these barriers?*
- *What is the best way to engage local stakeholders?*

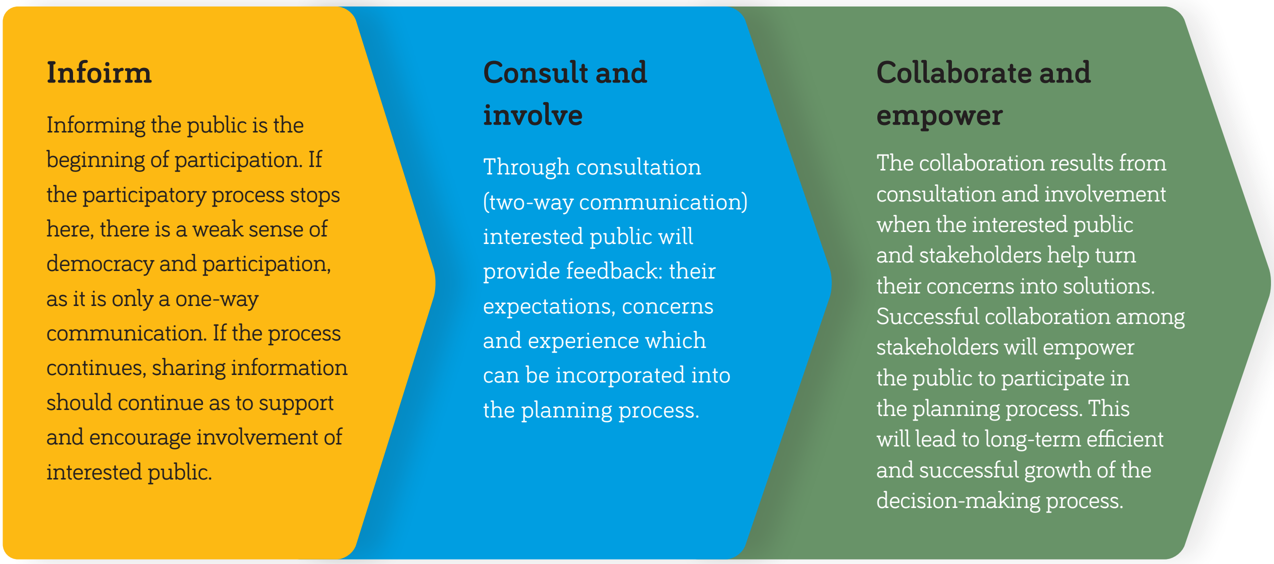
These questions can be addressed though active involvement of municipalities (local governments) through well-structured participatory planning, provision of information and tools to their citizens and other stakeholders, and inclusion of guidelines into their spatial plans and other planning documents.

How to design and initiate participatory planning?

At the very beginning of the planning process, it is necessary to set up a strategy for stakeholders' involvement in the planning process. The strategy sets the goals of the involvement level throughout the process, stages and methods that will ensure the envisaged participation level. Thereby, the timing of each participation stage must be aligned with the phases of the planning process.

In practice, the stakeholder participation is desired at all stages of the planning process, starting at the initiation of the planning process, throughout the plan development and finally as part of monitoring and evaluation of plan implementation. The stakeholders' participation is commonly implemented through several stages, starting by provision of information and consequently, through consultation, involvement and collaboration, building to full empowerment and inclusion in the planning process (Figure 5).

Figure 5. Stages of participatory planning



Methods for stakeholders' involvement in PV planning

A variety of strategies can be used to effectively engage stakeholders. Both the selected strategy and methods applied will depend on the characteristics of the plan being developed, the community size and structure, as well as the envisaged level of stakeholders' involvement.

In the initial phase of the planning, the aim is to inform and educate a wide range of stakeholders, i.e. individuals or groups of people who may have an interest or role in or may be affected by the planning process. Engaging a broad range of stakeholders is important because it lays the foundation for broad support. However, too broad an approach can undermine the effectiveness of the process. Therefore, it is important to identify key stakeholder groups and target these groups in the subsequent stages of the planning process. The choice of the right participatory methods should be based on the stakeholders' characteristics and roles.

The key stakeholders can provide useful insight into local context and help in identifying the existing barriers and facilitate the development of ideas on how to overcome them. Table 1 provides examples of methods that can be used in different stages of participatory planning.

