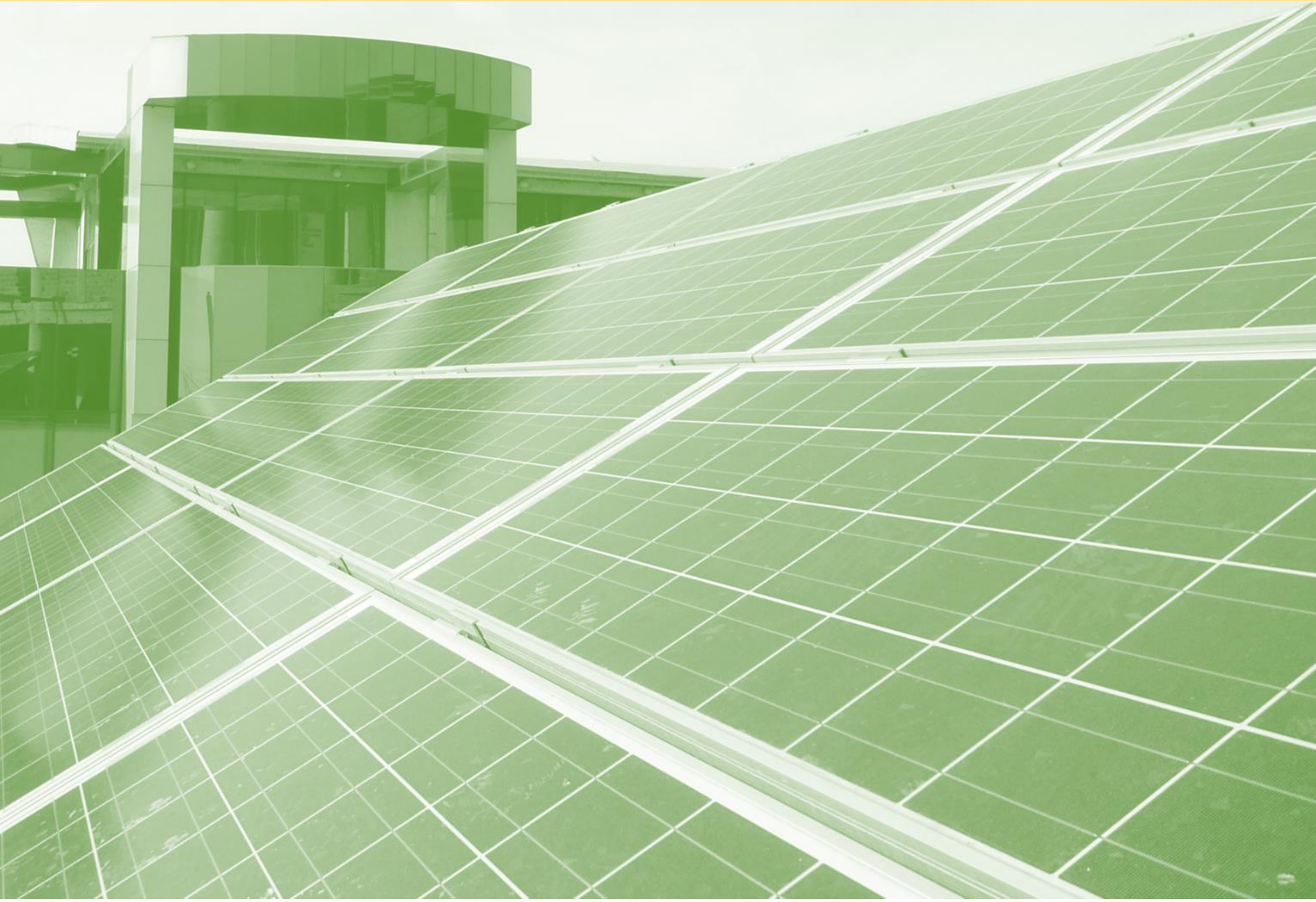
VET partnership For Green and Smart Electricity in Buildings

VET4GSEB

WP 2 / D 2.5
Report on new solutions for PV applications in buildings



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Contents

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Sofia Energy Centre

1. Introduction

With the climate changes we are facing new challenges to reduce harmful emissions. For this purpose, an energy transition from the use of fossil fuels to the use of energy from renewable energy sources must take place.

The installation of systems for production of solar energy on the elements of the building envelope is an extremely suitable solution because:

• The produced energy can be used directly for the needs of the building, which minimizes the load on the grid;

• There is no need to use additional undeveloped land.

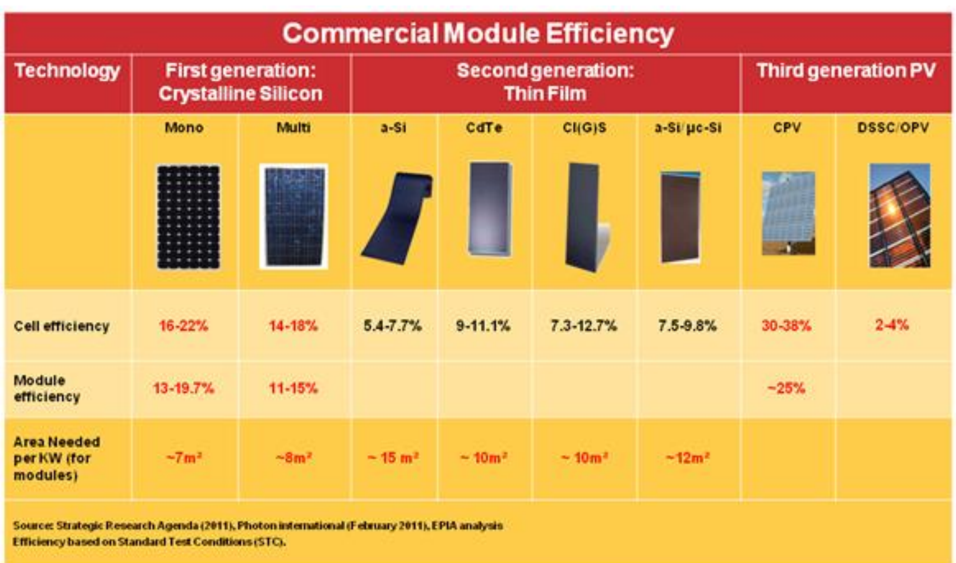
On the other hand, the new regulations on the energy performance of buildings require that a significant part of the energy required for heating, cooling and lighting is produced on site from a renewable energy source.

This can be successfully achieved with the installation of PV systems.

Here we will present you technologies and solutions for the installation of such PV systems.

