PVTRIN
INSTALLER CERTIFICATION

Installing Photovoltaics
Practical aspects for installers









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INTELLIGENT ENERGY EUROPE
FOR A SUSTAINABLE FUTURE

PV installers in Europe

The European Energy and Climate Change policies, together with the supporting EU Member States' legislations have resulted in high market growth for photovoltaics, reaching an installed capacity of 39.600 MW at the end of 2010. According to the industry's forecasts, a total installed capacity of over 600 GW is predicted for the year 2030, in EU MS.

The application of PV technologies, however, requires highly-qualified technicians for installation, repair and maintenance. Up to now, national markets have been growing at a faster rate than the qualified PV installers force can satisfy. The shortage of skilled workforce may result in a threat to the PV industry. To meet the market challenges, the appropriate education and training systems, as well as certification schemes which will validate the competence of the installers, need to be developed in order to ensure efficient installation and good functioning of installed PV systems.

Certification schemes can provide reassurance that the installer has the capacity (organisation, competence and equipment) to complete a PV installation safely and effectively. Along these lines, the recent **EU Directive (2009/28/EC)** is forcing MS for mutual acknowledged certification schemes. Furthermore, the interested parties (manufacturers, developers, investors) seek certified skills and quality assurance in all phases of a PV installation (design, installation and maintenance).

The PVTRIN initiative

The PVTRIN initiative focuses on the development of an appropriate training and certification scheme for technicians who are active in the installation and maintenance of small scale PV systems, and establishes the basis for the adoption of a mutual acknowledged certification scheme within EU MS. The PVTRIN training and certification scheme, creating a qualified installer workforce, supports the European Photovoltaic industry in addressing the need for skilled technicians. It will, initially, be implemented in six (6) countries: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain, incorporating the national legislation, the market's needs and the PV industry's requirements. Furthermore, the training and certification scheme integrates the criteria established in the 2009/28/EC RES Directive regarding requirements for certified training courses and training providers, thus providing a supporting instrument for EU Member States to meet their obligations for acknowledged certifications for RES installers until 31/12/2012. In order to incorporate the real needs of the market, to achieve consensus and to assure the broadest possible support, the key stakeholder groups are involved to transfer market experience and to provide consultation.

PVTRIN
INSTALLER CERTIFICATION

Benefits for the installers, the PV industry and the society

- By creating a qualified installers workforce, the PVTRIN certification supports the EU PV Industry to address the need for skilled technicians. The increased confidence of PV investors will lead to market growth.
- The certification enables PV installers to demonstrate their competence and quality of work to potential clients. They gain professional competitive advantage, improving their technical skills and knowledge through certified training; the certification provides them with a "passport" to the EU job market.
- Developers and engineers will profit by the existence of skilled installers. Involving them in their PV projects means efficient installations, less technical failures and satisfied customers.
- PV investors gain confidence that the appropriate level of quality and performance is met and maintained for their PV system.
- National authorities will have a supporting instrument to meet their obligations for acknowledged certifications for RES installers.
- Society as a whole will benefit; the higher PV penetration in the energy mix will reduce greenhouse gas emissions improving citizens' quality of life.

Supported by INTELLIGENT ENERGY EUROPE

CONTENTS

Scope / Objectives of the publication

This publication, developed within the framework of the European PVTRIN Project, presents an overview on photovoltaic basics and introduces the main stages of a typical PV installation life. It also provides successful examples of small scale PV installations in Europe, and it is designed to inform not only PV installers but also local authorities, engineers, developers and end users. It also aims to motivate PV installers to update continuously their technical knowledge and skills with respect to the latest technology and to seek for certified training. An acknowledged certification enables PV installers to demonstrate their competence and quality of work to potential clients, and awards them with professional competitive advantage.

1. Introduction: PV market/technology evolution

Photovoltaics exploits the energy of the sun, a free and infinite source of power. The sun hitting the earth's surface contains 2,000 times the total world energy consumed each year. Solar energy, together with other renewable energies - wind, solar thermal and geothermal as well as biomass - could contribute to achieving a 100% renewable and 100% reliable supply of clean, green energy.

The «photovoltaic effect», where a semiconductor generates a direct current (DC electricity) when exposed to light, was discovered by Becquerel in 1839 and forms the basis of modern photovoltaics, introducing a new way to get energy from the sun.

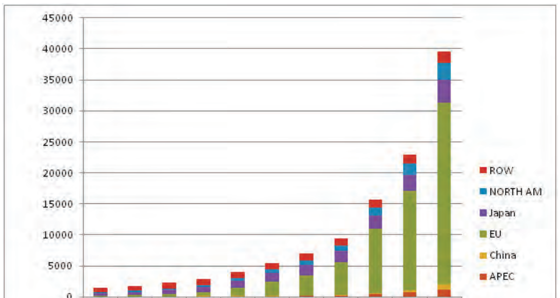
In the 1980's, the first PV systems were the low - power solar home systems (SHSs), supplying small amounts of electricity to individual homes with no access to an electricity grid, in developing countries. Although this SHS market was socially important at that time, it was limited.

In the 1990's the PV market started to grow significantly due to the shift towards grid-connected systems in the developed world.
This provided the up-front costs and stimulated the market to boost PV faster along its 'learning curve', leading to price reductions as overall production increased. This policy shift was supported by increasing awareness among governments of the importance of renewable energy for combating climate change, and by the growing enthusiasm of individuals and companies to install BIPV systems, even though the price of solar electricity was not yet competitive. Electricity utilities began to accept that the flow of electricity was not all 'one-way', allowing customers to be providers as well as consumers, and introducing tariffs for feeding electricity back into the grid. Governments' price support mechanisms devised for grid-connected systems have proved crucial for the PV market.