Table 1. Methods used in participatory planning

Aim	Method
To inform and educate stakeholders about the PV technology, possibilities and benefits as to raise knowledge and interest among broader public.	**brochures and newsletters** can be distributed to introduce and promote roof-top PV systems. This can also be done through an **advertisement, an exhibition or a visit** to a proposed or already developed site. These methods serve the purpose of providing simple and basic information to the readers.
To consult and involve as to obtain information about expectations and needs from different stakeholders, as well as to learn about their experience and identify barriers for PV deployment.	a **website** or telephone **hotline** can be established to provide more information and obtain feedback. **Questionnaires or surveys** can also be sent out to collect and analyse responses. These are cost-effective methods to publicize the process and gather opinions from a broad segment of the population. Another more direct way is to hold **interviews, public meetings, or staffed exhibitions** to gather further feedback.
To plan and design programmes, guidelines and other supporting actions (e.g. pilot projects) that will facilitate implementation of PV projects through **collaborate with stakeholders,** thus **empowering them.**	a **participatory workshop** can be a good opportunity to discuss specific issues and planned activities. Workshops provide an opportunity for public dialog about myths, misconceptions, and local concerns. Generating ideas, solving problems and defining goals can be achieved based on consensus. Using this technique can result in obtaining useful information from stakeholder groups and the public. **A series of workshops** can also be held to first introduce and explore the issue in greater depth, and then discuss and reach consensus in subsequent sessions. Depending on the stakeholders' roles, knowledge level and readiness for involvement, different models of participatory workshops can be organised. The **World Café**, for example, takes place in an informal and comfortable setting where participants discuss a specific topic in small table groups. The discussion is repeated in several sessions of 15-30 minutes, after which the collective discoveries are shared. **A focus group** is a planned and facilitated discussion among a small group (4-12 people) of stakeholders. The information about the opinions and values of the various stakeholders can be obtained and discussed. A structured discussion of an interactive group of stakeholders is facilitated in a civilized and non-threatening environment. Focus groups are often used to introduce key stakeholders to the planning process and to recruit leaders and workgroup representatives. **"Planning for real"** based on a 3-D model that replicates a local urban area can also be used. Participants use the model to express their opinions on the strengths and weaknesses of the area and to make their own suggestions for the further development of their community.

Identification and consultation with roof-top PV systems stakeholders in Starigrad and Koper

In SOLAR ADRIA project, participatory planning of PV systems in the municipalities of Starigrad (Croatia) and Koper (Slovenia) was initiated through stakeholders' mapping and consultation.

First, three key stakeholder groups were identified:

1. DECISION MAKERS: municipal administration (municipality employees, mayors, council members), Local energy agency GOLEA (Koper), Zadar County Development Agency NOVA (Starigrad),
2. DEVELOPERS: existing and potential investors, entrepreneurs, solar industry representatives,
3. WIDER PUBLIC: residents of Starigrad and Koper.

Upon desk-base analysis of each group, appropriate consultation methodology was defined for the three groups. Interviews based on a semi-structured questionnaire were conducted with decision makers and developers. This helped the conversation focus on a common theme, while allowing a degree of flexibility. On the other hand, in order to reach a broad audience, the public was surveyed using an online questionnaire (one for the residents of each municipality).

The interviews with **municipalities** focused on their interest in developing integrated PV systems, as well as their potential role of a regulator and promoter of the solar technology for citizens and developers. Interviews with **energy and development agencies** focused on county and municipal interests and efforts, the legislative frameworks and the agencies' own role in developing projects and policies.

Interviews with **investors** focused primarily on their motivations, experience, and perceptions of the investment and PV deployment process. **Technology providers** were primarily asked about the state of the solar market, their customer perceptions and their perceptions of the permitting process, and how they work with the public sector.

The questionnaires targeting **residents of Koper and Starigrad** were divided into three parts. The first part focused on respondents' self-reported knowledge of technical and administrative procedures and their interest in installing a PV system. The second part assessed attitudes, beliefs, and stereotypes about solar energy, while the third part collected demographic data. The interviews and questionnaires revealed the key concerns about the integrated PV systems and potential barriers for their boarder uptake in urban communities.

Information about the sample size, content of interviews and questionnaires, the detailed description of the consultation outcomes, as well as the main barriers for the deployment of PV can be found in the SOLAR ADRIA Report Baseline context analysis & Stakeholder engagement report.

The report is available at:
https://solaradria.azurewebsites.net/media/Baseline_and_stakeholder_engagement.pdf

Deployment of PV systems in local communities

How can municipalities promote solar energy?