2. PV Technologies

PV technologies are classified as first, second or third generation. First generation technology is the basic crystalline silicon (c-Si). Second generation includes Thin Film technologies, while third generation includes concentrator photovoltaic, organics, and other technologies that have yet to be commercialised on a large scale.



Commercial Module Efficiency

Technology	First generation: Crystalline Silicon		Second generation: Thin Film				Third generation PV	
	Mono	Multi	a-Si	CdTe	CI(G)S	a-Si/µc-Si	CPV	DSSC/OPV
Cell efficiency	16-22%	14-18%	5.4-7.7%	9-11.1%	7.3-12.7%	7.5-9.8%	30-38%	2-4%
Module efficiency	13-19.7%	11-15%					~25%	
Area Needed per KW (for modules)	~7m²	~8m²	~ 15 m²	~ 10m²	~ 10m²	~12m²		

Source: Strategic Research Agenda (2011), Photon international (February 2011), EPIA analysis
Efficiency based on Standard Test Conditions (STC).

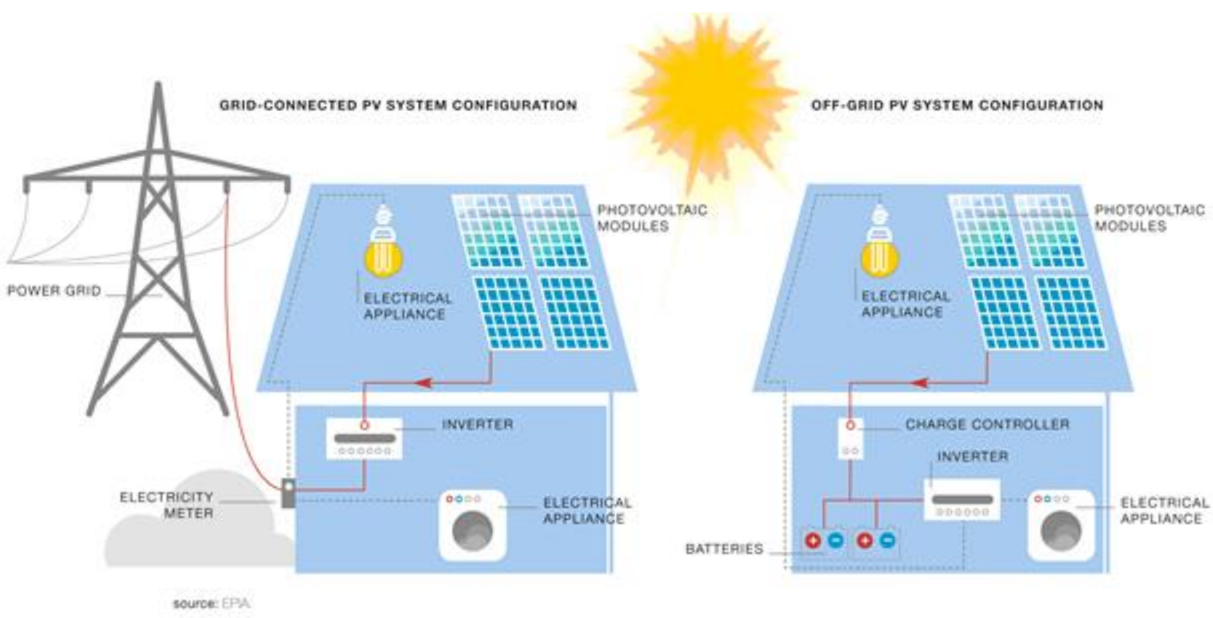
OVERVIEW OF EFFICIENCY OF PV TECHNOLOGIES. (Source: EPIA 2011, Photon International, EPIA analysis)

3. Types of PV systems and Applications

PV systems provide clean power for small or large applications. Many installations are already generating energy around the world in individual homes, housing developments, offices and public buildings.

Today, fully functioning solar PV installations operate in both urban and remote environments, where it is difficult to connect to the grid or where there is no energy infrastructure. PV installations that operate in isolated locations are known as stand-alone systems. In built areas, PV systems can be mounted on top of roofs (known as Building Adapted PV systems – or BAPV) or can be integrated into the roof or building façade (known as Building Integrated PV systems – or BIPV).

Modern PV systems are not restricted to square and flat panel arrays. They are flexible and may be curved and shaped to the design of the building. Innovative architects and engineers are constantly finding new ways to integrate PV into their designs, creating buildings that are dynamic, beautiful and provide free, clean energy throughout their working life.



DIFFERENT CONFIGURATION OF SOLAR POWER SYSTEMS. (Source: EPIA)

3.1 Grid-connected systems

When a PV system is connected to the local electricity network, any excess power that is generated can be fed back into the electricity grid. Under a "feed-in-tariff" regime, the owner of the PV system is legally entitled to payment for the power generated in this way. This type of PV system is referred to as being 'on-grid.'

Type of application	**Market segment**			
	Residential <10 kWp	Commercial 10kWp-100 kWp	Industrial 100kWp-1MWp	Utility-scale >1MWp
Ground-mounted			X	X
Roof-top	X	X	X	
Integrated to façade/roof	X	X		

SEGMENT FOR GRID-CONNECTED PV SYSTEMS. (Source: Solar Generation VI, EPIA and Greenpeace)

3.2 Stand-alone, off-grid and hybrid systems

Off-grid PV systems have no connection to an electricity grid. An off-grid system is usually equipped with batteries, so power can still be used at night or after several days of low irradiance. An inverter is needed to convert the DC power generated into AC power for use in appliances.

Typical off-grid installations bring electricity to remote areas or developing countries. They can be small home systems which cover a household's basic electricity needs, or larger solar mini-grids which provide enough power for several homes, a community or small business use.

PV MODULES ON THE FLOATING ISLANDS OF LAKE TITICACA (Source: SEC)

3.3 Making cities greener

With a total ground floor area of over 22,000 km2, 40% of all building roofs and 15% of all façades in the EU of the 27 are suitable for PV applications. This means that over 1,500 GWp of PV could, in theory, be installed in Europe, which would generate about 1,400TWh annually, representing 40% of total electricity demand by 2020. PV can seamlessly integrate into the densest urban environments. City buildings running lights, air-conditioning and equipment are responsible for large amounts of greenhouse gas emissions, if the power supply is not renewable. Solar power will have to become an integral and fundamental part of tomorrow's positive energy buildings.

4. BAPV and BIPV

4.1 Mounting and building integration options

4.1.1. BAPV and BIPV

Building-applied photovoltaic (BAPV) and building-integrated photovoltaic (BIPV) are PV modules installed in buildings to serve as a principal or additional energy source. The installation of a PV system in a building is a very sustainable solution, as roofs and façades are used instead of additional land.

