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INTRODUCTION

This manual is the result of the Leonardo da Vinci project titled: **Improving Vocational Education in the Construction Industry Sector with the aim of Identification and Recognition Qualifications in European Union Countries 2008-1-PL1-LEO05 -02059**.

Polish Association of Construction Industry Employers – Poland was the promoter of the project.

Partners of the project: Polish British Construction Partnership Sp. z o. o. – Poland, CREDIJ (Centre régional pour le développement la formation et l'insertion des jeunes) – France, University of Minho – Portugal, Ufficio Scolastico Provinciale di Venezia – Italy, Econometrica Ltd. – Greece, The Chartered Institute of Building – United Kingdom.

PROCONSTR is a project concerning developing an innovative program of vocational training based on eight selected construction professions for graduates from vocational schools technical secondary schools and employees who are professionally active and want to increase their skills.

The aim of the job modules is to promote ideas of regular vocational development, support activities leading to implementation of European tools concerning education and vocational training – equalisation of opportunities on European labour markets, intensification of co-operation among companies from construction sectors and social organisations in order to promote vocational development with reference to EQF and ECVET in Europe.

Moreover, the project's challenge is to make participants in the training sessions more aware of the requirement to increase their vocational qualifications with regular training sessions, as well as learning new techniques and technologies that are utilized in the construction industry and language education. Once these skills have been gained it will give them the opportunity of being employed across the whole territory of the European Union.

Unification of essential regulations of vocational qualifications in European Countries might simplify easy transfer of the most modern technologies as well as enabling common usage of knowledge and generating new employees that are able to meet the requirements of contemporary European market.

The nature of the training sessions is directed at men and women, with supporting efforts heading for equalisation to access vocational education and to ensure equality on the labour market, in this case, giving special consideration to the construction branch.

The outcome of the project is an innovative didactic resource for beneficiaries. Eight job modules were created on the basis of data and domestic markets available. The didactic materials were created with support of construction companies on national levels.

- **Job Module for Manson**

- **Job Module for Carpenter**
- **Job Module for Plumber**
- **Job Module for Electrician**
- **Job Module for Concrete builder**
- **Job Module for Roofer**
- **Job Module for HVAC worker**
- **Job Module for Plasterer**
- **Module for trainer**

Each job module consists of two parts with the first part being theoretical, including the latest know-how concerning specific trades necessary for employees. The second part consists of training with appropriate examples set out in exercises based on chosen innovative aspects.

The project's creators hope that the final product might have a long-term influence which can be utilised successfully in vocational education throughout the European Union. Exploitation of unified course of vocational training sessions in all countries would result in the elimination of formal and informal barriers concerning an easy-flow of employees and equalize differences in professional qualification levels.

Equalization of qualifications between European countries would result in the effective exchange of experiences; simplify identification of different types of problems (in less developed countries) and the implementation of preventive means.

Conclusions drawn from the executed project could be used to create new training solutions as well as to prepare vocational education system reforms on a domestic level.

More information on project website: www.proconstr.eu.

INFORMATION ABOUT THE COURSE

Participants should have the following knowledge prior to attending this course:

- Knowledge of working both AC and DC circuits
- Reading and interpreting plans and specifications
- Reading and interpreting codes and standards
- Using basic mathematics

The following innovations will be learnt at the course:

- The safe installation of photovoltaic systems

The advantages of this modern technology are:

- Use of environmental friendly energy sources (photovoltaic installations)
- knowledge about using specific materials and techniques
- quality work improvement

As the participant, you will gain knowledge about safe installation and reliable work of photovoltaic, new skills and competences concerning dealing with these specific systems and techniques.

After the course you will be able to make a safe installation of photovoltaic. Moreover you will be able to apply this technology on your own.

As a participant you will receive a manual and CD full of didactic materials like ppt, pdf and vocabulary.

You will be asked to participate in the theoretical lectures (1 day) and practical workshops (2 days) conducted by a vocational trainer. Moreover you will gain knowledge on how to read and use additional materials included in this course.

Your knowledge will be tested/assessed by a trainer with use of a set of questions at the end of the course.

After completion of the course you will gain the **PROCONSTR CERTIFICATE.**

PREFACE

The PROCONSTR project is intended for two main groups of construction workers; qualified workers and medium-level technical supervisors. Eight trades covered by the project represent the main professions of a large cubature house building sector as well as the infrastructure sector that constructs office buildings, hotels, commercial, cultural and sport centers, healthcare infrastructure and other public utility buildings. Experts in the fields covered by the project are also crucial for the single-family house building sector. They are equally important in the industrial and road construction sector.

Traditional trades like: concrete builder, carpenter, reinforced concrete builder, mason, roofer, and plumber are currently undergoing a dynamic evolution due to the technical progress in the construction field.

The common use of concrete pumps together with concrete mixers and widespread application of chemical products in construction such as self levelling floor compounds and resin are an important part of the prefabricated reinforced-concrete elements which are used for ceiling construction. Common use of prefabricated reinforcement elements such as meshes and cages has been an important influence on the change from the traditional idea of seperate concrete and reinforced concrete builders. Joining the two trades together creates a more universal trade for the reinforced concrete builder.

The widespread application of formworks and scaffolding used on all types of construction sites has a decisive influence on the ongoing changes in the profile of the carpenter's profession. Similarly, an exceptionally wide range of roof coverings and new methods of assembling makes a crucial impact on the modern definition of the profession of a roofer. Important changes are happening in the field of masonry, where masons are required to have an in-depth knowledge of all types of plasters and glues. The knowledge of an electric fitter has to cover a wide range of low current electric installations. A trade which is currently undergoing particularly dynamic changes due to a huge progress in the field of air conditioning techniques is the HVAC fitter.

Equally, significant progress can be seen in the field of sanitary techniques. A whole range of equipment is available on the market that has not been used before. The use of internal or external materials made of epoxy resins, carbon fibres and other synthetic materials has already exceeded the percentage use of traditional materials. The introduction of different types of plaster, dry walls or other wall elements like cardboards, significantly widens the requirements relating to the trade of a plasterer.

Apart from technological changes that have influenced the profile of vocational training, it is impossible not to mention general requirements which have to be fulfilled by modern construction teams.

These requirements include:

- a significant shortening of the project implementation cycle,
- limiting the area of construction sites, particularly in urban agglomerations,
- the expansion of vertical-building projects,
- the introduction of a top-down method, i.e. a simultaneous construction of both the underground and ground structures,

- carrying out the works in extreme weather conditions, due to the possibility of putting concrete layers at both low and high temperatures.

Nonetheless, health and safety at work is the most important issue, relating to both the dynamics of changes in vocational profiles and strict requirements.

The expansion of the European Community favors the free movement of services in the construction sector. This reinforces the creation of construction companies with international capital. It also creates the need for mobile construction teams, which together with the high quality requirements constitutes an incentive for the unification of qualification of construction workers on the highest level in the whole Union. The aforementioned reasons underline the importance of changes undergoing in the field of construction trades.

A good economic situation for the construction market affects economic development substantially. Demand for residential housing, office space and infrastructural building increases. Orders placed by investors motivate contractors to carry out their jobs and the contractors stimulate enterprises manufacturing building materials to maximize their production capacities; it enables quick completion of construction investments. Consequently, a system enabling stimulation of economies and decrease in the unemployment rate is launched.

When a market presents a demand for a quick and thorough carrying out of investments, the most serious problem there is finding a relevant contractor team consisting of high-class specialists knowing all aspects of a profession and that are trained to the latest methods and technologies used within the construction project, in particular, in fields of their specialization.

CHAPTER I GENERAL CONSIDERATION CONCERNING CONSTRUCTION TRADES

Everything suggests that the environmental economy is rapidly growing abroad, knocking on the door and our country with an extremely promising effect. Above all, Greece has the potential to become a paradise of green economy, especially investment in photovoltaic systems for two main reasons. The first being plenty of sunshine all year round and the second is that natural potential is still untapped, which provides a wide scope for attracting green investment. The willingness of the government to give incentives to promote renewable energies is given. Not long ago the Greek government passed a new law on energy production from renewable sources. The need for a new institutional framework dictated by the extremely poor performance of our country in its recovery and the pressing need to resolve chronic problems of concern to the industry: excessive bureaucracy, lack of investment incentives and spatial problems. After years of inaction, the new legal framework simplifies the process of licensing investment renewable energy, especially for small units. The issue is the competent agencies to apply the law as it should, ambitious investment plans do not face bureaucratic glitches - and I am sure the leadership of the Ministry of Development, assist this effort vigorously. The government's efforts have begun to bear fruit, and it seems hundreds of applications from business plans submitted for the creation of small and large units of production of green energy.

With regard to incentives, the new law explains the price of solar energy which can attract venture plans to build solar plants. The percentage of funding for new sustainable renewable facilities in our country can reach up to 50% of the total investment while Greek banks help finance investment projects and photovoltaics. The issue of siting renewable energy facilities in the country we are very industry. The specific spatial framework for recently published renewable energy clarifies much of the hitherto hazy landscapes of the settlement and will soon be the rule of law. Apart from the separate law on renewable energy and the specific land, the government has the institutional framework for the liberalization of energy in our country, and has introduced significant tax reductions of 20% for residential solar installations in the tax law.