Local governments, i.e. municipalities, bear the responsibility for economic and social development of their communities, which entails numerous aspects including provision of infrastructural, industrial and entrepreneurial development, as well as provision of social services and production of the environment. Furthermore, the municipalities are tasked to enable the implementation of the national and regional development goals on the local level. This is formally achieved through integration of national/regional targets into local spatial and/or development plans.

Although overall renewable energy targets and procedures regulating deployment of PV systems are prescribed on the national level, municipalities can do a lot to promote solar energy, encourage their citizens and entrepreneurs to invest in PV systems and overcome barriers they may face in the process. Such actions may include:

1. Provisions on integrated PV systems in spatial/urban plans

- Detailed and clear description of requirements and restrictions (technical and environmental), which apply to installation of PV systems
- Delineation of public spaces and areas where integrated PV systems may be installed, indicating spaces where PV systems are desired as well as those where they are not
- Detailed and clear guidelines about the permitting procedures and licencing which is under jurisdiction of local authorities

2. Support for developers in following local procedures and obtaining necessary licencing

- Well educated and organised municipality staff
- Provision of informative materials, that are written in an “easy-to-understand” manner
- Act as a focal point for both developers and all bodies involved in permitting procedures, e.g. by establishing a standard protocol of communication.
- Organisation of periodical meetings with representatives of administrative bodies which are open to all stakeholders

3. Develop baseline studies and provide tools that are accessible to all

- Conduct solar mapping of the municipality area
- Establishment information/meeting points for solar energy stakeholder
- Organise educative workshop or provide support to civil society organisations active in the field of solar energy

4. Installation of PV systems in public spaces and/or public building

- Integration of PV systems as part of building refurbishment in public buildings through direct investments or public/EU funding
- Leasing roofs and/or other public buildings to private developers
- Promotion of PV projects in commercial buildings through local tax reduction or prioritisation in licencing procedures

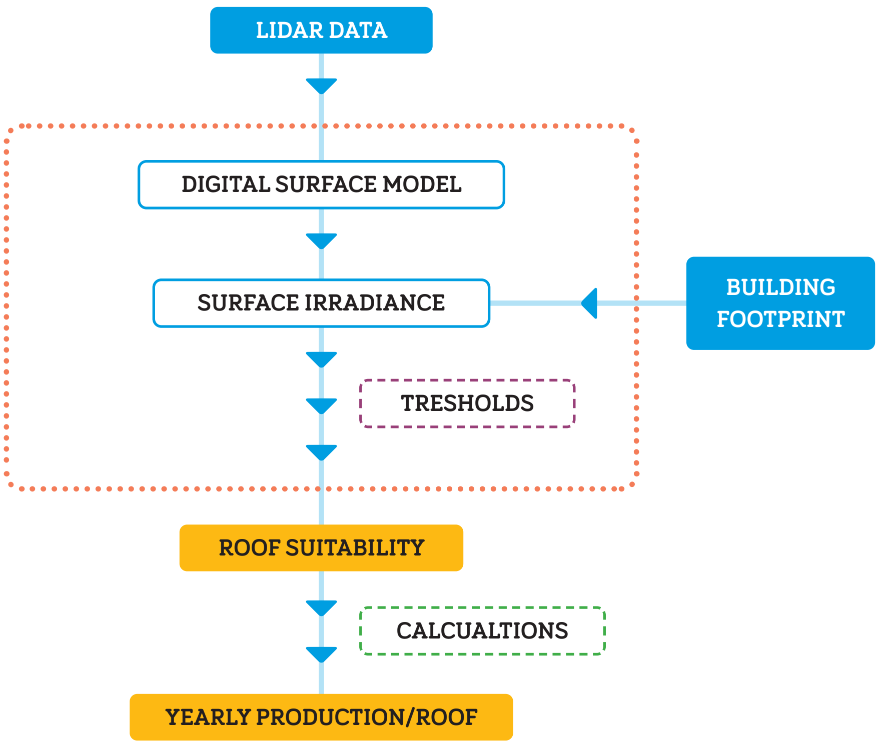
The following sections describe how to map a solar potential in an urban area and several different approaches the municipalities in Adriatic region and across Europe have taken to promote integrated solar systems in their areas.