Building-applied photovoltaics (BAPV) are photovoltaic installations fixed over the existing elements of a building envelope such as roofs, skylights, façades, balconies and shelters.

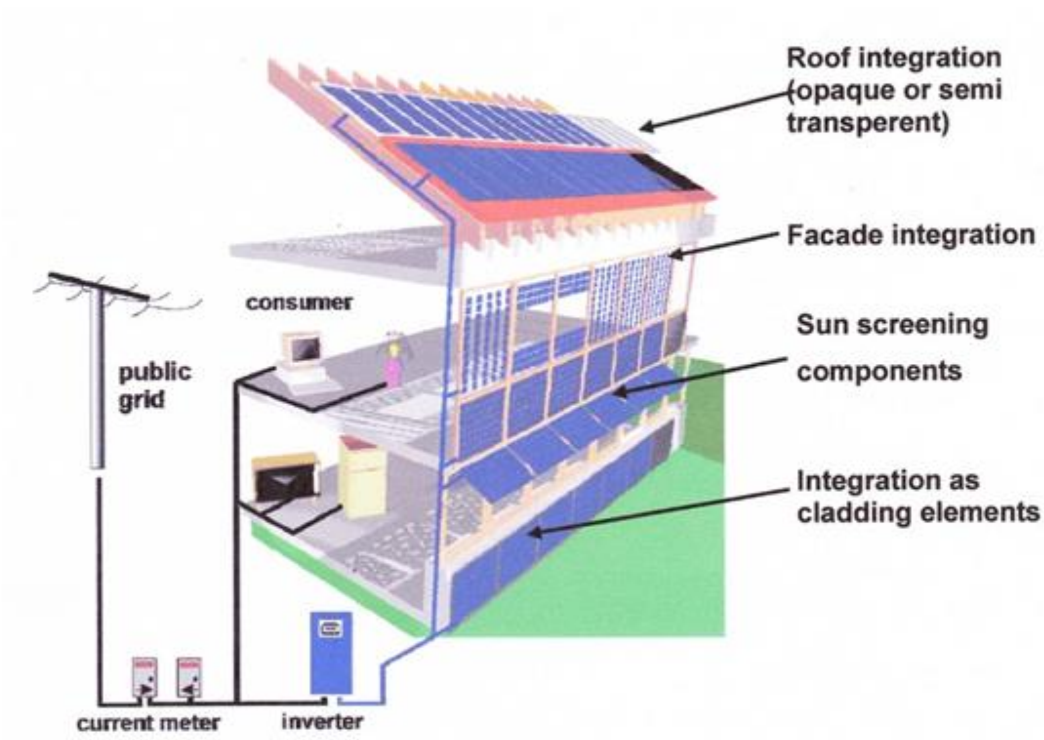
Building-integrated photovoltaics (BIPV) are photovoltaic products (sheets, tiles, glasses, etc.) that are used instead of conventional building materials in parts of the building envelope such as roofs, skylights, or façades. They are usually installed in new buildings, but they could also be installed in existing buildings during their renovation. The advantage of BIPV is that the costs of construction are reduced, as these modules replace traditional building materials. On the other hand, solutions with BIPV modules are usually more aesthetic.

4.1.2. Building integration options

BAPV and BIPV can be installed in all type of buildings: dwellings, houses, schools, all types of public buildings and industrial buildings as well in urban structures such as bus/parking shelters.

The key components of a grid-connected system are:

- The PV modules,
- The inverter,
- The current meter.



ALTERNATIVES FOR INTEGRATING PVs IN BUILDINGS (Source: PURE project. Roman et al, 2008)

The criteria for reliable integration of PV modules in buildings are:

- Natural integration,
- Architectural solutions,
- Pleasant composition of materials and colours,
- In line with the context of the building,
- Innovative design.

Several issues should be taken into consideration at the urban planning stage for seamless integration of PV systems in buildings:

- For PV on sloped roofs, the streets should be oriented east-west, such that they have south oriented slopes.
- For PV integrated in façades, the optimal orientation should be chosen, depending on the open spaces.
- Shading from other buildings or trees should be taken into account and minimised.

4.2. BIPV and BAPV on roofs

PV elements can be installed on all types of roofs – flat, pitched, and domed roofs.

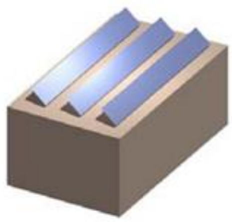
4.2.1. PV modules on flat roofs

The installation of PV modules on flat roofs is an excellent choice, as the modules can be oriented and inclined in the best position.

When installing PV modules on a flat roof, several aspects should be taken into account:

- The structure of the roof,
- The elements of the roof such as chimneys, exits, skylights, etc.,
- The orientation of the building.
- The material covering the roof.

The following figures illustrate different options for the integration of PV systems on flat roofs (ECN).



When PV modules are installed in new buildings, the structure of the roof is calculated according to the load of the installation, but when they are installed on existing buildings, the load bearing capacity of the structure should be checked. In some case, the roof structure should be reinforced in accordance with building regulations.

PV modules on flat roofs are fixed on metal or adapted concrete or plastic structures.

The water-proofing covering of the roof should be preserved, when the structures (metal or plastic) are installed. The structural fixtures on the roof should be insulated with water-proof materials.

Flat roofs are very convenient for PV systems, as they can be oriented in the best position, but distances of at least ½ of the height of the structure should be left between the rows of PV modules in order to avoid mutual shading. Shading from chimneys and walls should also be examined.

4.2.2. PV modules on pitched roofs

There are several integration options for installing PV modules on pitched roofs. They can be mounted over roof (BAPV) or integrated in the roof (BIPV).

BAPV have an independent support structure and are easier for installation.

They are more suitable than BIPV for retrofits of existing buildings and can be easily replaced.

Because of their independent structure they are cooled from the rear and there is no problem with over-heating.

BIPV offer better possibilities for a good integration.

Mutual shading is avoided.

ROOF TILES (HANENERGY)

4.3. PV on façades

The Energy Performance of Buildings Directive (EPBD) requires all EU countries to update their building regulations and take steps to foresee sufficient sources of renewable energy.

Although roofs are the best place for installing PV modules, space for PV elements should also be foreseen on the façades to ensure the required amount of energy production.

When examining the installation of PV modules on façades, it should be taken into account that the efficiency of the system will be at least 30% lower than a roof system with the best tilt and orientation.