The Public Private Partnership (PPP) may prove an extremely useful and versatile tool for investment promotion of RES. Support alternative energy investments from the CSF and the Public Investment Programme is progressing steadily. Through both the OP (Operational Programme for Competitiveness) and by the new Investment Law, funded viable investment projects contribute to the spread of renewable energy and photovoltaic systems in our country.

Let's see why the creation of PV systems is an attractive investment in Greece:

1. As mentioned above, the world's largest market is Germany. The basic parameter for the production of electricity with solar is sunlight. Comparing Greece and Germany one can clearly see the increased energy (by 15-20%) which can be produced in Greece due to the sunbelt.

2. The PV production increases at midday, when there is a greater demand for electricity in Greece. Moreover, the production of electricity is higher during the summer months due to the demand for air conditioners. Therefore not only is it competitive in the

production of electricity, but instead inject electricity into the grid when there is a greater need and potential blackout

3. Under the new law, renewable energy was passed on 6-6-2006 (N. 3468/2006), each kWh produced by the sun and injected into the electricity network will be strengthened by 0,4-0,5 euro. The contract for the sale of electricity is for ten (10) years and may be extended for a further ten (10) years, unilaterally, in a written statement by the producer. The price is adjusted each year based on the weighted average increases in tariffs of electricity or 80% inflation.

4. In July 2007 signed by the Development Act, which provides grant investment up 40%

The above reasons make the investment in PV one of the most attractive today. What must be taken into account by the investor to make a final decision are the goals and objectives of the available funds, borrowing capacity, compared to investment opportunities in other sectors.

It is obvious that water has entered the trench and that the prospects for solar systems in our country are extremely positive. The effort to promote green energy is a process that never stops. I believe that apart from the obvious, we can set more ambitious goals, and become politically more aggressive in the promotion of photovoltaic systems.

Chapter II LEGAL BASIS

Information about labour law

This document is a guide for safe installation and reliable work of photovoltaic (PV) systems. The following instructions are aimed at the design and implementation of any electrical installation issues. Without having to be considered binding regulations, they are the guidelines arising from international practice and experience.

It should be noted that in our country, as elsewhere, there are no statutory regulations for the installation of PV systems. Exceptions are the regulations and standards adopted by countries that have extensive experience in the field of building PV systems, such as USA, Germany, Australia and England. In these cases they have adopted (or legislated) regulations, which are both compatible with the Rules of internal electrical installations of the country (like the HD384) - relating to the formulation and implementation of electrical installation in the side of the grid E.R. - on the other hand consider the specific standards which refer to characteristics of PV generators (such as EN-IEC 61215, EN-IEC 61646, IEC 61730-1 and IEC 60364-7-712 Ed. 1.0). Specifically noted that the EN-EIC 61215 deals with the minimum technical standards for photovoltaic crystalline silicon, the EN-IEC 61646 deals with photovoltaic thin film technology, the IEC 61730-1 deals with matters relating to safety standards which must satisfy F / V materials and their connection and 60364-7-712 Ed. 1.0 deals with matters relating to the establishment of PV modules in building facilities. However, there are no single accepted regulations which refer to the implementation of electronic connection on the side of direct current (DC) or E.R.

Under Greek legislation all construction workers' professional activities are considered hazardous. Thus, the profession of the Electrician (PV installer) is also considered hazardous.

The major dangers are as follows:

- Falling from height
- Dropped tools or materials
- Incorrect use of equipment
- Fire
- Explosions
- Scalds

The legal framework for the PV installer profession covers the following sections:

1) Rules of preparing and undertaking the job
2) Health and safety regulations

The general rules for the Electrical installations are covered by:

P.D. 1073/81 art. 75,76,77,78,79,80,81,82,83,84

M.O. No 80225/19-11-1955,)

M.O. no 91184/3061/4-10-66)

Other rules are covered by:

1. Works near electrical wires

   P.D. 1073/81 art 78 par α, b, c, f, art 79

2. Works at height without scaffolds

   P.D. 778/80 art. 17

3. Works on scaffolds

   P.D.. 778/80 art. 9, 11

4. Works on roofs

   P.D. 778/80 art. 18, 19

5. Works in substations distribution

   Law 158/75

The health and safety regulations can be categorised as following:

- General regulations for health and safety
- Working at height using scaffolding and mobile platforms
- Protection from electrical shock
- Environment protection

Legislation referred to health and safety regulations:

P.D. 22/12/33 (I.G.G 406 A΄) "On security of workers using ladders"

P.D. 778/80 (I.G.G 193 A΄) "On security measures during building construction"

P.D.1073/81 (I.G.G. 260 A΄) "On security measures whilst performing tasks related to house building and engineering works"

L. 1396 (I.G.S 126 A΄) "Obligations of observance of security measures in structures"

L. 1430/84 (I.G.G. 49 A΄) "Ratification of the 62 International Employment contract, "As regards the safety provisions in the construction industry and resolving directly related issues"

L. 1568/85 (I.G.G. 177 A΄) "Health and safety of workers"

P.D.71/88 (I.G.G. 32 A΄) "Regulation for fire protection of buildings"

M.O. 9087 1004/96 (I.G.G 849 B΄) "Operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas"

P.D.395/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use of work equipment by workers at work in compliance with directive 89/655 EU"

P.D. 396/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use by workers of personal protective equipment at work in compliance with the directive of the Council 89/656/EU"

P.D. 105/95 (I.G.G 67 A΄) "Minimum requirements for safety and health at work in compliance with directive 92/58/EU"

P.D.16/96 (I.G.G 10 A΄) “Minimum safety and health in the workplace in compliance with directive 89/654/EU”

P.D. 17/96 (I.G.G 11 A΄) “Measures to improve safety and health of workers at work in compliance with the instructions 89/391/EU and 91/383/EU”

P.D. 305/96 (I.G.G 212 A΄) “Minimum safety and health requirements at temporary or mobile construction sites in compliance with directive 92/57/EU”

P.D... 62/98 (I.G.G 67 A΄) “Measures for the protection of young people at work, in compliance with directive 94/33/EK”

M.O. 7568 F. 700. 1/96 (I.G.S 155 B΄) “Fire protection measures for hot works”

M.O. 130646/84 (I.G.G 154 B΄) “Security measures calendar”

Glossary:

L.: Law

P.D.: Presidential Decree

I.G.G.: Issue of Government’s Gazette

M.O.: Ministry ordinance

The exceptions are the regulations and standards adopted from countries that have great experience in the P/V systems sector, like U.S.A., Germany, Australia and England. In these instances there are cases of regulations, which are compatible with regulations of the Home country's Electrical Installations and also taken into account, the specific standards on peculiarities of PV generators.

The main objective is the provision of information with the purpose of adopting practices which will contribute to a common and collective response to installation and safe operation of the interconnected PV systems, bearing in mind that these electricity producing units are installed in the vicinity of consumers with the aim of the long period of operation.

In Portugal

Labour Law: The Labour Code in Portugal is regulated by Law n. 7/2009 of 12th February. Further information regarding construction works contracts may be found in the Collective Work Contracts in the Construction Sector (CCT, Contratos Colectivos de Trabalho para o Sector da Construção) published by the Ministry for Labour and Social Solidarity in the Employment and Work Bulletin (Boletim do Trabalho e Emprego) n. 12 of 29th March 2009.

Standards for the Small and Middle-size Enterprises (SME): There are no specific regulations for SME. For the construction and real-estate companies there is a regulating entity (the Construction and Real Estate Institute -in PT, Instituto da Construção e do Imobiliário, INCI) and specific regulations concerning the admission and practice activity, namely:

- Decree-law n. 12/2004 of 9th January 2004 establishes the legal framework for the admission to and permanency in the construction activity;
- Decree n. 19/2004 of 10th January 2004 establishes the categories and subcategories related to the construction activity;
- Decree n. 21/2010 of 11th January 2010 establishes the value of the construction works according to the qualification categories of the building permit for 2010;
- Decree-law n. 211/2004 of 20th August 2004 regulates the real estate activity.

Basics of construction standards: General Regulations of Urban Buildings (in PT: Regulamento Geral de Edificações Urbanas, RGEU) approved by Decree-law n. 38382 of 7th August 1951 (altered by Decree n. 38888 of 29th August 1952 and further revisions). A new version is foreseen to be published soon (in PT: RGE).

Basics of construction Works Contract: For general contracts, the Civil Code approved by Decree-law n. 47344/66 of 25th November 1966 (1st version) and for public contracts, the New National Public Procurement Code approved by Decree-Law nº 18/2008 of 29th January 2008 (modified by Decree-law n. 278/2009 of 2nd October and Decree-law n. 223/2009 of 11th September).

Health, Safety and Welfare Regulations: Decree 41821 of 11th August 1958 establishes the work safety regulations for building construction; Decree-law 441/91 of 14th November 1991 establishes the general principles for the promotion of Health, Hygiene & Safety at work (transposes Directive n.º 89/391/CEE of 12th June); Decree-law 273/2003 of 29th October revises the legal framework on Health and Safety conditions in the construction site (incorporating the minimum prescriptions required for temporary/mobile construction sites established by the Directive n.º 92/57/CEE of 24 June).