TERZA Solar Ltd, Cyprus

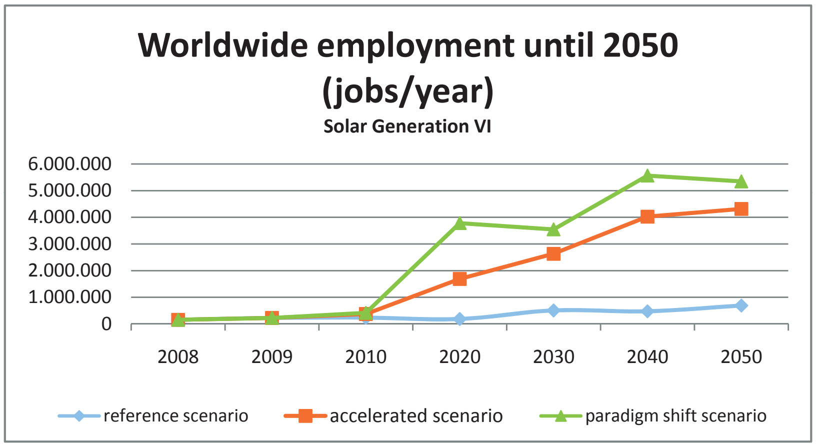

INEL, Spain

A large-scale up-take of RES installations requires a significant number of trained personnel. The PV industry estimates that 30 jobs are created per MW installed, 15 jobs for production and about 15 for the installation process. In 2010, over 150,000 people were employed directly by the EU PV industry. By 2030, according to the Advanced Scenario, 3,5 million full-time jobs will have been created by the development of solar power around the world; over half of these jobs will be in the installation and marketing of systems. In 2015 in EU, 465000 people could be employed by the PV industry in Europe, including installers. In 2020, 900000 people growing to reach around 1000000 in 2040.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ROW	758	814	894	971	1000	1010	1128	1190	1303	1427	1844
NORTH AM	146	177	222	287	379	496	645	856	1205	1744	2727
Japan	318	452	637	860	1132	1422	1708	1919	2149	2632	3622
EU	181	275	414	613	1319	2324	3307	5257	10387	16006	29252
China	19	30	45	55	64	68	80	100	145	373	893
APEC	38	43	49	57	66	80	112	170	466	718	1191

Cumulative PV market 2000-2010. Source: EPIA



2. Photovoltaics - More than a typical electrical installation

TECHNOLOGY

Photovoltaics allow electricity to be generated from sunlight. This electricity can then be sold to the grid or used on the spot. In Europe the fastest growing application is grid connected systems, because of the extended coverage of the utility grid, the flexibility of grid connected systems and the generally lower system costs involved.

ENERGY PRODUCTION

The energy production of a photovoltaic system depends on several factors which include the location, orientation and inclination of the system, as well as temperature and shadowing. A good design has to take into account all these factors.

QUALITY AND SAFETY

A photovoltaic system must be secured, both from the perspective of material and personnel, during assembly, operation and use. Safety must be considered from the design phase of the PV system, through to the execution and the performance phase.

ECONOMY: Efficient and profitable

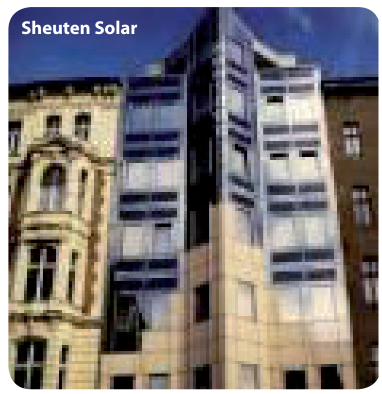
The selections of the best components which comprise a high performance system, together with good maintenance, make the PV installation efficient and profitable.

AESTHETIC – INTEGRATION

The incorporation of photovoltaics in urban environments has surprising and positive visual effects, which increase when integrated into the structure of buildings.

Artistic installation "Salutation to the Sun", Zadar (Croatia)

Integration of PV modules in the building as an architectonic element (roofs, glass roof, façade, canopy, solar louvers due to the variety of PV layouts, colours and transparencies make each building unique, allowing architects to either highlight or hide the use of photovoltaics. Photovoltaics has many possibilities **in the rehabilitation of buildings Even in heritage buildings.**



"Paul-Horn. Arena" Tübingen (Germany) / Ökotec building in Berlin (Germany)

ENVIRONMENT PROTECTION

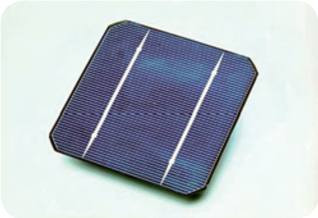
Photovoltaics, because of its capacity to generate clean CO2-free electricity from the sun, is part of the answer to today's energy and environmental problems.
Solar photovoltaic electricity can contribute to reduce progressively our consumption of fossil fuels, helping significantly the reductions in greenhouse gas emissions from the electricity sector.

3. Technology basics: Cell technologies

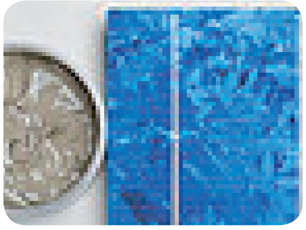
The most commonly used cell technologies are mono-crystalline, multi-crystalline and thin film.

Crystalline photovoltaic cells consist of a two-layer semiconductor with a screen-printed metallic network to collect the electrical current generated. As the voltage generated by a single cell is low, cells are joined together inside a protective «sandwich» of toughened highly transparent glass and plastic (transparent or opaque) to create modules.

Modules with crystalline cells dominate the market; they have a high efficiency and long life. Whilst they are generally shades of blue, many different colours can be made to order by changing the thickness of the anti-reflective coating on the cell. Mono crystalline cells are generally dark blue whereas polycrystalline cells have a less regular multi-crystal composition.

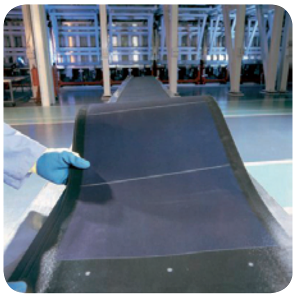


Mono crystalline cell - NREL



Multicrystalline cell - NREL

Thin film modules are created by the deposition of a thin layer of semiconductor onto a smooth homogenous surface (glass, metal... even flexible plastics). The deposition process gives thin film modules a smooth black appearance. Whilst thin film modules have a lower efficiency than crystalline cells, their manufacture requires less semi-conductor and is cheaper per square meter. Thin film products are particularly well suited to industrial building façades and roof elements as well as other places where large surfaces need to be covered.



Thin film NREL

Cell technologies

First Generation

- Single crystal silicon wafers (c-Si)

Second Generation

- Amorphous silicon (a-Si)
- Polycrystalline silicon (poly-Si)
- Cadmium telluride (CdTe)
- Copper indium gallium diselenide (CIGS) alloy

Third Generation

- Nanocrystal solar cells
- Photoelectrochemical (PEC) cells - Gräetzel cells
- Polymer solar cells
- Dye sensitized solar cell (DSSC)