4.3.1. Options for integration

There are several options for integration of PV modules on façades.

a) fully integrated

b) partly integrated

c) additional glass façade

d) fixed on the balcony

4.3.2. BAPV on façades

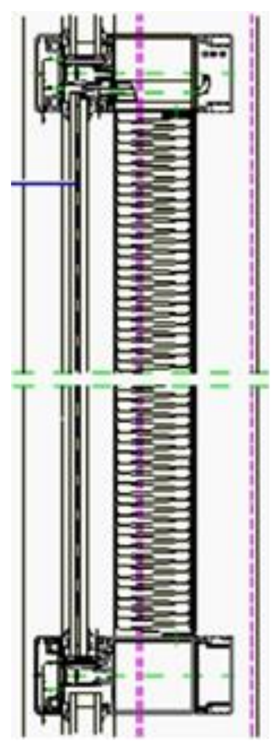
BAPV is a good choice for installing PV systems on the façades of existing buildings.

BAPV can be cheaper than BIPV because:

- One of the advantages of BAPV systems is that it is easier to ensure cooling of the system through the air gap between the PV panels and the wall.
- There is no need for cladding or decorative plastering on the walls behind the PV panels.
- There is no need to ensure air tightness between the joints.
- BAPV are easier for maintenance and replacement.
- The PV panels can act as additional thermal insulation.

BAPV ON REFURBISHED RESIDENTILA BUILDING (Source:SEC)

4.3.3. BIPV on façades



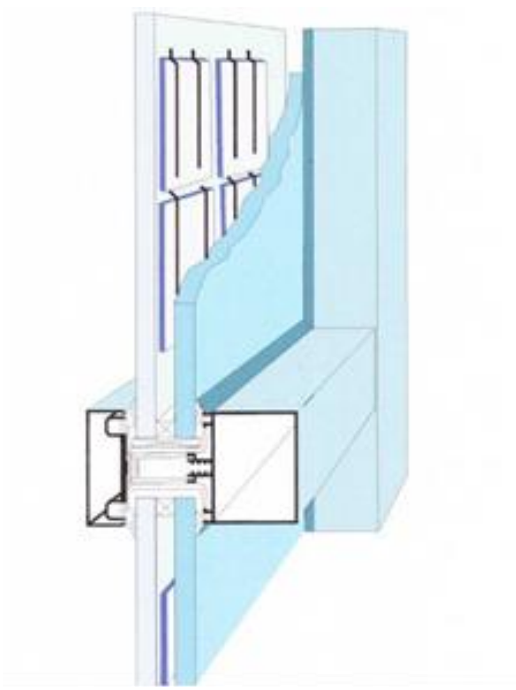
BIPV are suitable for new buildings. They give better opportunities for good architectural solutions.

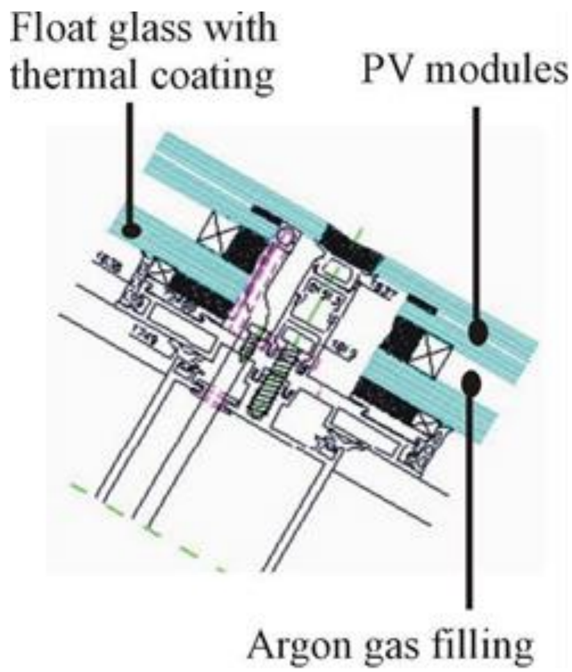
BIPV installations can be integrated in buildings as warm façades. In this case they are integrated in the structure of the façade as a part of the wall. The PV modules are fixed between two panes of glass and are incorporated in the structure of the façade. The façade panels may be composed of either a glass package with PV modules and a sandwich panel with thermal insulation, as shown in figure 57, or of a glass-glass package where the sandwich panel is replaced by an argon filled space and thermal-coated float glass, as shown in the figure.

Different architectural solutions may be applied through the integration of the modules in the structure of the façade:

- A fully glazed façade,
- Alternation of PV modules and glass.

The following figures show different examples of the integration of modules in façade construction. (Roman et al)





BIPV IN WARM FAÇADE

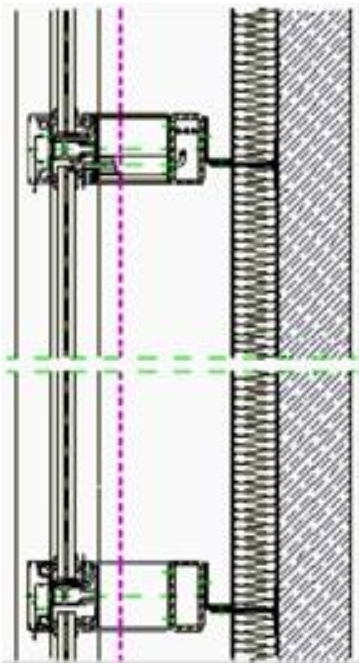
BIPV installations can be integrated in buildings as cold façades. In this case they act as a second "skin" of the façade, or double façade. PV modules are fixed on an additional structure with an air space between the modules and the wall. Depending on the distance between the modules and the wall, we can categorize facades as:

- Ventilated facades when the space between the wall and the modules is up to 10cm, as the fixing of the PV modules is not air tightened, the air can circulate between the wall and the modules and secure the necessary ventilation. In these facades the PV modules also act as finishing cladding.
- Curtain wall – the distance between the wall and the PV modules is more than 20 cm. and can even ressemble a glazed balcony.

Cold façades are more expensive as the modules are additional elements of the construction, but they have other benefits.

The solution with cold façade avoids the problem with cooling of the modules.

This second "skin" acts as a very efficient additional thermal insulation and can ensure a better indoor climate.