In Italy

In Italy the plumbing profession is regulated by the same legislation. In particular, Decree 22/01/2008 regulates activities concerning the installation, conversion, enlargement and extraordinary maintenance of systems. The list of the activities is described in the Decree and includes also those relating to our profession. The act doesn't deal with ordinary maintenance of systems and public systems such as the electricity distribution network, aqueducts, gas pipelines, or street lighting.

The activities of companies and workers in this sector are also regulated by Act 5/3/90 No. 46 "Safety regulations regarding the systems" and Decree 6/12/91 No. 447 which implements the previous law.

Other relevant Acts issued by the Government are: Decree 37/2008; Decree 412/93; Decree 192/05.

To perform work in this sector a company must submit a start-up declaration to the local Chamber of Commerce in order to be registered on the Companies Register.

The company, its' owner or its' partners must not be the subject of security or prevention measures or legal proceedings relating to the Mafia.

At least one Technical Manager (the owner or a partner) should be appointed to launch the company's activities.

A technical manager can work only in one company. Otherwise anyone who wants to work in the profession should meet one of the following technical-professional requirements:

- a degree in a specific technical subject (from a college of engineering, school of architecture, physical science, etc.)
- a secondary school diploma – second level with a sector-based specialisation, and a working period (of at least 2 years) in a company
- a qualification awarded by the Region or other authorized bodies and a working period (4 years) in a company
- employment with a company for a period (at least 3 years) as a "qualified worker" who performs installation, conversion, enlargement and maintenance of the systems. This period can also be worked in different companies.

According to Decree 37/2008 the company must issue a Conformity Declaration, which should be submitted to the Construction Counter Service of the Municipality where the system is located. The Municipality will send a copy of the declaration to the local Chamber of Commerce.

Important links:

- Ministry of Infrastructures and Transports: http://www.mit.gov.it/mit/site.php
- AEIT – Federazione Italiana Elettrotecnica, Elettronica, Automazione, Informatica e Telecomunicazione – Italian Federation: http://www.aei.it
- ANIE – Federazione Nazionale Imprese Elettroniche ed Elettrotecniche – National Association of Companies: http://www.anie.it
- CONFARTIGIANATO: www.confartigianato.it/elettricisti
- CEI – Comitato Elettrotecnico Italiano: http://www.ceiuni.it
- UNAE – Istituto Nazionale Qualificazione Imprese Installazione Impianti: http://www.unae.it
- ELETTRICO PLUS: http://www.elettricoplus.it

In Poland

- Act dated 07.07.1994 – Building Act (Journal of Laws 2006 No. 156, item 1118 with subsequent amendments, Journal of Laws 2006 No. 170 item. 1217 and Journal of Laws 2006 No. 193 item 1430)

- Regulation of the Minister of Economy, Labour and Social Policy dated 15.12.2005 on basic requirements for electric equipment (Journal of Laws 2005 No. 259 item 2172)

- Regulation of the Minister of Transport and Building dated 27.12.2005 on assessments of conformity with basic requirements for electromagnetic compatibility and EMC marking (Journal of Laws 2005 No. 265 item 2227)

- Regulation of the Minister of Environment Protection dated 30.10.2003 on allowed electromagnetic field levels in environment and checking of the electromagnetic field level observance (Journal of Laws 192 item 1883)

- Act dated 10.04.1997 Energy Law (Journal of Laws 2006 Nr. 89 item 625 with subsequent amendments)

- Act dated 27.04.2001 Environment Protection Act (Journal of Laws 2006 No. 129 item 902 with subsequent amendments)

- Regulation of the Minister of Economy, Labour and Social Policy dated 28.04.2003 on detailed rules for checking of qualifications of equipment, installation and network operators (Journal of Laws 2003 No. 89 item 828 with subsequent amendments)

- Act dated 30.10.2002 on social work accident and occupational diseases (Journal of Laws 2002 No. 199 item 1673 with subsequent amendments),

- Regulation of the Minister of Labour and Social Policy dated 26.09.1997 on general industrial safety regulations (Journal of Laws 2003 No. 169 item 1650 with subsequent amendments),

- Act dated 24.08.1991 on fire protection (Journal of Laws 2002 No. 147 item 1229 with subsequent amendments)

- Regulation of the Minister of Economy and Labour dated 20.12.2004 on detailed requirements for network connections and operation (Journal of Laws 2005 No. 2 item 6)

- Regulation of the Minister of Economy dated 17.09.1999 on industrial safety of works at power equipment and systems (Journal of Laws 1999 No. 80 item 912)

In the United Kingdom

Generally, the laws governing health and safety relate to all construction activities and trades (including design) and are not industry specific. There are several Acts and Regulations.

Some of the principal Acts which deal with health, safety and welfare in construction are as follows:

– Health and Safety at Work etc. Act 1974
– Mines and Quarries Act 1954
– Factories Act 1961
– Offices, Shops and Railways Premises Act 1963
– Employers Liability Acts – various
– Control of Pollution Act 1989

– Highway Act 1980
– New Roads and Streetworks Act 1991
– Corporate Manslaughter and Corporate Homiside Act 2007

The fundamental Act governing health and safety in construction is the Health and safety at Work etc. Act 1974. The principal regulations of this Act which affect design and construction, are:

– Management of Health and Safety at Work Regulations 1999 amended 2006
– Construction (Design and Management) Regulations 2007 (known as the CDM Regulations)
– The Work at Height Regulations 2005 amended 2007.

Some other related regulations and guides are:

– Site Waste Management Plans Regulations 2008
– Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995
– The Control of Major Accident Hazards Regulations 1999 (COMAH) amended 2005
– The Chemicals (Hazard Information and Packaging for Supply) Regulations 2003 (CHIP 3)
– The Health and Safety (Display Screen Equipment) Regulations 1992
– COSHH (Control of Substances Hazardous to Health) Regulations 2002: Provision and Use of Work Equipment Regulations (PUWER 98)
– Lifting Operations and Lifting Equipment Regulations (LOLER 98)
– Personal Protective Equipment at Work Regulations 1992
– Signposts to the Health and Safety (Safety, Signs and Signals) Regulations 1996
– Control of Asbestos Regulations 2006

Some of the principal Acts and Regulations which deal with environment, are as follows:

– The Environmental Protection Act 1990
– Environment Act 1995
– The Clean Air Act 1993
– Radioactive Substances Act 1993
– The Control of Asbestos Regulations 2006
– The Ionising Radiation Regulation 1999
– The Control of Lead at Work Regulations 2002

The regulatory organisations are (according to the Environment Act 1995):

– The Environment Agency (in England and Wales)

– The Scottish Environmental Protection Agency (in Scotland)

In France

1- Basic concepts: standards, DTU, Technical advice (Avis Techniques)

1.1 Standards: see: Standards and European directives (source: AFNOR)

French approved standards are mandatory for State and local government funded contracts. They are also recommended for privately funded contracts.

1.2 DTUs (Unified Technical Documents) are documents that contain technical rules relating to the execution of building works using traditional techniques. They are recognized and approved by construction professionals. They also provide a reference point for insurance experts and the courts. Failure to comply with DTUs may lead to the invalidation of warranties offered by insurance providers. DTUs specify standards for traditional construction methods and are considered the epitome of reference texts. They are intended for relevant state bodies as well as contractors (whether architects or general contractors), owners and other experts. They are authored by a committee advising on technical texts.

1.3. Technical advice is advice from a committee of experts specialising in relevant trades and the expected behaviours of materials, components or processes. They define the characteristics of any materials, components or processes involved, and give advice on their durability and suitability for use and how they comply with regulations.

2 - DTU

2.1. Status of DTU

The DTUs are established by a body created in 1958, the **"Groupe de Coordination des Textes Techniques / Groupe DTU"** (the "Coordinating Group of Technical Texts or Group DTU").

In 1990, this group became the **"Commission Générale de Normalisation du Bâtiment/DTU** "(the General Committee for the Standardisation of Building / DTU) in order to integrate it into the French official system, which was necessary to comply with European technical harmonization (Eurocodes)

This means that the DTUs have become standards. The transformation took place gradually through the regulatory procedures that govern standardsation.

As a result, the DTU(s) now have one of the following statuses:

Approved French standard (Norme française homologuée): this is a standard which has received official government approval, its technical value is recognized, and it plays an important role in the construction system;

Experimental standard (Norme expérimentale): which is undergoes a period of probation before being confirmed or amended to become a certified French standard;

Documentation booklet (Fascicule de documentation) : standard documents, essentially informative documents;

DTU: the original form of the documents. Not part of the official standard system. In most cases DTU status is temporarily held in anticipation of its integration into the official standard system.

2.2. Private works

DTU is implemented following an agreement between the “maitre d’ouvrage” and the construction contractor. A DTU only commits the signatories, giving it a sense of obligation of contract.

Some standards and some French registered DTUs can be mandatorily enforced by regulatory decisions (often when safety-related).

2.3. Public works

The amended Decree of January 26, 1984 governs the application of French standards in contracts approved by the government, local authorities, public bodies etc., except in special cases as listed in the decree.

2.4. Composition of a DTU

A DTU may consist of the following documents:

Technical specification clauses booklet **(cahier des clauses techniques: CCT)** which sets out the requirements for the selection and use of materials;

Specification of special provisions booklet **(cahier des clauses spéciales: CCS)** which defines performance limits and obligations to other trades;

Rules for calculating the structural design.

All these documents are contractual documents and must be adhered to. There are also other documents, such as memos and selection guides, which are useful for structural designs that are not intended to be imposed by contract.