Mapping of the solar potential

Solar potential is usually represented in 2D maps, 2.5D or 3D urban models and is in many cases showcased within web-based platform. The solar maps provide specific information for a specific location. Information usually includes solar radiation, estimated PV system size and estimated electricity production. The information that should also be available to the end user to benefit from the maps are the costs of PV system and the potential savings if another source of electricity is replaced.

A development of solar maps can be summarised in five main steps as depicted below.

Figure 6. Workflow for solar potential mapping



STEP 1: Data collection

For developing solar potential maps two basic data sets are required:

LIDAR data (or other topographic model of the area). LIDAR (Light Detection and Ranging), primarily used in airborne laser mapping applications, is an emerging cost-effective alternative to traditional surveying techniques such as photogrammetry. It is an active remote sensing technology that captures surfaces topographies in high detail and can be used for accurate automatic solar irradiance estimations. The application of LIDAR for modelling solar potential has been widely used at an urban scale. The LIDAR data are provided in digital format and should be processed in a GIS environment.

If data for a desired area are not available, they could be created by the application of an Unmanned Aerial Vehicle (UAV). Airborne LIDAR scanning service by UAV is offered today by many companies.

Building footprints. If not available at national level (e.g. building cadastre), one option is to use Open Street Map (OSM) building footprints. It is very likely that some buildings will not be recorded, while the area of others will not be correct. Manual adjustments of the data can improve the accuracy. This practice is reasonable for smaller settlements, but for large ones, manual adjustment of building footprints would demand too much time and workforce.

STEP 2: Lidar data processing to dsm

LIDAR data are processed within a GIS environment to create a Digital Surface model (DSM), which is a 2D raster map that contains elevation information for all objects and ground features, including buildings and trees.

Tools such as the Solar Analyst of the software ArcGIS or r.sun of the open-source GRASS-GIS platform have been utilized to develop a large number of cadastres for photovoltaic and solar thermal systems for locations all around the globe. These tools serve to calculate theoretical solar radiation potentials based on geographic and geometric parameters such as latitude, longitude, altitude, aspect and slope of surfaces and further basic parameters to account for the atmosphere. This theoretical calculation corresponds to the solar radiation under clear-sky conditions. To calculate solar radiation estimations under real-sky conditions, the tools include the possibility of integrating measured data to indirectly consider clouds and improve the solar radiation prediction. The calculation of the effect of shadowing of near and distant objects using DEMs (Digital Elevation Models) is also possible, and one of the major assets of GIS-based calculation methods, particularly when studying mountainous territories or urban areas, in comparison to studies based solely on satellite imagery.

STEP 3: Cropping map to building footprint

The building footprint layer is uploaded in the GIS environment, and the DSM and irradiation maps are cropped to the building footprints. The result is a map with data limited only to roof areas. It provides information how much solar energy is available on a given rooftop in a year.

STEP 4. Application of thresholds

To determine the roof suitability for PV installation, certain thresholds are applied related to shading (tilt, azimuth from DSM), minimum irradiation (900 kWh/m^2/y), roof slope (flat roof =< 13,5°), minimum size of the roof (20m^2 for flat and 40m^2 tilted) etc.

The result is exclusion of roofs with unfavourable characteristics, while the remaining roofs are classified in three categories based on their level of suitability.

Additional filters can be applied, as for example cultural heritage buildings.

STEP 5. Calculation of yearly electricity production from a roof

Through the application of these thresholds, it is possible to determine the available area for PV panel installation and the yearly irradiation on the surface and thus calculate the approximate installed capacity for a roof, as well as the annual electricity production and potential GHG savings, taking into account the efficiency of the technology.

The following steps are required for this calculation:

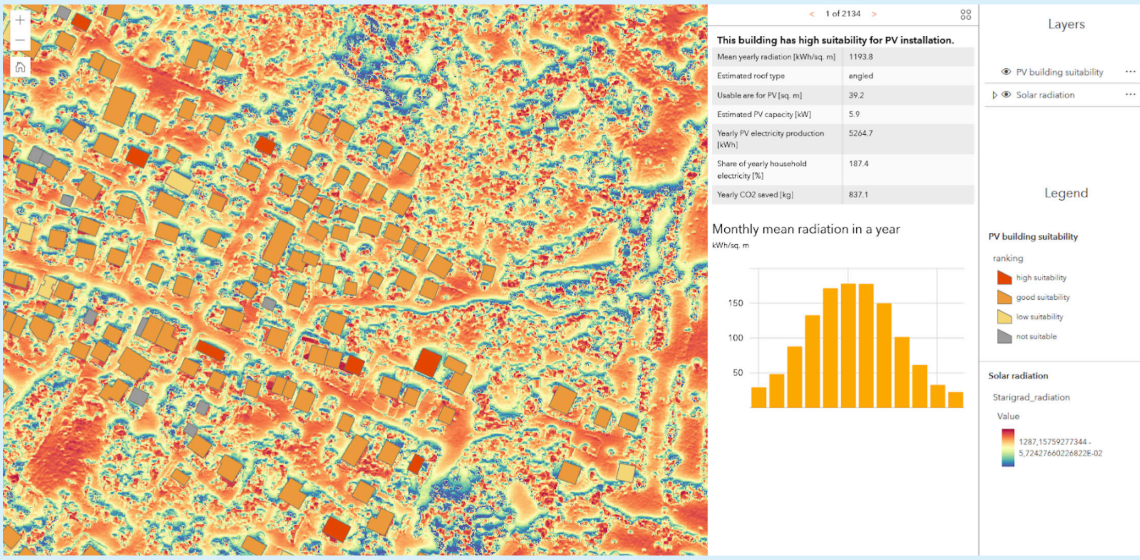
- Calculation of average solar irradiation of remaining cells (above 900 kWh/m^2) per building,
- Calculation of usable area for PV, by multiplying total area of suitable cells with 0.8 to incorporate misfit between the area and PV module geometry and the needs for addition infrastructure (powerlines, service pathways…),
- Calculation of possible installed capacity, by multiplying the area of favourable radiation with factors (150 W/m^2 for tilted, 80 W/m^2 for flat roofs),
- Calculation of possible generated electricity of the theoretical PV
- Calculation of the share of household annual electricity consumption that the PV could cover,
- Calculation of possible carbon savings, by multiplying possible generated electricity with publicly available CO2 emission factors.

Solar mapping for Starigrad and Koper

In order to provide a technical basis for planning purposes, inform the citizens and potential stakeholders about the solar potential in their municipalities and facilitate the installation of PV systems, solar mapping for Starigrad and Koper was conducted within the SOLAR ADRIA project.

The outcome of the solar mapping are online solar maps, which are easy to navigate and allow the user to explore the municipality area and acquire key information about solar potential for each building. The information about solar irradiation, PV building suitability and cultural heritage zones are presented in three different layers. Individual layers can be turned on and off, including an option to change their transparency.

Figure 7. An extract of the Solar map for Starigad – presenting solar irradiation and PV building suitability

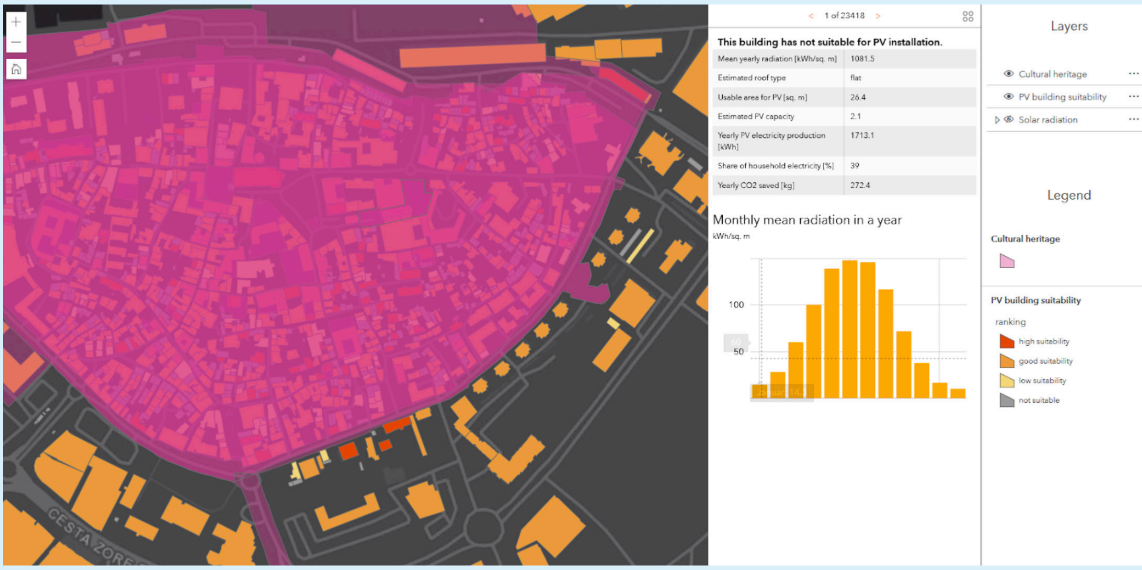


The information about PV suitability of buildings is obtained by selecting a building on a map and classifying it into 4 classes from “not suitable” to “high suitability” for PV installation. The suitability classes are displayed in different colours and are easy to identify on the map. The solar radiation is shown with a colour spectrum ranging from cool to warm colours representing lower and higher values of solar radiation, as shown in Figure 5.