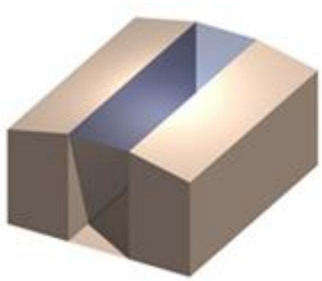
BIPV IN COLD FAÇADE
(Source: SST)

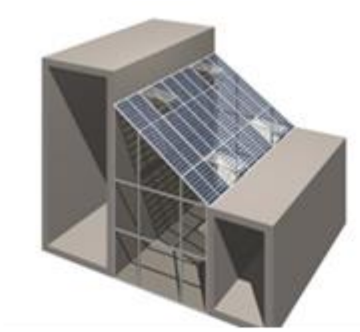
4.4. Glass roofs, shading systems and other applications

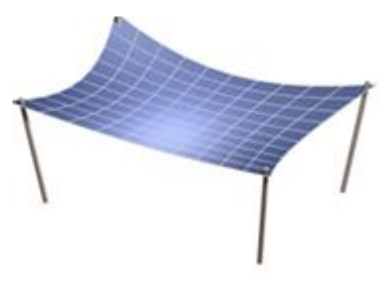
4.4.1. Glass roofs

Glass roofs from PV modules are an excellent choice. They can be integrated on flat roofs, sloped roofs or individual construction.

The following figures show possibilities for the integration of glass roofs from PV modules (ECN)



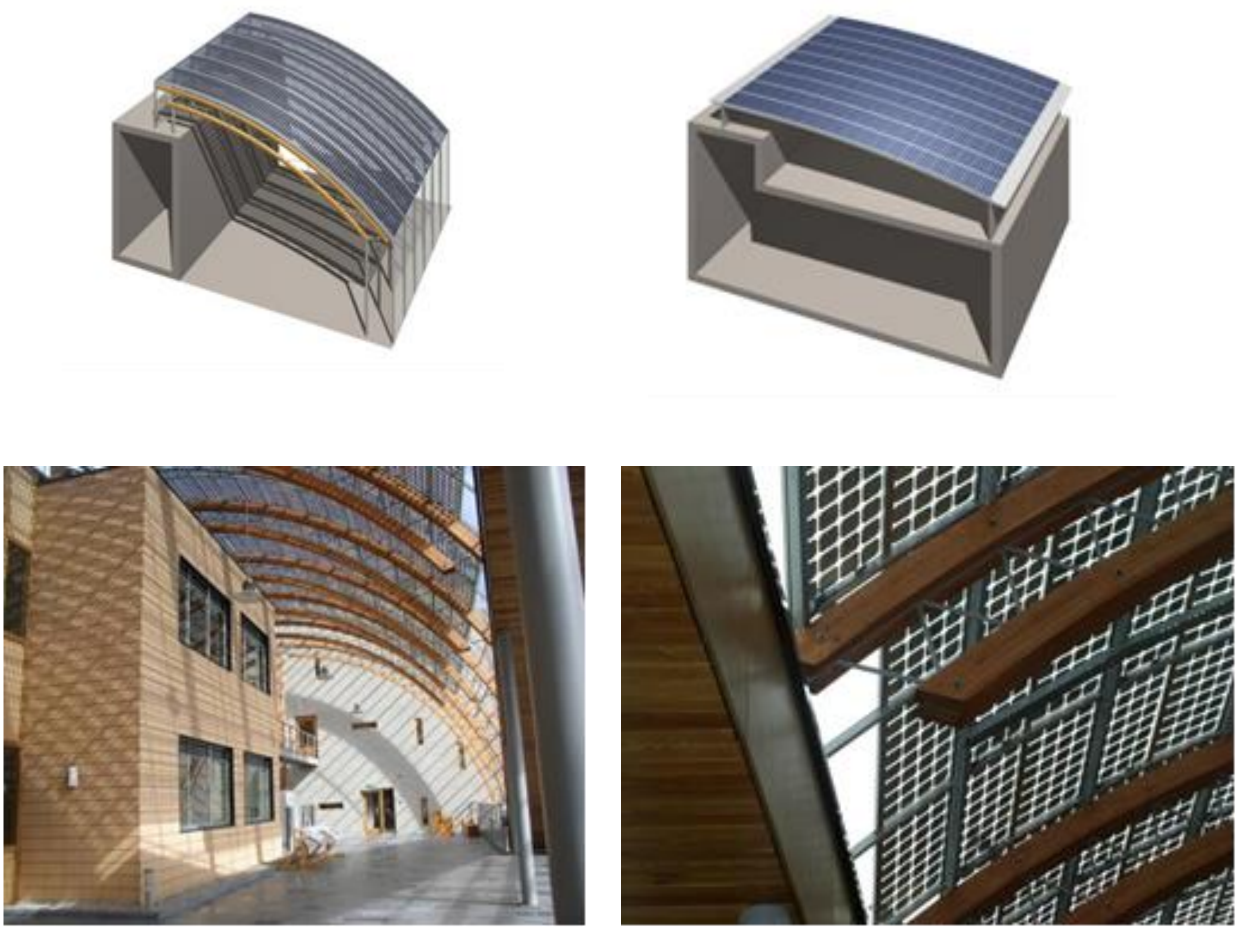




For example, a PV parasol makes good use of a glass roof. A roof construction in the form of a parasol covered with PV modules reduces the heat load, making the conditions within the building more comfortable.

The PV parasol can be with or without a water-retaining function, depending on the needs of the building. (ECN)

The following figure shows examples of a PV parasol with and without a water-retaining function.



EXAMPLE OF GLASS ROOF WITH PV MODULES (Source:SEC)

4.4.2. Shading devices

Shading devices are ideal for PV modules integration in buildings.

This solution is suitable both for new and existing buildings.

These shading devices composed of PV modules offer the following advantages:

- Passive cooling,
- Daylight control, as the best inclination for PV modules is the same as for providing most shadow,
- Electricity production.

There are several options for building integration of shading devices from PV modules.

They can be independent from the building envelope, incorporated in the building envelope as a curtain wall, or as an additional element of the building, such as a canopy.

They can be fixed or movable.

4.4.3. Other applications

PV modules can be used for other applications such as ensuring natural lighting.

PV on skylights should be installed on the southern side of the element. They will ensure a good light with the necessary sun protection for the premises in the building.

Laminated double glazed opaque cells with a space of 1-3 cm. between the cells should be used for sky lights.

PV modules on sky lights ensure diffuse or tempered light with interesting shadow patterns.

The integration of PV modules in buildings is widely used for passive solar design.

Elements from PV modules such as awnings, double façades and glass roofs prevent the building from overheating.

Transparent PV modules integrated in the building envelope improve the indoor climate and ensure access to daylight.

An innovative solution is the combined function PV-solar thermal.

The benefits of hybrid collectors with medium air or water are:

- Cooling the PV element improves its efficiency.
- Heat from thermal element can be used for hot water and heating.

This solution is attractive when the roof space is limited.

PV modules can be integrated in many urban constructions:

- Bus stops,
- Car parks,
- Roofs of railway or bus stations,
- Sound barriers,
- Information boards,
- Street lights, etc.