Like ISO standards, the DTU(s) must be bought. They can be found on the CSTB website: http://boutique.cstb.fr/

(CSTB = centre scientifique et technique du bâtiment: scientific and technical center for construction)

DTUs and other required documents are listed on the CSTB website. There are specific DTUs for each profession : (see example for roofers on the next page)

http://boutique.cstb.fr/dyn/cstb/Upload/Fichiers/Liste_0310.pdf

HEALTH AND SAFETY

On building sites required by the coordinator of safety to have a general plan of coordination, the companies involved must create a **PPSPS** (Particular plan of safety and protection of health) valid for **all workers** on the building-site

PPSPS: Particular plan of safety and protection of health

Contents of the PPSPS

1. The name and address of the company, the address of the building site, the name and qualifications of the person in charge of the work.
2. The description of work and methods of work showing the company’s specific risks and chosen means of prevention, taking into account any environmental

constraints. Work involving risks of interference arising from co-activity with other companies, mutual risks and the prevention methods available.

3. Procedures for observing any measures of general coordination defined by the coordinator.
4. Rules for hygiene and for workers' areas as laid out in the general coordination plan .
5. First aid organization of the company; including the medical equipment available, first-aiders and on site, measures for evacuating any injured persons, according to the general coordination plan.

The descriptive part of the plan is the most important; it must be accompanied by a detailed analysis of the risks related to procedures, materials, devices and installations, the use of dangerous substances or preparations, and to circulation on site.

Plans or sketches drawn for the building site can effectively replace text. Photocopies of documents are to be avoided in general , except for private copies.

The plan can evolve and change, so it is always possible to modify any of the given procedures or preventive measures if the incurred risks are decreased or if the preventive measures give an equivalent guarantee.

Texts referring to the **labor regulation:**

Principle of prevention articles R 230-1 with R 234-23,

General plan of coordination R 238-20 to R 238-36.

texts **for the prevention** **and the safety of the workers:**

N° circular 6 DRT of April 18th, 2002 of the ministry for employment and solidarity,

Law N° 91-1414 of December 31st, 1991 published with the OJ N°5 of January 7th, 1992,

European directive 89/391/CEE of June 12th, 1989,

Decree 2001-1016 of November 5th, 2001 relating to the single document published in the 258 Olympics of the 11/7/01 page 17523.

Standards for the Small and Middle-size Enterprises (SME)

There are major environmental and social problems facing our planet which require large incisions. The business world cannot keep uninvolved what is happening, especially when those problems directly affect the competitiveness and profitability. Each company can play one or more roles imposed by the current energy and environmental realities. Even smaller companies can make a difference, trying bravely jumping into a future requires innovation and entrepreneurial courage. Clearly we are at the dawn of what is called "green business".

Health, safety and welfare regulations

Safety is of the utmost importance. The crew should have a safety meeting before the unloading of solar equipment, installation hardware and tools. It is recommended that all the crew is trained. The meeting should include safety issues presented in the solar water-heating section, such as preventing falls from cluttered work areas, setting up and using ladders correctly, wearing gloves and safety glasses, and being careful to not drop tools or equipment. The meeting should also include a lengthy discussion of electric shock and its potential when working around PV systems should be presented.

Common electrical accidents result in shocks and/or burns, muscle contractions, and traumatic injuries associated with falls after the shock. These injuries can occur any time the electric current flows through the human body. The amount of current that will flow is determined by the difference in potential voltage and the resistance in the current path. At low frequencies (60 Hz or less) the human body acts like a resistor but the value of resistance varies with conditions. It is difficult to estimate when the current flow or severity of the injury that might occur, because the resistivity of human skin varies from just under a thousand ohms to several hundred thousand ohms depending primarily on skin moisture.

If a current greater than 0.02 amperes (only 20 milliamperes) flows through your body, you are in serious jeopardy because you may not be able to let go of the current-carrying wire. This small amount of current can be forced through sweaty hands with a voltage as low as 20 volts and the higher the voltage the higher the probability that current will flow. High voltage shock (>400 volts) may burn away the protective layer of outer skin at the entry and exit points. When this occurs, the body's resistance is lowered and lethal currents may cause instant death. The data in the following table shows the reaction of the human body to various levels of current flow.

Electric Shock Hazard - Current Level		
Reaction	AC Current (ma)	DC Current (ma)
Perception - Tingle, Warmth	1.0	6.0
Shock - Retain muscle control; reflex may cause injury	2.0	9.0
Severe Shock - Lose muscle control; cannot let-go; burns; asphyxia	20	90
Ventricular Fibrillation	100	500

Heart Frozen - Body temperature rises; death occurs in minutes	1000	1000

Electrical shock is painful and a potentially minor injury is often aggravated by the reflex reaction of jumping back from the source of the shock. Anytime a PV array contains more than two PV modules, a shock hazard should be presumed to exist.

To avoid shock, always measure the voltage from wire to wire, and to the ground. Use a clamp-on ammeter to measure the current flowing in the wires. Never disconnect a wire before you have checked the voltage and current. Do not presume everything is in perfect order. Do not trust switches to operate perfectly and do not trust that schematics will always tell everything you need to know. Use a voltmeter often—it could save your life.

Basics of construction works contract

Using solar energy to convert the photovoltaic systems into electricity, is one of the applications of renewable energy sources (RES) which may, because of the solar potential of Greece, contribute decisively to address its energy problem. Given also the objectives of the EC contribution of renewables in energy consumption (Directives 2001/77/EC, 2003/30/EC, 2009/28/EC) and the Kyoto Protocol, ratified by N 3017/2002,. There is no coincidence that in recent years, albeit late, has there been legislative activity in our country for greater promotion of renewable energy in particular photovoltaic systems, even among private consumers.

Initially the N 3468/2006 (Government Gazette A 129/27.6.2006), which transposed into Greek law the Directive 2001/77/EC, provides rules for the generation of electricity from renewables and sets the framework for the necessary licensing procedures. It provided particular (14) development program Photovoltaic Stations in First phase 2020, which was subsequently developed by the RAE and approved by the Ministry of Development (D6/f1/oik 8684/24.4.2007, Gov. 694/3.5.2007, amended by the Decree D6/f1/oik 15450/18.7.2007, GG B 1276 / 24.7.2007). [Note however that a decision of the Ministry of Development (RM D6/F1 / Economics Gazette 7037 II 707/22.4.2008) suspended applications in the flat article 14 paragraph 1zx 3468/2006 Development Programme Photovoltaic Stations].

Environmental approvals

The JMD into no plot 104247/EFPE/YPECHODE (GG II 663/26.5.2006) defined the process of Environmental Assessment and Evaluation (PEEA) and the Environmental Conditions (OP O) works for Renewable Energy Sources (RES) in accordance with Article 4 N 1650/1986, as replaced by Article 2 N 3010/2002 and JMD into no plot 104248/EFPE/YPECHODE (GG B 663/26.5.2006) the content, documents and other data Promeleton Environmental Impact Assessment (P.P.E.) Environmental Impact Assessment (EIAS) and related studies in environmental projects Renewable Energy Sources (RES).

Regulation permits production by RM D6/F1/oik 5707/2007 Ministry of Development (Government Gazette B 448/3.4.2007) Licensing Regulations envisage the electricity generation using renewable energy through Combined Heat and Power High Performance for the granting, variation, transfer, licensing power and decisions required to take exception to permit production using RES.

Specific context of spatial planning and sustainable development in the RES into 49,828 no decision of the Coordinating Committee on Governmental Policy Planning and Sustainable Development (Official Gazette B 2464/3.12.2008) was adopted under special planning and sustainable development of renewable energy and strategic environmental impact assessment . Article 17 lays down the criteria for siting facilities to exploit solar energy, giving priority area arid or non-high-productivity areas, preferably invisible from busy areas and providing for exclusion zones, such as forests and monuments.

The N 3734/2009 (Government Gazette A 8/28.1.2009) modified the above N3468/2006 particularly inter alia provides new rates to sales generated by photovoltaic power stations (which may be amended by a decision after consulting Yp.An the RAE, and updated annually by 25% of the CPI for the previous year).

It is also stated that the contract of sale for electricity, generated from photovoltaic plants, will last 20 years and conclude with the reference value of the table that corresponds to the month and year of signing the contract. This is providing that the start trial operation (or not provided), activates the link station within a specified time, otherwise it shall be the price of the month trial operation or activation of the association in accordance with the then power station

Designated license fee for the power or decision of exemption for electricity production from photovoltaic stations, may not be transferred before you start them. As the ban was later (N 3769/2009, article 19 paragraph 7, Gov. A 105/1.7.2009), excluding cases where the transferor company is entirely owned by a shareholder of the acquiring company.

Finally, N 3734/2009 (Article 27A Fri the 8th) has provided the Special Training Program on Development of Photovoltaic Systems in buildings and in particular to roofs and facades.