cWhen you select an individual building on the map, a graph of mean radiation values for each month of a year is displayed, as well as a mean annual radiation value in the table above. Selecting each building displays a table with information about the usable roof area, estimated PV capacity, and annual PV electricity production.

A layer with cultural heritage zones is added as an Indicator of possible limitations. It marks the areas where development of PV could be difficult due to preservation of original architecture of the building, including the roof. Cultural heritage zone for Koper is visible on Figure 6., encompassing mostly the oldest part of the city.

Figure 8. An extract of the Solar map for Koper – presenting PV building suitability and cultural heritage zone



A detailed description of the solar mapping methodology and mapping results can be found in the SOLAR ADRIA Report Mapping solar potential in pilot municipalities.

The report is available at:
https://solaradria.azurewebsites.net/media/DII.1_Models_Final.pdf

The solar map of Koper is accessible at:
https://experience.arcgis.com/experience/d82a5297696840bcb907756482da895b

The solar map of Starigrad is accessible at:
https://experience.arcgis.com/experience/128fe14264e348cbaa9668c90a04b62b

Meeting point for solar energy stakeholders

In many cases citizens and companies are interested in establishing a PV system on their buildings, but they do not know how to start – where to find the information how costly it is and if it feasible, who can build the system and/or maintain it later. On the other side, providers of services, potential investors and technology developers are not aware of their potential clients unless they contact them directly.

Therefore, a dedicated space, either physical or virtual, can spark networking and boost cooperation, which will consequently result with faster development of the market.

As a showcase, within SOLAR ADRIA project, a virtual **"PV match-making" Platform and PV calculator** was developed.

SOLAR ADRIA “PV match-making” Platform and PV calculator

The “match-making platform” is designed to connect owners of facilities and providers of various services, whether they are designers, investors, equipment distributors or similar. Using the platform is very simple and intuitive and does not require any prior knowledge.

Maps on the matchmaking platform can be viewed by any user, but if a user wants to establish collaboration – e.g. mark their roof as potential site for project development, or offer a service, they need to register on the page with an email address and an arbitrary access code.

After opening the matchmaking platform, the user selects one of the offered cities that are on the platform (for the moment Koper and Starigrad are included, but other municipalities can be added). Upon selecting the municipality, the platform offers on option to filter roofs according to the available area for the installation of a PV plant and according to the level of sun exposure of the roof surfaces (four suitability categories).

After selecting the criteria, a display of roofs that meet the criteria appears on the interactive map. Roofs are indicated as circles that correspond with the relative roof area and change by zooming to the target area on the map.

Clicking on each individual circle (roof) opens up information about the roof surface and its suitability for installing a photovoltaic power plant. The user can mark the selected roof as his own or to express interest as an investor/designer/builder. If both parties express interest in developing a project on a particular roof, that is, the owner marks the roof as his own and leaves his contact information, and the potential investor/designer/builder leaves his information, the system allows them to see each other's contact information and initiate communication.

The online calculator can be used to assess investments in PV power plants in urban areas. The calculator provides the user a simple and graphic feedback about investment options according to their needs and the profitability of the investment.

Based on the user’s input of basic data, such as the annual consumption of the facility where the PV system would be installed, the online calculator provides an overview of the relevant technical data for solar power plants such as the required installed power of the PV system to meet their own needs and the estimated annual production of the system. In addition to technical data, the calculator provides key economic indicators of the project feasibility: estimated investment costs, payback period, internal rate of return and project duration.

The SOLAR ADRIA “PV match-making” Platform and PV calculator can be accessed at:

https://solaradria.eu/solars

Promotion of Energy Communities

Energy Communities (ECs) include different energy consumers, individuals and organizations, and they are established with the aim to produce energy form renewable sources and then share it between the community members, who are consumers and/or shareholders of the production facilities. They can contribute significantly to the clean energy transition, by promoting energy efficiency and the use of renewable energy sources within local communities, while also allowing citizens to participate actively.