Fourth Generation

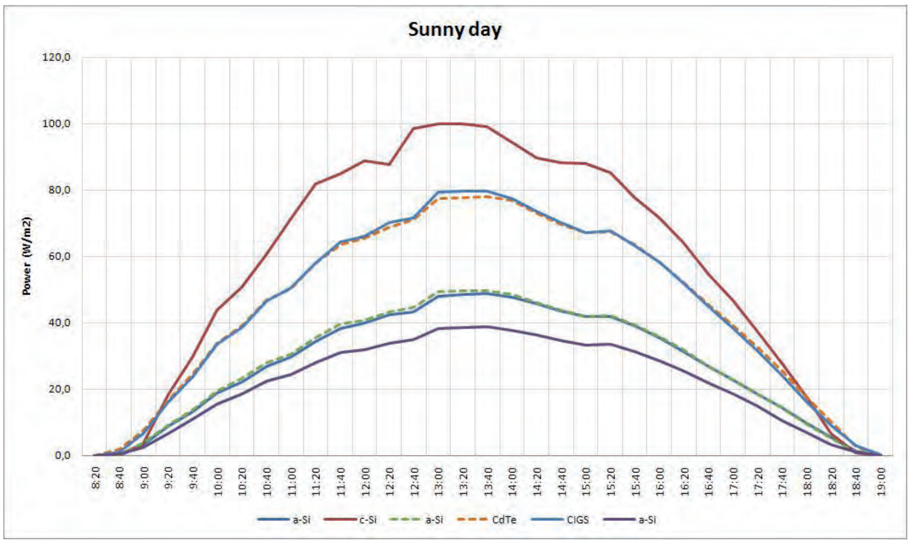
- Hybrid - inorganic crystals within a polymer matrix

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).

Commercial modules efficiencies. (source. EPIA)



Generated power with different PV technologies in a sunny day in Valencia -Spain. (source ATERSA)

4. Installation alternatives

Photovoltaic power systems could be classified in different ways:

Connection to the grid

· Isolated PV systems:

The purpose of an isolated PV installation is usually to supply electric power to recipients where there is no electrical grid. Since a photovoltaic system will only produce electricity when exposed to sunlight, at night the building grid must be supplied by batteries. So in isolated PV systems the design phase is very important to determine the demand for energy and electricity, to estimate generated energy and to sizing the storage system.

· Grid connected PV systems

The main aim of a grid-connected photovoltaic installation is to generate as much energy as possible, adapted to the physical space available and the cost of investment, to be fed into the grid.

Depending on the local legal framework:

- The entire production is exported to the grid. Electricity fed into the grid can either be sold at the same price as the electricity bought from the grid (net metering) or at a different price (feed in tariff).
- In a photovoltaics system building, energy production supplies the building's needs, and any excess production is fed into the grid.

Methods for capturing solar energy

· Sun-oriented fixed systems

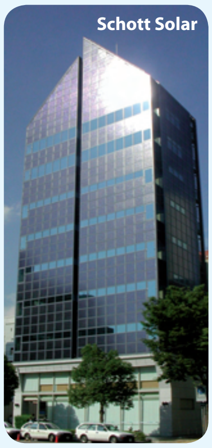
· Solar tracking systems with one or two axis

Location

· PV on the ground

· PV in building / street furniture

Photovoltaic power systems, installed on the surfaces of buildings, allow the possibility of combining energy production with other functions of the building covering Electricity is generated at the point of use. This contributes directly to the building occupant's electricity requirements, avoiding, at the same time, transmission and distribution losses and reducing capital and maintenance costs for utilities.



· PV in transport

5. Photovoltaics in buildings

Adding photovoltaics to a building offers a lot of benefits and may turn into a profitable investment; the building owner reduces his carbon footprint and earns money at the same time. PVs are available for many building applications today; not only converting roofs and buildings into energy producers, but when used in the building covering they can provide weather protection, heat insulation, sun and noise protection, modulation of daylight and security. Used as a building material, PVs can also save money by replacing traditional building materials.

PV systems in building are usually between 5 kWp and 200 kWp, and with some exceptions, in blocks of buildings, up to 2MWp. Residential applications are usually < 10 kWp and commercial ones 10kWp - 100kWp.

5.1 BAPV (Building Adapted Photovoltaic Systems)

BAPV consist of the architectural superimposing of the PV plant over the building elements: flat roofs, façades, etc.

Photovoltaic elements are in parallel with the building covering or use a structure to change to the optimum tilt and inclination .


Fotonapon


Fotonapon

5.2 BIPV (Building Integrated Photovoltaic Systems)

From an **electrical point of view** BIPV consists of incorporating a PV plant in the building for electricity generation.

From an **architectural perspective,** BIPV consists of substituting construction elements of the building with PV modules, adding different functions. Cost savings through these combined functions can be substantial.

There are many possible ways to integrate photovoltaics into buildings. Generally there are three parts of a building where photovoltaic modules can easily be integrated:

· The roof

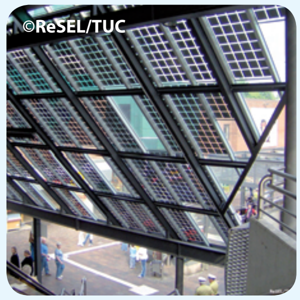
Roofs are ideally suited for PV integration. Usually there is less shadowing at roof height than at ground level. Roofs often provide a large, unused surface for integration.


Fotonapon

· The glass roof or skylights

Skylight structures are usually one of the most interesting places to apply PV. They combine the advantage of light diffusion in the building while providing an unobstructed surface for the installation of PV modules or laminates.

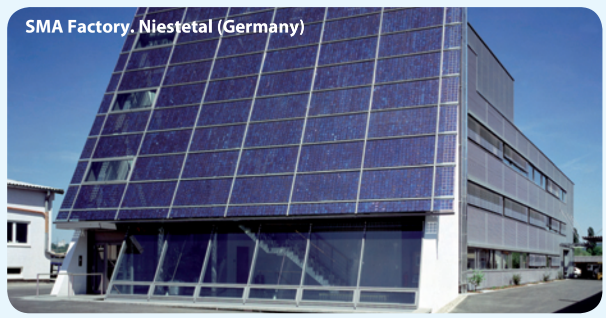
In this type of application, PV elements provide both electricity and light to the building. The structures, which may be unspectacular from the outside, produce fascinating light effects for hallways, walkways and floors and allow for stimulating architectural designs in terms of light and shadow.


©ReSEL/TUC


OPTISOL®-Scheuten-Solar-SMA

· The façade:

For facades there are several alternatives to integrate solar modules, such as a glass curtain, ventilated façade,…


SMA Factory. Niestetal (Germany)

· The sun screening components:

There is a growing need for carefully designed shading systems due to an increasing tendency in today's architecture towards the use of large window openings and curtain walls.

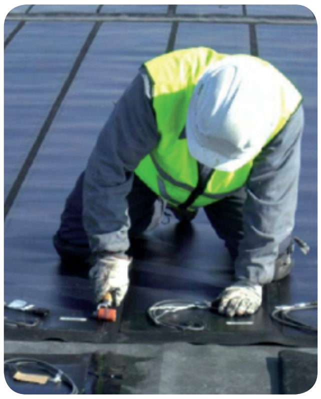
PV modules of different shapes can be used as shading elements above windows or as part of an overhead glazing structure. Since many buildings already provide some sort of structure to shade windows, the use of PV shades should not involve any additional load for the building structure. The exploitation of the synergy effect reduces the overall costs of such installations and creates added value to the PV as well as to the building and its shading system. PV shading systems may also use one-way trackers to tilt the PV array for maximum power while providing a variable degree of shading.