Basics of construction standards

There are no special construction standards in Greece. We have adopted regulations, which are both compatible with the Rules of internal electrical installations of the country (like the HD384) - relating to the formulation and implementation of electrical installation in the side of the grid E.R. - on the other hand consider the specific standards which refer to characteristics of PV generators (such as EN-IEC 61215, EN-IEC 61646, IEC 61730-1 and IEC 60364-7-712 Ed. 1.0). Specifically noting that the EN-EIC 61215 deals with the minimum technical standards for photovoltaic crystalline silicon, the EN-IEC 61646 deals with photovoltaic thin film technology, the IEC 61730-1 deals with matters relating to safety standards which must satisfy F / V materials and their connection and 60364-7-712 Ed. 1.0 deals with matters relating to the establishment of PV modules in building facilities. However, there are no single accepted regulations which refer to the implementation of electronic connection on the side of direct current (DC) or E.R.

Chapter III CONTEXT

The environmental considerations and technological evolution

Today, more than ever, we must adopt a new model of development for the country. A model of development that serves people and their real needs. The green development, the one that respects the environment and treats it as a development reserve is the only feasible and sustainable solution to the country.

Successive crisis – annonary, energy, financial, tighten while the environmental crisis is evolving too. The encounter may be the way out of the socio-economic crisis too. The green development is a new strategy to exit from this crisis with the reconstruction of the country's productive base, balanced regional development and the creation of new jobs. All this cannot be done without investing in education knowledge, innovation, and new technology. The emergence of this new development model opens new opportunities from the agricultural to the tourism sector, creating new opportunities in the manufacturing, construction and energy sectors. Priorities are the climate and energy, restructuring of the productive sectors and saving natural resources, priorities associated with the activity of the newly established Ministry of Environment, energy and climate change.

In a gifted by nature place like Greece, the transition to a template based on renewable energy sources, in energy conservation and management of energy makes demand feasible. Saving energy will be at the centre of the energy policy in the coming years. Conservation and proper management of energy is the most important, ecological optimum and domestic source of power of our country. For this, energy conservation and promotion of ΑΠΕ, with parallel development of know-how and technology, subject to increasing employment and added value to our economy are priorities. In the field of management of natural resources, priority is given to the protection of the natural environment and the management of water resources. Policies on forests are about their conservation and development. If we manage the forests of our country wisely and effectively we will create an advantage for a development compatible with the environment in areas geographically blocked, the benefits of which will be disseminated throughout the local population.

Sustainable development

The upgrading of city life through urban rehabilitation and the establishment of free spaces of green are aiming to transform cities into safe and sustainable places. The green Development is considered as a new model with implementation in all sectors of society. At the same time it is a multidimensional objective for the future, for the modern landscape that is being shaped. There is an immediate requirement to move to the Green direction in order to achieve a better quality of life and sustainable development.

The changing needs of the labour market

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Chapter IV DESCRIPTION OF NEW SOLUTION

State of the art materials,

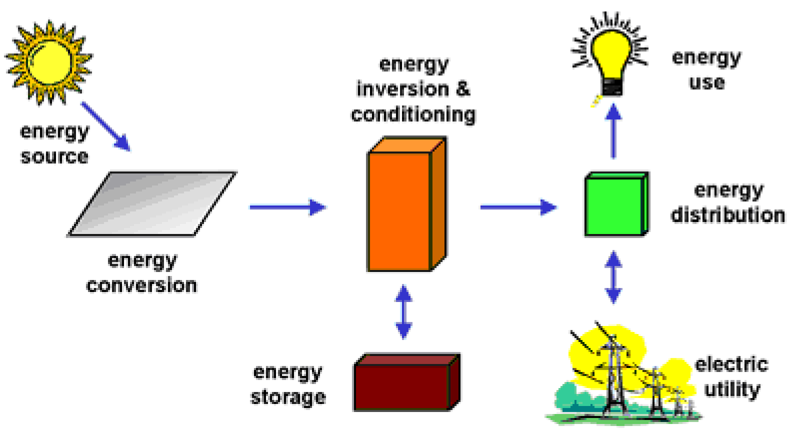
Three general technical areas — crystalline silicon, films, and modules — are discussed, with further levels of detail provided within the discussions.

Crystalline silicon technology is advancing through research of materials, devices and processes. With improved starting material, we can produce better solar devices. With improved devices, we can increase efficiencies and decrease fabrication costs, and with improved processes, we also reduce costs.

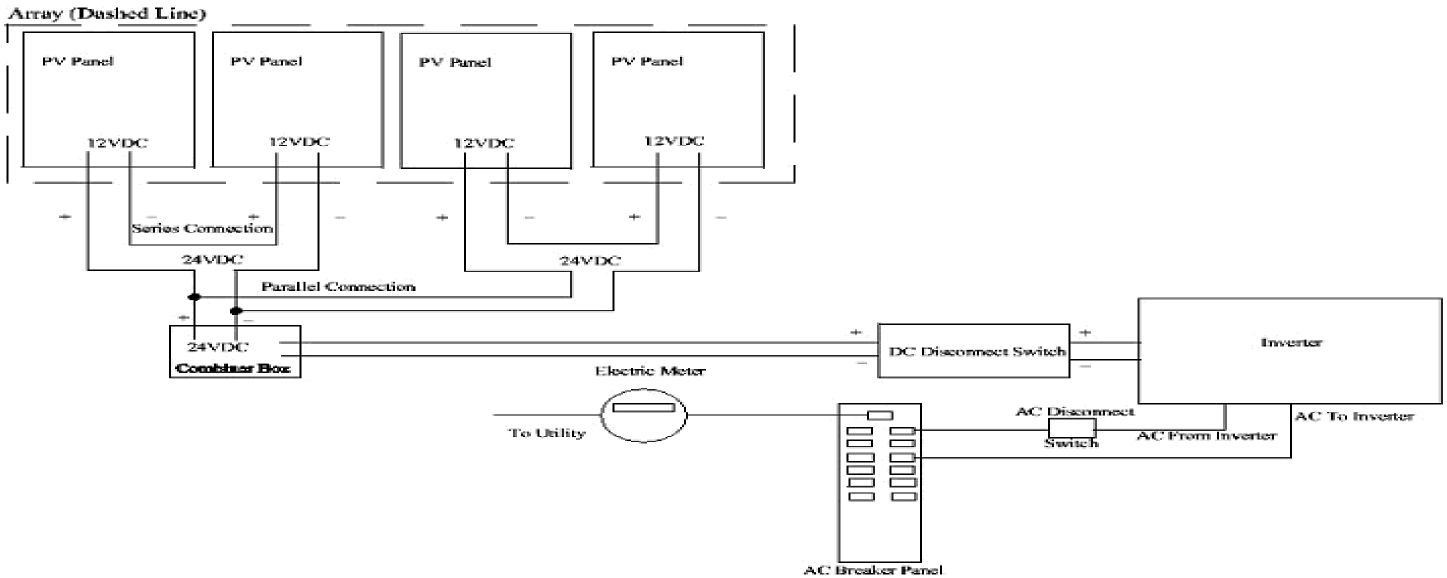
Thin Films of special photovoltaic materials produce solar cells with relatively high conversion efficiencies, but use much less material than crystalline silicon cells. We will discuss the following key materials or technologies: amorphous silicon (a-Si), copper indium diselenide (CIS) and its alloys, cadmium telluride (CdTe), and thin films using a multijunction design.

PV modules are optimised to improve performance beyond present limits. To optimise the modules, we must know and control technical details such as doping profiles, morphology, short-range order, stoichiometry, and process uniformity. Research also helps to decrease the costs of module manufacturing.

Specific PV system components may include a DC-AC power inverter, battery bank, system and battery controller, auxiliary energy sources, and sometimes the specified electrical load (appliances). In addition, an assortment of balance-of-system hardware, including wiring, over-current, surge protection and disconnect devices, and other power processing equipment may be included. The following diagram illustrates the relationship of individual components.



Grid-Connected PV System Components



PV **modules** are mounted on **mounting racks** and are attached to a structure or may be mounted on a pole. A number of modules assembled together are called an **array**. Individual modules produce electric current and voltage depending on the specific module. The electric output wires of the modules are wired together in a **combiner box** in order to get the voltage and current required by the inverter. The array output can be disconnected by a **DC disconnect switch**. In order for the system to be disconnected from the grid by utility workers, a **utility accessible AC disconnect switch** is installed on the inverter output. The inverter may have two connections to the **breaker panel**

Solar Cells

The primary material used to convert sunlight to electricity is called a **semiconductor**. There are two basic types of semiconductors: **p-type** and **n-type**. The p-type semiconductor material has an abundance of “holes” with a positive electrical charge, while the n-type semiconductor material has an abundance of electrons with a negative electrical charge. When these two semiconductors come into contact with each other, a **p/n junction** is created at the interface. At this junction, excess electrons move from the n-type side to the p-type side, resulting in a positive charge along the n-type side and a negative charge along the p-type side. This creates an electric field much like a battery with one side having a positive charge and the other a negative charge.

The process through which the device converts sunlight into electricity is called the **photoelectric effect**. The device is commonly called a photovoltaic or PV cell. Sunlight striking a PV cell is either reflected, absorbed, or it passes through. The light that is absorbed in the PV cell transfers energy to the electrons in the cell’s atoms. With the added energy from the absorbed light, the electrons escape from their normal position and become part of the electrical flow in an electrical circuit through, for example, a motor on a model car, shown at left.

Arrays

Modules are commonly connected in series and parallel strings to form what is called an **array**. The output of an array can be designed to meet almost any electric requirement, large or small.