In this sense, energy communities can improve local social welfare by tackling energy poverty, reducing electricity costs and creating new job opportunities for the members of the community. Additionally, they play a significant role in the deployment of renewables, as they can boost social acceptance, while also creating a favourable environment to attract private investments and enhance local development. Lastly, energy communities encourage innovation in the energy sector, by promoting sustainability and energy efficiency for decentralized energy production.

The European Climate Initiative (EUKI) has initiated several projects that aim to support the uptake of energy communities, by promoting knowledge sharing and capacity building, as well as providing guidelines for the development and operation of energy communities. Some of these projects are implemented in the Adriatic region, so the others can learn from their experience!

Energy Communities on Greek Islands

The aim of the ECOISM project is to support and foster the creation and operation of Energy Communities (ECs) on Greek islands. This will be achieved by providing information and strengthening the capacities of local authorities, businesses, as well as the general public regarding the benefits of ECs on the local economy and development.

Within the scope of the project, local island communities will be informed on the opportunities generated by a recently announced legal framework on ECs, which include incentives and subsidies enabling the set-up of Energy Communities. Additionally, in order to foster the development of ECs, the project aims to enable dialogue between the policy- and decision-makers, as well as other relevant stakeholders, while also developing guidelines for the process of EC project development and implementation on islands.

In order to achieve these goals, several events will be organized at the DAFNI Network of Sustainable Greek Islands to raise awareness: 11 workshops on the largest and most populated islands and 31 local meetings at the remaining member islands. Moreover, throughout the project, the potential of different types of renewable energy sources will be assessed for each island, thus creating a pool of suitable projects for each island to be developed by the ECs. Lastly, the ECOISM project will be responsible for providing technical and financial support to five selected island municipalities, in order to enable them in setting up ECs.

As part of the project, the publication 'Participatory Toolbox for Energy Communities' was developed. It provides various instruments to support initiators of community energy projects to engage others in their project.

This project was implemented over two-years period (10/19 - 03/21) with a total budget of EUR 185,362. A major part of the funding was provided by the European Climate Initiative (EUKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Information about the project is available at:
https://www.euki.de/en/euki-projects/energy-communities-greece/

ENCREMENCO - Enhancing the Capabilities of Regions and Municipalities to Participate in Energy Communities, Greece

The aim of the ENCREMENCO project is to support the development of energy communities in Greece through capacity building for local stakeholders at all levels and sectors. The project's main goal is to promote the use of renewable energy sources in Greek municipalities, thus addressing the issue of energy poverty and contributing to the reduction of GHG emissions. It will enable municipalities and local decision-makers to gain awareness and access to information regarding energy communities, in order to be able to implement a recently adopted legislation on energy communities, which allows Greek municipalities to participate in energy communities by producing, storing, distributing and supplying their own energy using renewable energy sources.

Within this project, nine regional campaigns will be organized across Greece that will focus on knowledge exchange and capacity building between Greek and German stakeholders.

This project was initiated in September 2018 and finalised in May 2021. The total budget of the project was EUR 256,645, and it was supported by the European Climate Initiative (EUKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Information about the project is available at:
https://www.euki.de/en/euki-projects/encremenco/

Balkan Solar Roofs

The project aims to foster the participative urban solar power and heat in Poreč (Croatia), Kragujevac (Serbia) and Mostar (Bosnia and Herzegovina). In order to achieve this goal, several activities will be developed. First, multi-disciplinary groups of municipal employees will participate in a collaborative process, where they can exchange and gain knowledge on the different forms and benefits of urban solar community energy. Additionally, a local energy roadmap will be developed, aiming to guide the municipality, community energy groups, small and medium enterprises and citizens through all the steps and actions for the development and installation of new community solar projects. Subsequently, a communication workshop will be organized, in order to inform group members how to efficiently communicate the potential benefits of participative urban solar power and heat.

Moreover, within this project, a campaign to mobilise citizens and SMEs for the production of community-owned energy will be developed. Lastly, it will be ensured that the experiences and knowledge will be shared beyond the pilot cities by engaging other municipalities to follow the example and reaching out to policy makers to make sure national frameworks are supportive of similar initiatives.