5. CASE STUDIES

5.1. PV installation in Aurinkolahti Comprehensive School

City (Country): Helsinki (Finland)

Type of application: roof mounted

Summary

The City of Helsinki is committed to many energy efficiency agreements as well as to the reduction of its CO2 emissions. Through those agreements, the City of Helsinki has also committed itself to use increasing amounts of renewable energies. The Aurinkolahti solar power station is a pilot project for testing renewable energy sources. Targeted annual energy saving at Aurinkolahti comprehensive school is 6.5% every year, when compared to its consumption of electrical energy purchased off the national grid.

Description of the solution

<u>Background description</u>

- Description of the site/building type: School building
- Partners and stakeholders involved: the City of Helsinki, Public Works Department, PWD Construction Management
- Duration of the pilot project: ± six months
- Duration of the installation works: ± two weeks

<u>Technical description</u>

- Total installed power: 20.4 kWp

- Area needed per kW: 7.35 m2/kW

- PV technology used: Crystalline silicon technology

- Type of Inverter: SMC6000TL (6300 W, 600 V, 26 A)

- Maintenance, warranties and lifetime of solution: the system is nearly maintenance free; duration of guarantee 25 years, expected lifetime of 30 years

Results/achievements

- Energy production: 14 691 kWh/first year of action (L3 phase inverter failure from June 2010 to August 2010 influenced 5000 kWh loss of energy production)

- CO_2 emissions reduction: 3482 kg CO_2 (emission factor used: 237 g CO_2/kWh)

- Other benefits: educational purpose when teaching natural sciences

Contact details

- Contact: sirpa.eskelinen@hel.fi

5.2. Solar power plant BERDEN

City (Country): Bogojina, Slovenia

Latitude/Longitude: 46°/16°

Type of application: BIPV

BERDEN SOLAR PLANT. (Source: www.plan-net.si)

Summary

Solar PV modules are integrated in the roof of a new building. This integrated solution was made with a view to save additional roof covering costs. The roof is covered with 216 PV modules Upsolar UP-M230P. We used five 10kW Riello inverters, for a 49.68 kW power plant. Power plants will bring annual savings of 30 t Co2.

Description of the solution

Background description

- Description of the site/building type: The building is located in NE Slovenia and is used for business purposes.
- Partners and stakeholders involved: The investor is a self-employed farmer.
- Duration of the installation works: Work was carried out within a period of one month.

Technical description

- Total installed power: 49.68 kWp
- Area needed per kW: 7.1 m2/kW
- PV technology used: Crystalline silicon
- Type of Inverter: Riello HP 1000065, 10 kW
- Maintenance, warranties and lifetime of solution: Project lifetime is estimated at 30 years, warranties were issued for PV modules (10 years), inverters (5 years), and general warranty (2 years.)

Results/achievements

- Energy production: 49 MWh per year
- CO2 emissions reduction: 30 000 kg CO2, (based on a global average 0.6 kg of CO2 per KWh.)

Contact details

- Online information: www.bisol.com

5.3. Athens Metro Mall

City (Country): Athens, Greece

Latitude/Longitude: 37.941363 /23.739974

Type of application: BIPV

Summary

Designed with the aim of saving resources and being environmental friendly, Athens Metro Mall combines various characteristics that make it a bioclimatic building with very low energy consumption. Solar panels cover 400sqm on the south side of the building achieving a reduction in energy consumption of up to 5%.

Description of the solution

<u>Background description</u>

- Description of the site / building type: The BIPV consists of two façades and the south side of the Trade center “Athens Metro Mall”.

- Partners and stakeholders involved: The entire project was financed by the owner of the trade center: TALIMA VENTURE INC.

- Duration of the works: 20 days.

<u>Technical description</u>

- Total installed power: 51 kWp

- Area needed per Kw: 7.72 m2
- PV technology used: Crystalline silicon
- Type of modules: SCH660P from SOLAR CELLS HELLAS SA
- Type of Inverter: Sunergy ELV 230/5000W
- Maintenance: Maintenance services are delivered under contract by ACE POWER ELECTRONICS
- Warranties: 5 years for Inverter and PV panels
- Lifetime of solution: approximately 25 years.

Results/achievements

- Energy production: 39,900 kWp /year
- CO_2 emissions savings: 23.940 kg

Contact details

- Online information: www.schellas.gr , www.acepower.gr

5.4. Blackpool Centre for Excellence in the Environment

City (Country): Blackpool (United Kingdom)

Latitude/Longitude:

53°47'0"N 3°3'27.56"W

Type of application: Inclined roof - transparent roof

BLACKPOOL CENTRE FOR EXCELLENCE IN THE ENVIRONMENT. (Source: Blackpool City Council)

Description of the solution

Background description

- Description of the site/building type: Non-residential buildings - 2 floors
- Partners and stakeholders involved:

The Centre for Excellence in the Environment, also known as Solaris, is a sub-regional multi-agency partnership. The project was commissioned by Blackpool Borough Council and is intended to contribute to tackling the major regeneration challenge facing Blackpool. Other partners in the project include Lancaster University, Blackpool and the Fylde College and Blackpool Environmental Action Team.

Technical description

- Total installed power: 18.067 kWp
- Area needed per kW: 9.08 m2/kW
- PV technology used: Multi-Crystalline silicon technology
- Type of Inverter (power and rating): SMA (4 types -SMR1700, SMR3000, SMR2500, SMR850)
- Combined nominal inverter power: 14.85kW

Results/achievements

- Energy production: 12.776MWh
- Other benefits:

The building was designed to meet best practice guidelines and has attained an excellent rating from the BREEAM environmental assessment. The energy usage within the building is monitored and optimised via real time monitoring.

Solaris was built as a foundation for the education and promotion of sustainable design and incorporation of renewable energy in the area. The building is of passive design, taking advantage of natural energy flows to maintain thermal comfort and negate the need for mechanical heating and cooling.

The building fabric comprises recycled and sustainable materials: the building’s concrete blocks contain pulverised fuel ash, a by-product from the power industry; and recycled newspapers are used as insulation in the external cavity wall.