©ReSEL- TUC

5.3 Building Integrated Photovoltaic installations faster and more easily

Nowadays there are a number of photovoltaic products on the market which make installation in buildings faster and easier.

Cover integration: rubber blankets with amorphous silicon cells

Gisscosa-Firestone

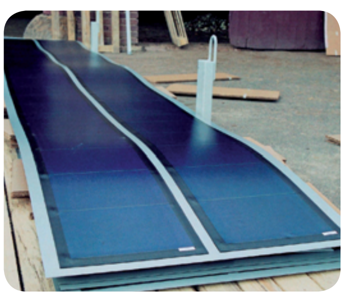
Cover integration: self-adhesive panels





Lumeta Inc

Cover integration: flexible panels




BIOSOL PV Plate de BIOHOUSE

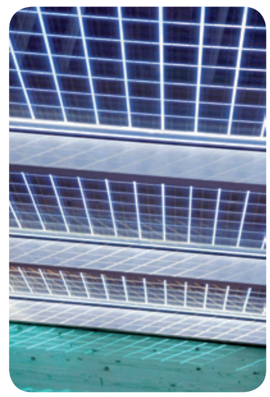
Roof integration: Solar Tiles

Lumeta Inc

Sol Sureste

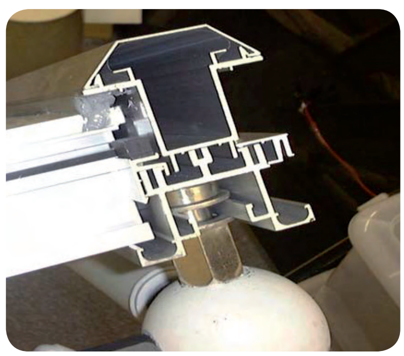
PV modules for façades and skylights:

OPTISOL

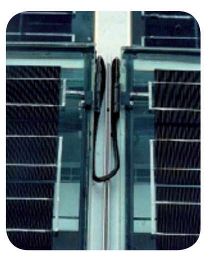
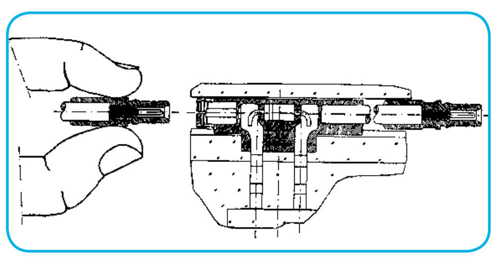


OPTISOL

The glass-glass modules for façades and skylights have a very easy-to-handle electricity connecting system. With these types of electrical connection it is possible to hide the cables inside the substructure to achieve a uniform, aesthetically appealing result with no distracting cableways.




PHOTOVOL GLASS (MSK)

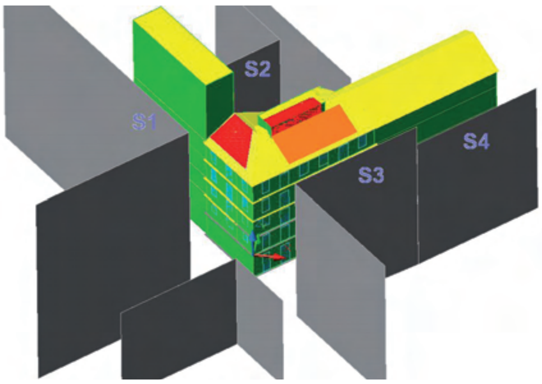
Scheuten Solar

6. Life Cycle: Design – Installation – Performance - Maintenance - Recycling

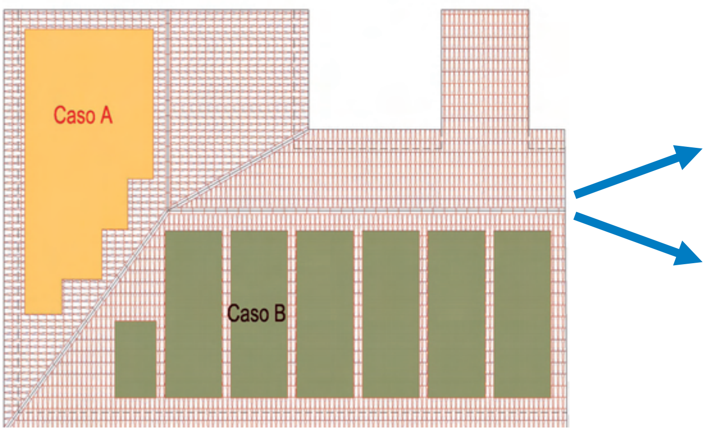
The **design** of an installation may define its total life cycle. It should be designed carefully and take into account all the possibilities, in an attempt to get the best characteristics with a focused resources evaluation and possible system losses, matching the optimum profitability. This may be done in different ways, but the choice of the best components (a good inverter can provide 2% more production with the same materials) and the installation technique used are very important.
The installation requirements must be clear and must provide sufficient specifications to achieve the desired profitability for the system. Also a maintenance plan should be drawn up at the design stage, even if it is revised at a later stage and adapted to the specific requirements of the installation.

Roof of the building under consideration

Location of obstacles to be considered

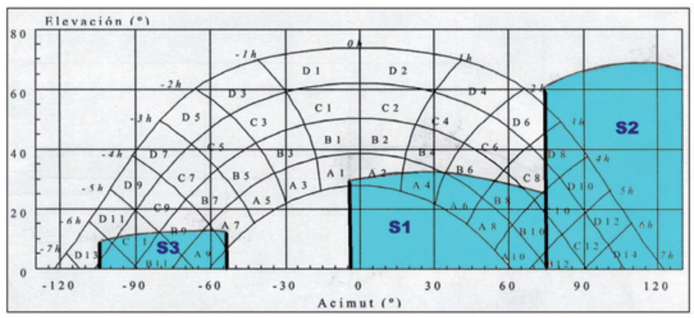


Two place options:

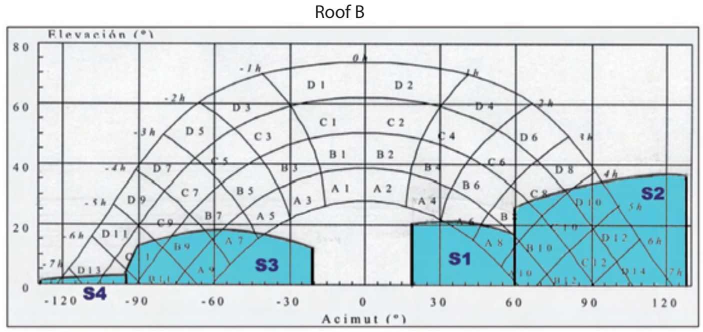


Sun path diagram and calculation of shadows. losses due to other building

Roof A



Roof B



The **installation stage** must satisfy the design requirements where possible, and should comply with the standards and regulations in force, to gain the maximum electricity production possible from the system, and reduce losses in the net transmissions.