Mounting Structures

Generally, solar modules do not have the structure needed to withstand wind loading, and so must be mounted on a mounting structure. Mounting structures are usually made of steel or aluminium and may be attached to the roof of the home in a fashion similar to that for solar water-heating panels. Mounting structures may be mount fixed, to allow the array to be tilted seasonally, or may, on pole mounts, be able to track the sun.

Combiner Box

Another major component of a PV system is the **combiner box**. Modules are commonly connected into an electrical string to produce the desired voltage and amperage. The resulting wires from each string are routed to the combiner box. In this box all the strings are combined into one electrical output that is then fed to the inverter.

Inverters

PV cells, modules and arrays produce direct current (DC). Electric loads that are not connected to the utility grid can use the PV-generated power if they are designed to operate on direct current. Using a charge controller, PV-generated power can charge a bank of storage batteries which can power DC loads when the sun is not shining on the array. Most appliances and equipment found in the home are designed to operate on alternating current (AC) which is generated by electric utility companies. The device that converts DC to AC for use in the home is called an **inverter**. In stand-alone or grid-connected PV system installations, inverters are commonly used to power household appliances, tools and other equipment. These inverters do not need the utilities voltage and frequency reference to produce AC with electrical characteristics much like utility-generated AC. Inverters that are connected to the utility grid produce AC that is identical to the power produced by the utility. These inverters sense the utility's generated voltage and wave form characteristics and produce AC of the same form.

Equipment and tools

Anode — the positive electrode in an electrochemical cell (battery). Also, the earth or ground in a cathodic protection system. Also, the positive terminal of a diode.

Battery — two or more electrochemical cells enclosed in a container and electrically interconnected in an appropriate series/parallel arrangement to provide the required operating voltage and current levels. Under common usage, the term battery also applies to a single cell if it constitutes the entire electrochemical storage system.

Bypass Diode — a diode connected across one or more solar cells in a photovoltaic module such that the diode will conduct if the cell(s) becomes reverse biased. It protects these solar cells from thermal destruction in case of total or partial shading of individual solar cells whilst other cells are exposed to full light.

Cadmium Telluride (CdTe) — a polycrystalline thin-film photovoltaic material.

Cathode — the negative pole or electrode of an electrolytic cell, vacuum tube, etc., where electrons enter (current leaves) the system; the opposite of an anode.

Charge Controller — a component of a photovoltaic system that controls the flow of current to and from the battery to protect it from over-charge and over-discharge. The charge controller may also indicate the system operational status.

Charge Factor — a number representing the time in hours during which a battery can be charged at a constant current without damage to the battery. Usually expressed in relation to the total battery capacity, i.e., C/5 indicates a charge factor of 5 hours. Related to charge rate.

Charge Rate — the current applied to a cell or battery to restore its available capacity.

Combined Collector — a photovoltaic device or module that provides useful heat energy in addition to electricity.

Concentrator — a photovoltaic module, which includes optical components such as lenses (Fresnel lens) to direct and concentrate sunlight onto a solar cell of smaller areas. Most concentrator arrays must directly face or track the sun. They can increase the power flux of sunlight hundreds of times.

Conduction Band (or conduction level) — an energy band in a semiconductor in which electrons can move freely in a solid, producing a net transport of charge.

Conductor — the material through which electricity is transmitted, such as an electrical wire, or transmission or distribution line.

Converter — a unit that converts a direct current (dc) voltage to another dc voltage.

Distributed Generation — a popular term for localised or on-site power generation.

Electrode — a conductor that is brought in conducting contact with a ground.

Fresnel Lens — an optical device that focuses light like a magnifying glass; concentric rings are faced at slightly different angles so that light falling on any ring is focused to the same point.

Gel-Type Battery — lead-acid battery in which the electrolyte is composed of a silica gel matrix.

Inverter — a device that converts direct current electricity to alternating current either for stand-alone systems or to supply power to an electricity grid.

Junction Box — a photovoltaic (PV) generator junction box is an enclosure on the module where PV strings are electrically connected and where protection devices can be located, if necessary.

Line-Commutated Inverter — an inverter that is tied to a power grid or line. The commutation of power (conversion from direct current to alternating current) is controlled by the power line, so that, if there is a failure in the power grid, the photovoltaic system cannot feed power into the line.

Liquid Electrolyte Battery — a battery containing a liquid solution of acid and water. Distilled water may be added to these batteries to replenish the electrolyte as necessary. Also called a flooded battery because the plates are covered with the electrolyte.

Multi-Stage Controller — a charging controller unit that allows different charging currents as the battery nears full state_of_charge.

Primary Battery — a battery whose initial capacity cannot be restored by charging.

Pulse-Width-Modulated (PWM) Wave Inverter — a type of power inverter that produces a high quality (nearly sinusoidal) voltage, at minimum current harmonics.

Pyranometer — an instrument used for measuring global solar irradiance.

Pyrheliometer — an instrument used for measuring direct beam solar irradiance. Uses an aperture of 5.7° to transcribe the solar disc.

Rectifier — a device that converts alternating current to direct current.

Regulator — prevents overcharging of batteries by controlling charge cycle-usually adjustable to conform to specific battery needs.

Ribbon (Photovoltaic) Cells — a type of photovoltaic device made in a continuous process of pulling material from a molten bath of photovoltaic material, such as silicon, to form a thin sheet of material.

Sacrificial Anode — a piece of metal buried near a structure that is to be protected from corrosion. The metal of the sacrificial anode is intended to corrode and reduce the corrosion of the protected structure.

Sealed Battery — a battery with a captive electrolyte and a resealing vent cap, also called a valve-regulated battery. Electrolyte cannot be added.

Secondary Battery — a battery that can be recharged.

Series Controller — charge controller that interrupts the charging current, by open-circuiting the photovoltaic (PV) array. The control element is in series with the PV array and battery.

Series Regulator — type of battery charge regulator where the charging current is controlled by a switch connected in series with the photovoltaic module or array.

Shallow-Cycle Battery — a battery with small plates that cannot withstand many discharges to a low state-of-charge.

Shelf Life of Batteries — the length of time, under specified conditions, that a battery can be stored so that it keeps its guaranteed capacity.

Single-Stage Controller — a charge controller that redirects all charging current as the battery nears full state-of-charge.

Starved Electrolyte Cell — a battery containing little or no free fluid electrolyte of the rated capacity.

Storage Battery — a device capable of transforming energy from electric to chemical form and vice versa. The reactions are almost completely reversible. During discharge, chemical energy is converted to electric energy and is consumed in an external circuit or apparatus.

String — a number of photovoltaic modules or panels interconnected electrically in series to produce the operating voltage required by the load.

Subsystem — any one of several components in a photovoltaic system (i.e., array, controller, batteries, inverter, load).

Sulfation — a condition that afflicts unused and discharged batteries; large crystals of lead sulphate grow on the plate, instead of the usual tiny crystals, making the battery extremely difficult to recharge.

Temperature Compensation — a circuit that adjusts the charge controller activation points depending on battery temperature. This feature is recommended if the battery temperature is expected to vary more than ±5°C from ambient temperature.

Transformer — an electromagnetic device that changes the voltage of alternating current electricity.

Tray Cable (TC) - may be used for interconnecting balance-of-systems.

Uninterruptible Power Supply (UPS) — the designation of a power supply providing continuous uninterruptible service. The UPS will contain batteries.

Utility-Interactive Inverter — an inverter that can function only when tied to the utility grid, and uses the prevailing line-voltage frequency on the utility line as a control parameter to ensure that the photovoltaic system's output is fully synchronized with the utility power.

Varistor — a voltage-dependent variable resistor. Normally used to protect sensitive equipment from power spikes or lightning strikes by shunting the energy to ground.

Vented Cell — a battery designed with a vent mechanism to expel gases generated during charging.

Vertical Multijunction (VMJ) Cell — a compound cell made of different semiconductor materials in layers, one above the other. Sunlight entering the top passes through successive cell barriers, each of which converts a separate portion of the spectrum into electricity, thus achieving greater total conversion efficiency of the incident light. Also called a multiple junction cell. See multijunction device and split-spectrum cell.

Window — a wide band gap material chosen for its transparency to light. Generally used as the top layer of a photovoltaic device, the window allows almost all of the light to reach the semiconductor layers beneath.

Installing Tools and Equipment

Stairways and Ladders

Hand and Power Tools

Personal protective equipment (PPE) as safety glasses, goggles and face shields for eye and face protection, hardhats for head protection, safety shoes for feet protection, gloves for hand and arm protection, and earplugs and earmuffs for hearing protection.

Mounting Materials

Wires, Fuses and Circuit Breakers

Grounding Equipment

Generators

Maintenance Tool and Equipment

Many of the same tools and equipment used to install PV systems are also required for their maintenance and service. These include basic hand and power tools, ladders, and personal protective equipment (PPE), as well as electrical test instruments, solar shading devices, pyranometers, hydrometers and thermometers. Advanced testing and analysis may require special equipment such as IV tracers, insulation and ground resistance testers, and dataloggers. Handheld devices or personal computers may also be linked to inverters or system controllers, to monitor system performance in real time, to download historical data or other events, or conduct programming and system control functions. Watt-hour meters are often used for recording system energy production, and routinely included integral to inverters or as separate equipment at the system output. Power analyzers may be used for power quality measurements, such as harmonics, power factor, voltage sags and surges, inrush currents and other load or power source conditions.