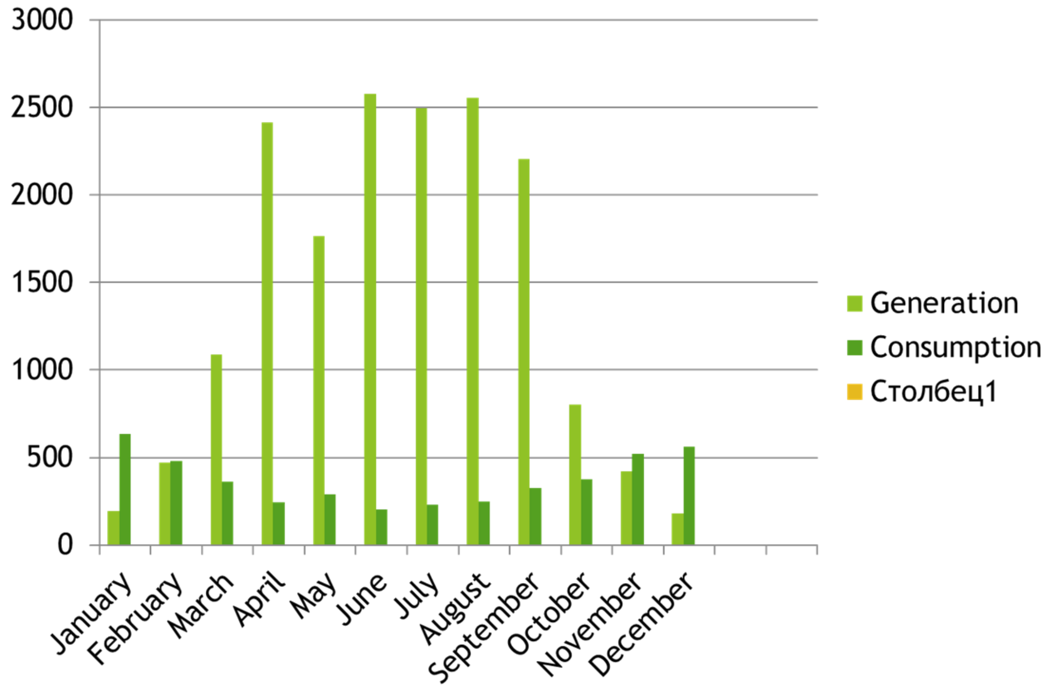
- Online information: www.solariscentre.org

5.5 Sunny power plant

Location: Plesetsk, Kyiv region, Ukraine

- Total installed power: 100 solar panels with a capacity of 285 watts each
- PV technology used: DNA60-5-285P polycrystalline solar panel:
    - working range -40...+85°C;
    - wind load up to 2400 Pa and
    - snow up to 5400 Pa;
    - overall dimensions 1650x992x35 mm;
    - weight is 19 kg.
    - The linear warranty for the panel is 25 years.

Electricity generation



5.6 "Smart flower"

Location: Ternopil region, Ukraine

On August 5, 2022, the company's first innovative solar energy system installed in Ukraine was officially opened in Ternopil

Smart Flower Solar.

The nominal power of the Smartflower solar system is 2.5 kW, so in a year you can get from 4000 to 6200 kWh of energy depending on the weather and climate.

Batteries from NEC Energy Solutions with a capacity of 5.5 kWh are able to work at extreme temperatures (from -40°C to +60°C).

The Smart Flower installation uses an intelligent sun tracking system, producing up to 40% more energy than traditional stationary solar panels.

Every day at sunset, the Smart Flower will automatically fold and clean itself to maintain maximum solar electricity production.

Together with foreign partners, LLC "Energy Engineering Company" plans to place 100 such installations in Ternopil Oblast.

5.7 İzmir-Çeşme, Turkey

Photovoltaic Facility System Features with 10 kWp Installed Power

Application Type	Grid Connected Facility
Usage	Individual
Application Place	Izmir-Cesme
Installed Power	10.08 kWp
Module Type	monocrystalline
Module Power	240 Wp
Number of Modules	42 pieces
Inverter Power	10 kWe
Load Coverage Ratio of the System	% 100

5.8 Ankara-Gölbaşı Gazi Technopark, Turkey

Photovoltaic Facility System Features with 263 kWp Installed Power

Application Type	Grid Connected Facility
Usage	Public
Application Place	Ankara-Golbasi
Installed Power	263 kWp
Module Type	monocrystalline
Module Power	250 Wp
Number of Modules	1052 pieces
Inverter Power	250 kWe
Load Coverage Ratio of the System	90%

5.9 Hatay-Antakya Önder Gıda, Turkey

Photovoltaic Facility System Features with 200 kWp Installed Power

Application Type	Grid Connected Facility
Usage	Company
Application Place	Hatay-Antakya
Installed Power	200.4 kWp
Module Type	monocrystalline
Module Power	300 Wp
Number of Modules	668 pieces
Inverter Power	200 kWe
Load Coverage Ratio of the System	% 100

5.10 Muğla Sıtkı Koçman University, Turkey

Facility with 120 kWp Installed Power System Features

Application Type	Grid Connected Facility
Usage	Public
Application Place	Mugla
Installed Power	120 kWp
Module Type	monocrystalline
Module Power	250 Wp
Number of Modules	480 pieces
Inverter Power	100 kWe
Load Coverage Ratio of the System	40%

6. Simulation software

There is a great variety of software tools for sizing and simulation of performance of grid-connected and stand-alone PV systems. Some of them are very complicated; others are user friendly, others may lack accuracy or reliability. The installer is advised to access the results to ensure consistency.

Indicative software solutions regarding PV analysis and planning and site analysis are briefly presented in this chapter.

PV analysis and planning	
PV*SOL	http://valentin-software.com
PV F-CHART	www.fchart.com
PVSYST	www.pvsyst.com
PV-DesignPro	www.mauisolarsoftware.com
PVPlanner	http://solargis.info/doc/4)
Nsol!-GT	www.nsolpv.com
Solar Pro	www.lapsys.co.jp/english /products/pro.html
RETScreen	www.retscreen.net
PVGIS	http://re.jrc.ec.europa.eu/ pvgis/apps4/pvest.php
Solar Sizer	www.solarray.com
PVselect	www.pvselect.com
Performance Calculation	http://www.volker-quaschning.de/software/pvertrag/index_e.ph
Educational Sun applets	http://users.cecs.anu.edu.au/~Andres.Cuevas /Sun/Sun.html
Site Analysis	
ECOTECT	http://usa.autodesk.com/adsk/ servlet/pc/index?siteID=123112&id =12602821
Shadows	http://www.shadowspro.com/