The **performance and maintenance** of the system, after the installations stage, will enable the system to give the highest production rates possible. Each system needs to be maintained, and a system, such as PV, that is exposed to extreme weather conditions, theft and other hazards must be correctly maintained, according to a maintenance plan which provides the critical check points of each part of the system and rewards the owner with reduced operational costs.

Source: DEMOHOUSE Project (TECNALIA)

6.1 Installation Design

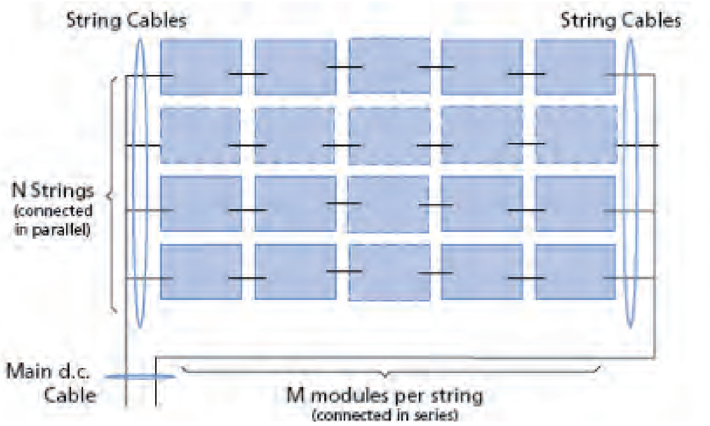
Good design of a PV system involves the correct choice and matching of components (PV modules, inverter and other equipment, the avoidance of electrical losses where possible and the minimisation of losses where unavoidable). This document does not cover the overall principles for the design of a PV system, but it does introduce some useful aspects for the system designer, and also for other interested parties who wish to understand the important design features of a PV system.

· PV modules and technology selection

The designer must take into account the efficiency and the average price per Wp of the different PV cell technologies, and also all the electrical parameters, installation and maintenance costs. The designer should then make different future scenarios for the owner of the PV installation so that he can decide which solution would suit him best. Maybe the most economical one for the first stage of the installation is not the most cost efficient as regards the maintenance stage and could result in higher operation costs than expected.

· Strings with the same power

PV modules are connected in series forming a string. Several strings are connected in parallel forming an array or the generator itself, in order for a PV array to generate the required output voltage.



· Cable connections

All cables from every string are interconnected in the string control. The appropriate safety equipment must be chosen to ensure the PV installation's operation and personal safety: Fuses, RCD, circuit breakers.

· Cables sizing and string.

Among the regulation and legal requirements for PV installations, **the crossover and longitude of the wire** must be carried out in accordance with two main factors:

- Drop voltage following the national regulation on electrical supplies.
- Current carrying capacity due to the thermal effect measured by two parameters:
  1. Short circuit temperature.
  2. Operation temperature based on the configuration of the cables into the installation and the exposition to air.

· Shading

Shade makes a big impact on the performance of a PV system. Even a small degree of shading on the part of an array can have a very significant impact on the overall array output. Shade is one element of system performance that must be specifically addressed at the system design stage – by careful selection of array location and layout in the electrical design (string design to ensure shade effects only one string).

· Module temperature

An increase in module temperature results in a decrease in performance (eg 0.5% per 1°C above stc for a crystalline module). Sufficient ventilation must be provided behind an array for cooling (typically a minimum 25mm vented air gap to the rear).

For building integrated systems, this is usually addressed by the provision of a vented air space behind the modules. On a conventional pitched roof, batten cavity ventilation is typically achieved by the use of counter battens over the roof membrane and by the installation of eaves and ridge ventilation.

· Inverter ventilation

Inverters dissipate heat and should be sufficiently ventilated. Clearance distances as specified by the manufacturer should also be observed. Failure to follow this may cause a loss in system performance as the inverter will de-rate when it reaches its maximum operating temperature. This should be highlighted in the O&M manual and maybe a label – do no block ventilation – should placed next to the inverter.

· In case of Isolated Systems

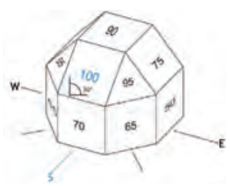
the designer must determine the demand for energy and electricity needs, estimate generated energy (taking into account the available solar energy, losses due to orientation, inclination and shading), and determine the storage system.

· In cases of BIPV

- Select the optimum facades and roofs angles

  PV Production depends on the inclination and orientation of facades or roofs:

  - Optimum Orientation = South
  - Optimum Inclination angle = Latitude(º) – 10º



(Source: Landesgewerbeamt Badenwürttemberg)

- Modules placed on different eaves with different inclinations or azimuth have to be connected to different strings.
- Ensure roof stability (weight, condensation…)

6.2 Installation assembly

The quality of the system's installation has a strong influence on the ongoing performance of the system and in meeting expected system lifetimes and output levels. Issues to be addressed:

· Installer training and qualifications:
Everybody working on a Photovoltaic system must be experienced/trained in working with such systems and fully acquainted with the voltage present in that particular system. Besides continuous updating in technical knowledge and skills, new products, legislation etc. is recommended.

· Follow design considerations:
The installation and commissioning phases of the project provide the means to implement good design practices.

· Follow manufacturer's recommendations:
Having selected appropriate components for the PV system it is important that they are installed in accordance with the manufacturer's recommendations, especially in terms of required fixings, ventilation, calibrations, operating temperature ranges and safety aspects. Failure to adhere to the correct operating conditions can lead to poor performance levels, reduction of lifetime of components and even failure of the system in some cases.