New technologies

a) Wafer – Based silicon Solar Cells

- Crystallic Silicon PV technologies for low-cost high Efficiency and reliable Modules
- Bi-facial thin industrial multi crystalline Silicon solar cells
- Development of solar-Grade silicon feedstock for crystalline wafers and cells by purification and crystallisation

b) Thin film

- Improved integrated PV using thin-film CIS modules for building retrofit
- Roll to roll technology for the production of high efficiency and low cost photovoltaic modules
- High speed production lines and development of plasma-Chemical Equipment

New health and safety requirements

The IEC 61730-1 deals with matters relating to safety standards which must satisfy F / V materials and their connection and 60364-7-712 Ed. 1.0 deals with matters relating to the establishment of PV modules in building facilities.

The health and safety legislation mentioned before for Greece.

However, there is no single accepted regulations which refer to the implementation of electronic connection on the side of direct current (DC) or E.R.

Protection of the environment

There is not any environmental damage by the photovoltaics installer

Precautions are needed for:

Avoid Fire due to bad connections or false grounding

Avoid pollution due to battery fluid leaks

Keep the workspace clean after the installation

Workplace organization and ergonomics

A PV installer needs to know how to determine whether a proposed site for a PV installation will be adequate for proper operation of the system. A site assessment involves

- Determining whether the array can operate without being shaded during critical times,
- Determining the location of the array,
- Determining the mounting method for the array,
- Determining where the Balance-of-system (BOS) components will be located, and
- Determining how the PV system will interface with the existing electrical system.

Special competences needed

- Strong knowledge of health and Safety regulations
- Strong knowledge of Electrical Installations Regulations
- Reading and interpreting plans and specifications
- Reading and interpreting codes and standards
- Using basic mathematics and some trigonometry (addition, subtraction, multiplication, division, calculations of area and volume, fractions, decimals, percentages, calculating the sides of triangles, square roots, powers of numbers, and solving simple algebraic equations for unknown variables)

Chapter V TRAINING PART

LESSONS FOR PHOTOVOLTAIC (PV) INSTALLERS TRAINING

LESSON 1

<u>WORKING SAFELY WITH PHOTOVOLTAIC (PV) SYSTEMS</u>

1. Regulations
2. Electrical Safety
3. Fall Protection
4. Stairways and Ladders
5. Hand and Power Tools
6. Personal Protective Equipment (PPE)
7. Working Space for Electrical Systems
8. Photovoltaic Modules
9. Battery Safety

LESSON 2

<u>CONDUCTING A SITE ASSESSMENT</u>

1. Shading
2. Array Orientation
3. Array Location
4. Array Mounting Methods
5. BOS Locations

LESSON 3

<u>SELECTING A SYSTEM DESIGN</u>

Differentiating Among Available Modules and Inverters

LESSON 4

<u>ADAPTING THE MECHANICAL DESIGN</u>

1. Roof Mounting
2. Mounting Materials
3. BOS Layout
4. Tracking Mounts

LESSON 5

ADAPTING THE ELECTRICAL DESIGN

1. PV Modules
2. Wire, Fuse, Circuit Breaker, and Disconnect Sizing

2.1. Temperature and Conduit Fill Corrections for Ampacity of Conductors

2.2. Voltage Drop for Circuits

3. Sizing Conductors Based on Power and Required OCPD Ratings
4. Grounding
5. Batteries and Battery Wiring
6. Charge Controllers and Linear Current Boosters
7. Generators
8. Inverters
9. Point-of-Utility Connection
10. Optional Standby System Panels

LESSON 6

INSTALLING SUBSYSTEMS AND COMPONENTS AT THE SITE

1. Electrical Component Mounting
2. Testing and Programming Equipment
3. Marking and Labelling

LESSON 7

PERFORMING A SYSTEM CHECKOUT AND INSPECTION

LESSON 8

MAINTAINING AND TROUBLESHOOTING A SYSTEM

1. Array Maintenance
2. Battery Maintenance
3. Inverter and Charge Controller Maintenance
4. Maintenance Tools and Equipment
5. Performance Monitoring

I. Aims of training

The purpose of this training is the safe installation and reliable operation of photovoltaic systems, interconnected with the central electric network AC mains. The training focuse mainly on planning and delivery of electrical installation.
The main objective was to inform stakeholders to adopt practices that contribute to the joint and addresses the installation and safe operation of the Building interconnected photovoltaic systems. Taking into account that the installed power plants close to consumers during the long period of operation, highlighted the need for high quality design and installation of these power plants to ensure the safety of users of the Greek Power System and the proper and safe operation of the Greek Power Systems.

II. Contents of training part

1 Development of photovoltaic systems in building and facilities including a penthouse and buildings stages
1.1 Structure of the Building Interconnected PV Systems
1.2 Classification of the Building Interconnected PV Systems
1.3 Buildings Connected PV systems under the Independent Producer
1.4 Establishing the connection with maximum power of PV system

2 Selection of installation site of PV system
2.1 Orientation of PV Modules
2.2 Shading Problems
2.3 Static Study Materials & Support
2.4 Selecting the platform area of electronic converters

3 Design PV systems
3.1 Typical electrical values of a PV system
3.2 Co P / N - inverter

4 Installation systems
4.1 General Information
4.2 Investigation errors
4.3 Protection

5 Ground reverse

6 Wiring
6.1 Side S.R.
6.2 Side E.R.
6.3 Markings

7 Protection of Building PV System by ypertaseis-Lightning Protection

8 Standard systems electrical intallation Building Grid PV System

9 With network interface
9.1 Connecting the Building solar electric systems in
9.2 Formulation of the interconnection of building solar installations - grid
9.3 Harmonic Distortion and permissible limits of harmonic components Injection
9.4 Detection situations isolated operation - effect of the 'island'

III. Audiovisual examples


Test part

1. Give three ways that a PV cell and a battery are alike.

2. A battery converts chemical energy into electrical energy. What type of energy does a PV cell convert?

3. Since each individual PV cell's electrical output is small, how can the cells be configured to produce the electrical output needed to power a high electric demand?

4. In most situations, why is an inverter needed for a PV system?

5. What function does the combiner box perform in a PV system?

6 During the initial site visit to check a single story building acceptability for a PV system, you note that the asphalt-shingled roof has a 4/12 slope and is oriented 10 degrees to the west of true south. The south-facing roof is a rectangle that is 30 feet wide and 20 feet from the eaves to the roof top. Is this building a good candidate for a PV installation? If it is and given that the roof can support the PV system and a 3-person installation crew, what would you suggest to the building owner as the largest, safe array (peak output) to install?

7 For the same building described in question 1, what conditions might you encounter that would make you reject the site for a system installation?

8 What estimated cost would you tell the building owner for an installed PV system with a peak output of 3000 Watts?

9 Why is an inverter needed in a grid-connected PV installation?

10 Why is an inverter needed in a remote or stand-alone PV system?

11 Given that the building owner wants to install a grid-connected PV system, how would you size the inverter?

12 What is the colour of the grounded conductor in a PV installation and how is it sized?

13 What is the colour of the equipment/frame ground wire in a PV installation and how is it sized?

14 What function does the equipment/frame ground perform?

15 Given that a PV system uses modules outputting a nominal 12 volts at 5 amperes, the modules are 30 feet from a combiner box, and you can only tolerate a 2% voltage drop, what gauge of wire should be used to connect the modules with the combiner box? What gauge of wire if the modules strings were 24 volt at 5 amps?

16 Why is the equipment ground necessary between the modules and the inverter? Can the same reason be used for installing the equipment ground between the inverter and the electric panel?

17 Why is low-voltage power dangerous?

18 Does a PV module with an open circuit voltage and amperage of 27 and 3.5 respectively under full sun conditions present a shock hazard for someone who comes in contact with the wires? Explain your answer.

19 What is the function of the combiner box?

20 Why is there disconnect switch between the inverter and the PV array?

21 Why is there a disconnect switch between the inverter and the building's electric panel?

22 What are the two factors used to determine the size of wire to install in the PV system?

23 Why is it important to evaluate the voltage drop in DC circuits?

24 What three methods are commonly used to locate the rafter centres when on the roof?

25 Why mount the PV array at a level 3 to 4 inches above the roof?

26 What are the two instruments needed to properly perform the maintenance and troubleshooting tasks for a PV system?

27 During routine maintenance why is it important to check the voltage and current level at various points in the PV system?

28 Where is a good place to check the open-circuit electrical characteristics of the strings in the PV array?

29 What are the characteristics that should be measured and recorded in Question 3 and how are they determined?

30 If you open a disconnect switch while checking the continuity of the grounding system and the ground is broken, what needs to be done and why?

31 Give three sources or causes of damage to roof top components of a PV system.

32 During maintenance you discover that one string in the combiner box has a much lower open-circuit current level compared to the other strings from the PV array. Give two possible causes and explain how you would fix each problem.

33 When checking the array string open-circuit voltages, what are the two conditions that would cause a low voltage reading compared to the other strings from the array?

34 If you were measuring the open-circuit current level of a string and the level dropped suddenly, stayed low for 10 seconds or so and then jumped back to the level you first measured, what is the most probable explanation for the event?