This is an ongoing project. The implementation started in August 2021, while the finalisation is planned for November 2023. A major part of the budget (EUR 394,443) was provided by the European Climate Initiative (EUKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Information about the project is available at:
https://www.euki.de/en/euki-projects/solar-roofs/

Installation of PV systems in public spaces

By installing PV systems in public spaces, either as public, private or joint public-private investments, municipalities can show-case good-practice examples which can raise awareness and interest among the citizens. For example, public buildings can be equipped with PV systems to cover part of their energy demand thus achieving budgetary savings, which can then be allocated for other purposes. Moreover, PV systems can be coupled with charging stations for electric vehicles. The users can be offered to charge electric vehicles for free or at a reduced price, and in that way the municipalities can also promote electromobility. Inclusion of PV systems into spatial plans and prioritising green investments though simplified municipality-level permitting procedures can encourage entrepreneurs and business owners to invest into the development of solar power production.

Such projects are often supported though EU funding and many municipalities have used this opportunity. Other municipalities can learn from the those with experience!

INCIRCLE Project in Rethymno, Crete, Greece

Rethymno is a city located on the island of Crete in Greece. The area of the municipality is 396.3 km^2, with a population of 55,525. In 2020, the Rethymno Municipality successfully completed the 1st demonstrator project in the framework of INCIRCLE, that promotes Renewable Energy Sources and Electromobility. The focus was the installation of PV panels on a parking lot as to provide energy for charging electric vehicles. Two solar carports with grid-connected PV systems were installed. The installed capacity of PV systems were 10 kW and 20 kW. Additionally, three electric vehicle charging station for six vehicles and five micro-mobility charging stations for 20 e-bicycles and e-scooters were also built.

The budget/investment of this project amounted 85,000 EUR. The project was co-funded by the European Regional Development Fund and national funding.

More information about the project can be found here:

https://incircle.interreg-med.eu/no-cache/news-events/news/detail/actualites/pilot-demonstrator-in-rethymno/

PV System Installation on DeMeent Sport Complex, The Netherlands

Alkmaar is a municipality in the province of North Holland, Netherlands with a population of 109,895. De Meent is a semi-covered 400-meter ice rink in Alkmaar. It was built in 1972 and it is owned and managed by the municipality.

The municipality initiated POCITYF Project aiming to introduce the use of PV panels for electricity production at the DeMeent Sport Complex. In total, 940 PV panels were installed above the parking spaces on the south side of the DeMeent ice rink, with a potential electricity generation of about 300 MWh per year. Additionally, 16 charging stations for electric cars and 20 stations for electric bicycles were installed. The electricity generated in the PV system provides electricity for both, the sports' complex and to power the charging stations for the electric vehicles.

During the renovation of the ice rink in Alkmaar, another project was launched: Sunprojects. Its aim was to install PV panels on the roof of the rink. Overall, more than 1,100 PV panels were installed on the ice rink and 600 PV panels on the Sports hall. With a total installed capacity of more than 500 kW, this PV system produces approximately 400 MWh per year.

The two systems can cover a large portion of the complex's annual consumption.

Additional information about the project can be at https:

https://pocityf.eu/news/sun-carport-off-at-de-meent-car-park

https://sun-projects.nl/eng/project/de-meent-alkmaar-ijsbaan-sporthal

PV System Installation on the roof of the Ljubljana Airport Garage

Ljubljana is the largest city and the capital of Slovenia. The Ljubljana airport is located 24 km northwest of Ljubljana and is the largest airport in the country. Fraport Slovenija and Resalta were in charge of the installation of PV panels on the roof of the Ljubljana airport's parking garage and its office annex. The project aims to provide clean electricity from solar energy to cover part of the energy demand of the airport.

The project partners were responsible for the installation of 1,347 PV panels on the roof of the airport, with an overall installed capacity of 500 kW. This PV system is estimated to be able to generate around 530 MWh of electricity per year and cover an estimated 7 % of the airport's annual electricity consumption. It will enable the airport to reduce its operating costs, while also reducing its CO2 emissions by approximately 200 tonnes per year.

The investment of EUR 350,000 was funded by Fraport Slovenija and Resalta.

Additional information about the project can be at:

https://www.fraport-slovenija.si/content/raport-company-slovenija/en/newsroom/news/2021/a-solar-power-plant-on-the-roof-of-the-ljubljana-airports-parking-garage.html

Sep 15, 2022

SOLAR ADRIA

How to: Promote integration of PV solar system through urban spatial planning