Ekain taldea, Spain

INEL, Spain

· Follow safe working practices:

Cristal Tower MARTIFER SOLAR SA

Demonstration Building KUBIC -TECNALIA

· Select the PV modules for the same string with similar manufacturing parameters; the chain is as weak as its weakest part.
In the case of BIPV installation, the following issues have to be given special consideration:

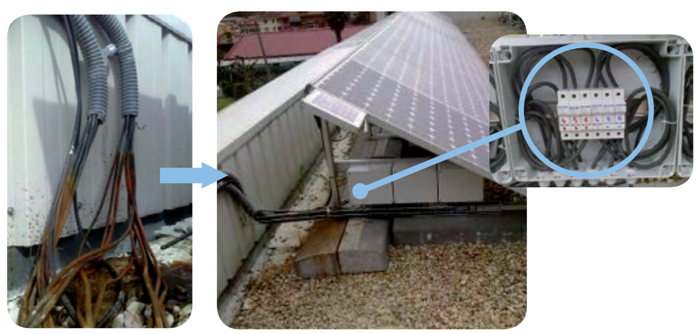
· Ensure roof stability and weather tightness
Particularly in retrofit systems a feasibility study or structural evaluation of the roof should be carried out in order to ensure that the strength of the existing roof is sufficient to support the weight of the PV modules. At the same time, it is important to avoid roof perforation during installation to guarantee roof weather tightness

BIOHOUSE

· PV modules structure, ballast and anchorage

Ekain taldea, Spain

· Cables disposition (not loose, not tight, cables layout
Attention should be paid to minimising cable lengths and, particularly, to ensuring that all connections are correctly made and protected. The solar array wiring should be housed in a rack to avoid flooding and accumulations of dirt and rust. Whilst it may not affect the initial performance of the system, a poor connection can become more influential with time and lead to performance reduction in the long term.



ZUBIGUNE

· Grounding: Each technology
Connection of parts of a PV system to earth affects:

- The electric shock risk to people in the vicinity of the installation.
- The risk of fire under fault conditions.
- Transmission of lightning induced surges.
- Electromagnetic interference.

6.3 Performance and maintenance

Assuming that good design rules have been followed and the appropriate quality procedures have been applied to the installation and commissioning process, the PV system should have a good performance level at the start of its operation. However, it is important that this performance level is maintained throughout the system lifetime in order to obtain the maximum benefit from the PV system. This sections deals with recommendations concerning operating and maintenance procedures.

6.3.1 Field maintenance tasks requirements and issued to be addressed.

Inspection and measurements

· <u>Visual inspection</u>

- General condition of equipment: modules, cables, junction boxes, inverters, and grounding electrodes.
- Panel position: shading, distances, proper azimuth and inclination.
- Structure and ballast: consistency and rust (more frequently in saline areas or corrosive atmospheres)

· <u>Environmental measurements:</u>

Inclination and azimuth of the PV generator by placing the sensor irradiance G and the temperature TC with the inclination and azimuth, and at the same temperature (placed 1 hour before) .

· <u>Electrical measurements</u>

The inverter output will be taken (simultaneously) the parameters: VMPP and IMPP (DMM) CAP (single or three phase analyzer) G and CT. These data allow us to study the efficiency of the inverter directly.

Cleaning photovoltaic modules

Periodically cleaning with water and non abrasive elements improves the performance of the installation. In areas with an abundance of birds, deterrents should be placed to prevent them from defecating on the panels.

NREL

Prevent and avoid new shadows

due to tree, streetlight or aerial over PV modules.

Schott Solar

6.3.2 Measuring and monitoring system.

Monitoring of the relevant data of the PV system:

In a local way by means of LEDs and displays

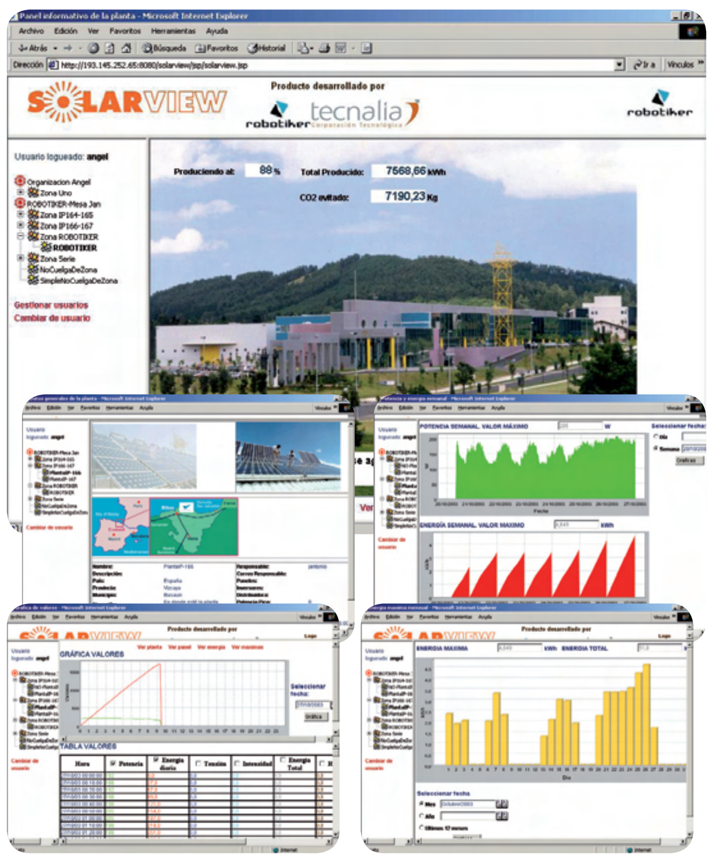
· Local and Photovoltaic Panels temperatures (ºC).
· Solar radiation (Watts/m2).
· Instantaneous power in W.
· Accumulated Total energy in kWh.
· Equivalent in Kg of CO_2 to the Generated Total Energy.

TECNALIA

In a remote way by Monitoring SW application:

monitor the local or remote PV system in order to get information, register and analyse the PV system generation, with such functionalities as:

· Instantaneous Monitoring of the PV system.
· Historical registry of data in a Database.
· Graphs of generated energy and power daily, weekly and monthly.
· Daily tables with the monitored values
· Production comparisons between the individual connected PV systems.
· Individual invoicing of the PV systems.
· Adaptable to the necessities of each client by means of configuration:



TECNALIA

6.3.3 Preventive Maintenance

Predictive maintenance involves photovoltaic system data analysis (measured generally, by string, or by module) using algorithms to predict the behaviour of the PV system and thus determine in advance possible failures or degradation, even identify specific anomalies, to trigger a warning alarm warning maintenance staff and indicating the procedure to resolve it. Possible functions of the monitoring system are:

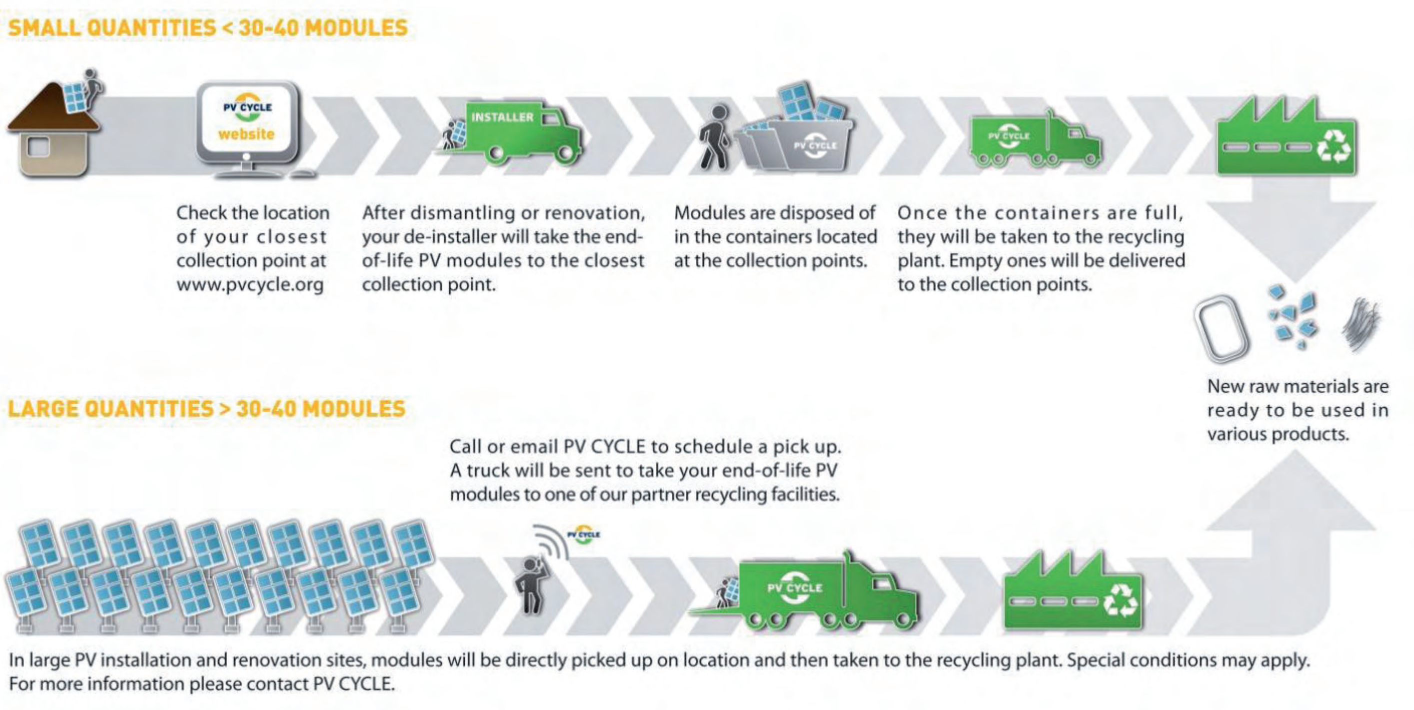
- Monitoring the PV panel performance degradation.
- Assessing the impact of permanent shadows on the PV.
- Anomaly detection: effect of hot spots, dirt spots etc.

This will improve the performance ratio of the plant by solving the problem before it occurs and reducing maintenance costs by having located the damaged item. Preventive maintenance is particularly relevant in BIPVs.

6.4 Recycling

PV modules contain materials that can be recovered and reused in new products. Industrial recycling processes exist for both thin-film and silicon modules. Materials such as glass, aluminium, as well as a variety of semiconductor materials, are valuable when recovered. Recycling not only benefits the environment by reducing the volume of waste, but it also helps to reduce the amount of energy required to provide raw materials and therefore the costs and environmental impacts of producing PV modules.

PV modules are designed to generate clean, renewable energy for over 25 years. With the first significant installations in the early 1990s, full-scale end-of-life recycling is still another 10-15 years away. Nevertheless, the PV industry is working to create truly sustainable energy solutions that take into consideration the environmental impacts of all stages of the product life cycle, from raw material sourcing through to end-of-life collection and recycling. Leading manufacturers embrace the concept of producer responsibility and have come together to put in place a voluntary, industry-wide take-back and recycling programme: PV CYCLE.



Source: PV CYCLE

To learn more about PV CYCLE: http://www.pvcycle.org/

To learn more about global activities regarding the recycling of PV systems: http://www.iea-pvps-task12.org/13.0.html

7. Examples of BAPV- BIPV applications

Integration into façade. Renovation in heritage buildings

Tourist Information Office Alès, Gard (France) Source: TENESOL

The remains of an 11th century church in Alès, Gard (France) have been used to create a tourist information centre; using a south-facing double PV and insulated semitransparent façade optimises and balances the climatic behaviour of the building.

3 multi level bay windows increase the usable space within the tourist information centre. Each of these bays is a double PV and insulated glass façade, with an 11cm gap between the semitransparent PV modules and the double glazed glass wall. The air in this gap, warmed by the sun, is used for pre-heating the building in winter and for ventilation in the summer.

The PV designer's goal was to "imagine an active South façade that would optimise and balance the climatic behaviour of the building"(Yves Jautard). The modules are semi transparent glass-glass with a brown/black antireflection coating, selected for aesthetic reasons.

Installed at 38° west of south, each of the three façades contains 70 Photowatt modules of 46Wp (for a total of 210 modules or 9.6kWp). The modules are connected in 3 series to a SMA 25000 inverter before finally delivering their production to each phase of the building's three-phase connection. Production and consumption is measured through two disc meters installed in series.

Integration in façade

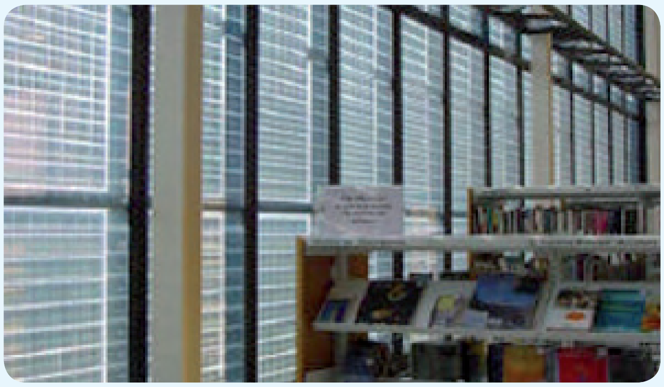
Designed on the axis of saving resources and being environmental friendly, Athens Metro Mall combines characteristics which make it bioclimatic building with very low energy consumptions. The solar panels -crystalline silicon modules from SOLAR CELLS HELLAS SA- cover 400sqm of the south side of the building achieving a reduction in energy consumption of up to 5%.

The BIPV consists of two facades and the south side of the shopping center.

The 51,00 kWp system injects power into the public grid (feed-in tariff 0,394€/KWh). According to the estimations the system will produce approximately 39,9MWh/year and the total investment is expected to be paid off in approximately 9 years. The annual CO_2 savings are estimated as: 23.940 kg.