6.1. PV analysis and planning software

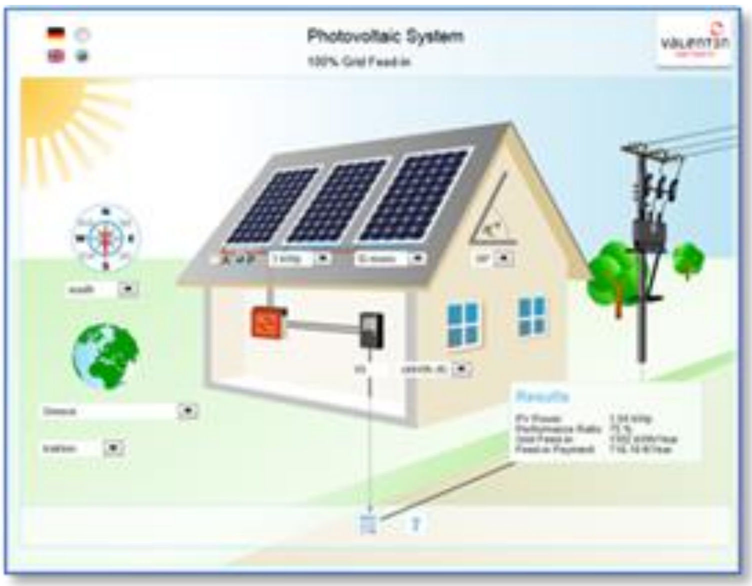
PV*SOL (http://valentin-software.com)

PV*SOL consists of a multi-product software suite appropriate for the design, simulation and financial analysis of PV systems, from small off-grid residential systems to large commercial grid-connected and utility-scale systems. The calculations are based on an hourly data balance and the results may be presented in graphic form, in a detailed project report or in summary form. PV*SOL products are among the most widely used.

PV*SOL programs include:

- PV*SOL basic,for the design of PVs<300kW,
- PV*SOL Pro, for the analysis of PVs<100MW,
- PV*SOL Expert, containing all the capabilities of PV*SOL Pro plus the added capability of 3D array design and detailed shade analysis.

A demo may be downloaded from the relevant website. An on line easy-to-use tool is also available for draft estimations.



ON LINE PV*SOL TOOL

PV F-CHART (http://www.fchart.com)

The program provides monthly-average performance estimations for each hour of the day to calculate the long-term average performance of utility interface systems, battery storage systems, systems with no interface or battery storage. Each system is described using two sets of parameters (system and economics). The system set contains the parameters that describe the optical, thermal and electrical performance of the system. PV F-Chart contains weather data for over 300 locations, hourly load power demand profiles for each month, statistical load variation, buy/sell cost differences, time-of-day rates for buy/sell, and life-cycle economics.

PVSYST (www.pvsyst.com)

This software is suitable for grid-connected, stand-alone and DC-grid systems, and offers extensive meteorological and PV-components database. It offers 3 levels of PV system study, corresponding to the different stages of the development of a real project:

i) Preliminary design: system yield evaluations are performed using only few parameters.

ii) Project Design: aiming to perform a thorough system design using detailed hourly simulations.

iii) Measured data analysis: importation of measured data is allowed to display tables of actual performances and perform close comparisons with the simulated variables.

An evaluation mode is available and may be downloaded for monthly trial use, free of charge.

PV-DesignPro (www.mauisolarsoftware.com)

The PV-DesignPro has been designed to simulate PV energy system operation on an hourly basis for a year, based on the user's selected climate and system design. There are three versions of the PV-DesignPro program: "PV-DesignPro-S" for standalone systems with battery storage, "PV-DesignPro-G" for grid-connected systems with no battery storage, and "PV-DesignPro-P" for water pumping systems.

Nsol!-GT (www.nsolpv.com)

Nsol!-GT is a sizing software, specifically optimised for grid-tied PV systems. It includes databases for solar resource, PV modules, and grid-tied PV inverters. The software allows rapid and accurate system design and performance analysis. It also includes a basic economic payback analysis, including value for system rebates, tax credit and production credits.

Nsol! V.4.6 includes modules for standalone PVs, PV-generator hybrids and grid-tied PV. The standalone version includes the "Loss-Of-Load-Probability" statistical analysis. A demo version is available for download.

Solar Pro (www.lapsys.co.jp/english/products/pro.html)

Solar Pro develops and supports virtual simulations for PV systems, allowing the computation of solar power from module arrays. It also performs shade analysis and includes the influence of shading in the sizing process, in order to check optimal settings and module designs. The software calculates the amount of generated electricity based on the latitude, longitude and the weather conditions of the installation site. The calculated data are presented in graphical form so they can be used for reports and sales presentations of the PV system.

RETScreen (www.retscreen.net)

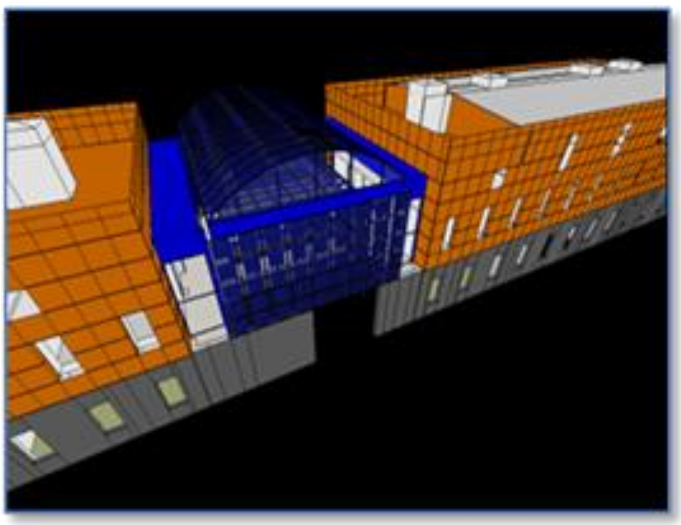
The RETScreen Software - Photovoltaic Power Model is used to evaluate energy production and savings, costs, emission reductions, financial viability and risk for central-grid, autonomous and grid connected PV systems.

RETScreen models a wide variety of projects, from large scale multi-array central power plants to distributed power systems located on commercial buildings and houses, or stand-alone battery storage systems for lighting. The software is available in multiple languages and includes project and climate databases for free downloads.

6.2. Software tools for site analysis

ECOTECT

Ecotec performs an entire building energy analysis in 3D. Furthermore, the position and path of the sun as well as solar radiation on windows and surfaces, over any period of the year, may be estimated and visualized.



BIPV VISUALIZATION ON EXISTING BULDING IN CHANIA USING ECOTECT

Shadows

Shadows is a useful program for solar energy engineering and assists in the design of sundials and astrolabes. It simulates, displays, and animates the shadows of different objects at different locations.

Shade Analysis,

A tool to estimate shading losses for panels at different locations and orientations with different tilts and slopes.

www.honeybeesolar.com/shade.html.

For further details on the above simulation software, the installer may visit the relevant website and/or contact the supplier or the software developer indicated in the software references.

Contact and information at www.vet4gseb.eu

VET4GSEB Partners:

The Project is realised by a consortium of 8 partners from: Bulgaria, Albania, Armenia, Georgia, Turkey and Ukraine

Sofia Energy Centre, coordinator

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