Athens Metro Mall, Greece. Source: Solar Cells

Integration of PV system in façade as curtain wall



The Pompeu Fabra library in Mataró was designed with the twin aim of producing solar and thermal energy and ensuring maximum comfort. The installation consists of a curtain wall with polycrystalline silicon solar cells, allowing interior visibility.

There are three curtain-wall type windows with opaque monocrystalline silicon solar cells.

Surface: 603 m2

Annual energy production: 50MWh

Emissions saved: 11,5 Tons CO_2/year

Integration of PV system in façade. Pompeu Fabra Library, Mataro (Spain). Source: TFM

Superposition into façade. Renovation in multifamily dwellings

In the early 2000s, the Municipality of Tavros (part of the Athens Metropolitan area) decided on the pilot energy upgrade of 2 buildings in its region. The aim of this project was to design and incorporate innovative energy concepts and solar techniques in social housing buildings. This project was included in a programme of the European Commission called Joule-Thermie.

The block of flats was built around 1960. It is a 10-storey building with an elaborate construction and central heating. Different RES technologies and passive system technologies were applied to increase the energy efficiency of the building.

The PV panels are integrated in the southern part of the building. The main target was to cover the needs for lighting in public areas and around the block. The system is also used for preheating the indoor areas by dissipating the heat from the modules in winter.

The total installed power of the PV system is 10kW and the area covered is approximately 100m2.

Renovation of the façade of multifamily dwellings integrating photovoltaics (Tavros, Atenas) Source: SOURSOS

Semi-transparent PV modules into an inclined roof

Skylight structures are usually one of the most interesting places to apply PV. They combine the advantage of light diffusion in the building while providing an unobstructed surface for the installation of PV modules or laminates. The Zuckerman Institute for Connective Environmental Research (ZICER) building is home to the University of East Anglia's School of Environmental Sciences which runs, among other projects, the 'Community carbon reduction project'. The building has glass/glass PV fitted to the atrium-like arrangement on the top floor. It has been designed to maximise the potential for demonstrating PV - both on the vertical and gently sloped roof surfaces. Glass/glass laminates were selected to give semi-transparent glazing that also included PV.

Roof installation in ZICER Building. University of East Anglia, Norwich, UK – Source: BP Solar

Skylights: semi-transparent PV modules

The Ludessch Community Centre, in Austria, has an ecological structure with a photovoltaic roof that is currently the largest photovoltaic system with transparent solar cells in the whole of Austria. The massive roof (350m2) incorporating 120 high - performance modules with transparent Sunways Solar Cells offers numerous benefits: in addition to the lucrative generation of power (16,000 kilowatt hours of green electricity annually), it also protects the village square from rain and excessive sunshine. The translucent photovoltaic modules only allow around 18% of sun's rays to pass through, thus providing a pleasant and optimal lit living and working environment right in the centre of Ludesch.

Ludessch Community Centre, Austria Source: SUNWAYS

8. EU Policy and Legislation

Europe has to address major energy-related issues such as: climate change, a growing dependence on energy imports, volatile oil and gas prices and an increasing demand. To do this, the European Energy Policy is built on sustainability, competitiveness and security of supply via a range of measures involving the promotion of renewable energy and energy efficiency.

In 2007, EU leaders endorsed an integrated approach to climate and energy policy and committed to transforming Europe into a highly energy-efficient, low carbon economy. They made a commitment to reduce emissions of greenhouse gases by 20% by 2020, and they set a series of demanding targets to be met by 2020:

- To increase energy efficiency, saving 20% of EU energy consumption by 2020
- To reach 20% of renewable energy in total energy consumption in the EU by 2020.

The "Climate and Energy Package" proposed binding legislation to implement the 20-20-20 targets and became law in June 2009.

Supporting Policies in Europe

- Action Plan for Energy Efficiency: Realising the Potential, COM(2006)545 final
- The "Energy and climate change package" of the European Commission adopted on 12 December 2008
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (EPBD recast)
- A strategy for competitive, sustainable and secure energy COM/2010/0639 final
- Energy Efficiency Plan 2011, COM/2011/0109 final

The European Union, through its policies, is the biggest promoter of renewable energies and PVs, in Europe. The most important of these are the EPBD Recast (Directive 2010/31/EU) and the RES Directive (2009/28/EC).

The recast of the Energy Performance of Buildings Directive, 2010/31/EU, means that from 2020 onwards all new buildings will have to be 'nearly zero energy buildings', to comply with high energy-performance standards and supply a significant share of their energy requirements from renewable sources. For public buildings these standards need to be met by the end of 2018. Furthermore, EU Member States (MS) were also called upon to promote the conversion of old buildings to high energy performance and renewable energy sources. Each MS will define its specific standards.

The RES Directive on the promotion of the use of energy from renewable sources, 2009/28/EC, contains a series of elements which aim to create the necessary legislative framework for making 20% renewable energy become a reality. It requires each Member State to adopt a national renewable energy action plan, setting specific national targets for the share of energy from renewable sources consumed in transport, electricity and heating and cooling in 2020 and adequate measures to achieve these targets.

European Commission

The PVTRIN Certification will offer:

To installers
· Proficiency
· Recognition
· Mobility
· Aspirations
· Employability

To PV investors
· Confidence
· Better system performance
· Reduced risks

To PV industry
· Efficient workforce
· Satisfied customers
· Lower operational costs
· Increased credibility

The 2009/28/EC, among others, obliges EU MS to develop and mutually recognize certification or equivalent qualification schemes for installers of small-scale renewable energy systems (e.g. biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps) by December 2012, Article 14 (3). The Directive, aimed at creating a qualified and appropriate skilled installer workforce, states:

· "MS shall ensure that certification schemes or equivalent qualification schemes become or are available by 31 December 2012."
· "MS shall make available to the public information on certification schemes or equivalent qualification schemes. Member States may also make available the list of installers who are qualified or certified in accordance with the provisions."
· "Each MS shall recognise certification awarded by other Member States in accordance with the criteria in Annex IV".

According to the Directive's requirements:

· The training leading to installer certification or qualification shall include both theoretical and practical parts and shall end with an examination, including a practical assessment of successfully installing PVs.
· The accreditation of the training programme or provider shall be effected by MS or administrative bodies they appoint.
· The installer certification should be time restricted, so that a refresher seminar would be necessary for continued certification.
· At the end of the training, the installer must have the skills required to install the relevant equipment and systems to meet the performance and reliability needs of the customer, incorporate quality craftsmanship, and comply with all applicable codes and standards.

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A great deal of additional information on the PVTRIN project is available on the web at: www.pvtrin.eu.
We would welcome feedback on this publication, if you have comments or questions please contact the project coordinator.

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Project references:

PV CYCLE, SUNRISE, PREDAC, PURE, DEMOHOUSE

PVTRIN
INSTALLER CERTIFICATION

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