35 Why wash the PV modules whenever maintenance is scheduled?

Training based on 1 innovative example

PV System installation on the roof

On the roof, the physical site for the PV array needs to be chosen and within this area, the rafters must be located. The composition of the roof will dictate how the mounting rails or rack—which hold the modules in the array—should be installed. The mounting procedure is basically the same as for the solar water-heating installation. You have the choice of using lag screws into the centre of the rafters; using the J-bolt next to the rafter; or using a spanner board, all thread, and compression block to mount the clips for holding the rack system which holds the modules securely in place.

Locating the rafters and their centres from up on the roof could involve using a stud finder, tapping with a hammer, using the fascia board/rafter nail connection, or a combination of these methods.

If you cannot locate the rafters from the roof, you will have to get into the attic space. Once you get oriented in the attic space, use a long 1/16th inch drill bit to drill a hole up through the roof right next to one of the rafters that you will be using to attach the mounting clips. If you do not have someone on the roof to note where the drill bit comes up through the roof, push a piece of wire up through the hole to allow you to easily see the hole when you go back up on the roof. Drill two holes, one at the upper level of the mounting rack's location and one at the lower level of the rack. Be sure to measure the distance between the rafters at each level of the drilled hole—this will allow you to locate the centre of rafters, including those that were not installed parallel to each other.

For a roof covered with masonry or ceramic tiles, the installation process needs some adjustments. The roof structure is commonly designed near the limit of the dead load of the tiles. In this case, the rafters must be enhanced to support the additional dead load of the PV system and the live load associated with the installation. An alternative is to remove the tiles where the PV system is to be installed and transition to a roof of asphalt or composition shingles. Doing this should allow the installation of the PV system without enhancing the roof structure.

Install the mounting clips according to the manufacturer's instructions. Use a sealant that is UV-resistant to prevent leaks when screwing down the mounting clips. If you had to drill up through the roof to locate the rafters, be sure to force sealant into those holes. For an installation with the array installed parallel to the roof slope, the mounting clips should be such that the PV modules are situated 3 to 4 inches above the roof. This allows cooling air to circulate below the modules, allows rain to run off under the array, and helps prevent ice dams from forming during freezing conditions. Depending on the mounting equipment, rails are commonly attached to the mounting clips and serve as a secure structure for attachment of the modules and sub-arrays. Connect all dissimilar metals (such as steel and aluminium) using non-conductive washers to prevent galvanic corrosion. Make sure that all connections of the mounting clips and mounting rails are tight—once the modules or sub-arrays are attached, it might not be possible to get to the nuts and bolts.

Visually check the modules for any cracked glazing, and check that the frame, wiring box, and the back's potting material are intact. Check the open circuit voltage and current of each module before hauling them up onto the roof. Depending on the mounting technique and the inverter's input voltage, you may be able to assemble a group of modules into a sub-array on the ground. The modules can be connected with the proper size, colour, and type of wiring to form the sub-array, and then the sub-array's open circuit voltage and current can be checked before being moved to the roof as a unit. Label each wire pair for connection in the junction—this is used to document and identify the string and circuit going to the inverter and can be used for troubleshooting purposes at some point in the future. To prevent shocks, be sure to use wire nuts and/or electrician's tape to cover the ends of wires coming off the modules or sub-array. When the modules are exposed to sunlight, they are electrically hot and are capable of providing the closed-circuit (normal) operating voltage and current levels to any material that can become a circuit. Before closing the electrical connector box on each module, check that the wiring connections are tight.

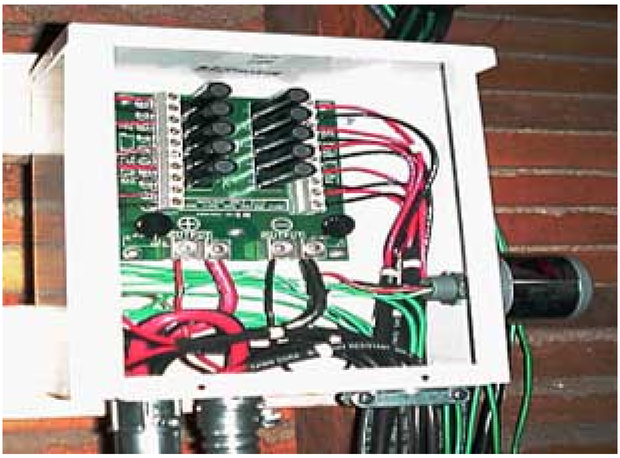
Getting the modules or sub-array to the roof can be as simple as one man on a step-ladder lifting a module up to a second person on the roof of a single story building. In the case of a sub-array, two people could be on the roof using ropes or straps to pull the sub-array up a ladder or two with another person below stabilising and pushing the sub-array upward. In the picture below, an articulated man lift is used to move sub-arrays to the roof of a three-story building.

Note two points of interest:

1) there are two people on the left-facing roof—they are in a harness and tied off and will move to the south roof to attach the sub-array when it is positioned near the mounting rails; and
2) the table to the right of the white truck is used to assemble the modules into sub-arrays.

Before the module or sub-array is attached to the mounting rack on the roof, the frame ground wire needs to be attached. Modules have a designated spot to attach the equipment ground wire. You will need to procure the correct type of stainless steel fastener and connector (sometimes supplied with the module). The wire for the equipment ground shall be bare copper. The ground needs to be continued to the common DC equipment ground bus. This can be accomplished by transitioning to a green THHN ground wire in the roof junction box which is carried thru the steel conduit to the PV DC disconnect or inverter.

The bare copper wire can be run outside the conduit to the junction box, then the combiner box and on to the inverter or other disconnect means where it is connected to a equipment-grounding screw. The size of the equipment grounding wire is dictated by the rating of the over current device (breaker/fuse) protecting the circuit. If for example the over current breaker is rated at 30 amps, the grounding conductor should be AWG #10 copper. Check the tightness of the equipment ground connection and tighten as necessary – you will probably not be able to reach all of them when the modules or sub-arrays are mounted securely on the rails.



The locations for the junction box(es) and combiner box(es) were determined during the initial site survey. Re-evaluate the sites, install the hardware, and connect the pieces of equipment with conduit. The combiner box is basically a device that connects the input PV strings in parallel to produce one circuit. Remember that paralleling electric circuits increases the current flow in the downstream circuit. The combiner box output wire must be sized larger for the higher current and to minimize voltage drop and line losses of the PV generated DC power going to the inverter. The conduit between the junction box (es) and the combiner box (es) must be sized to safely hold the number of module or sub-array wire pairs passing through.
In the fused combiner box (es), the fuses should be removed and the appropriate number of properly sized wire pairs should be fished from the combiner box (es) to the junction box (es). Each wire pair should be labelled at each end for connection in the combiner and junction boxes. Connect the wire pairs in the combiner box (es) first and then connect them to the wires from modules or sub-arrays in the junction box (es).

CAUTION: When making PV source circuit electrical connections in junction and combiner boxes, make absolutely sure that each source circuit is broken by keeping a series connection disconnected for each source circuit (typically made with MC style plugs).

The very last connection should be the plugging together these series connections. In this way, you will never be exposed to the lethal voltages involved. The junction box(es) should be sized larger than required for the number of wire pairs to be connected in them. Over sizing allows safe connection of the wire pairs outside the box and then the long leads are coiled neatly inside the box. The combiner box above has 10 input strings (this box is installed in an attic space - note the green equipment ground wires). Before you close up the junction box(es) make sure that the wire connections between the PV strings and the extension wires to the combiner box(es) are tight.

The conduits between the combiner box(es), DC disconnect switch, and the inverter must be sized to accommodate the size and number of wires passing through them. With the fuses out of the combiner box(es), the inverter and the DC disconnect switch in the off position, and the appropriate wires can be pulled through the conduit and connected to the combiner box(es), disconnect switch, and the appropriate inverter inputs. Note that only the positive wire is switched by the disconnect. The equipment ground wire can also be connected at the combiner box(es), the DC disconnect switch, and the inverter.

A DC grounding electrode should be installed that connects with the equipment ground at the inverter. This ground should in turn be connected to the existing AC grounding system in the building's electric panel. The size of this equipment grounding should be #8 Copper minimum. Conductor size for the DC output is determined by the amp rating of the circuit protection from the combiner box(es) and the DC disconnect switch. The grounding wire size for the AC side of the inverter to the building's electric panel is determined by the amp rating of the circuit breaker and must be #8 copper at a minimum.

If the installation crew is large enough, the inverter and disconnect switches can be installed in the building while the modules are being installed on the roof. The meter that looks like a utility meter is the building owner's way of keeping track of the number of kWhs produced by the PV system installed on the roof. This inverter does not have the capability to display the number of kWhs produced by the PV system.

This picture shows the inverter mounted on a board. The AC disconnect switch is mounted to the left of the inverter and the DC disconnect switches are mounted to the right side of the inverter's. This is a clean arrangement with critical switches being next to each other, to enable easy shutdown in an emergency or whenever work has to be done on the solar electric system is ideal. Assembling the board with the inverter and disconnect switches already mounted saves install time in the building. Mounting the inverter board close to the combiner box(es) reduces the amount of large gauge wire needed between the combiner box(es) and the inverter. Thus the longer run is smaller gauge wire for the AC circuit from the inverter to the building's electric panel. A note here, if the inverter has multi-speed cooling fans, the noise when the fans operate on high is often too loud to hold a meeting in the same room. It is best to install the inverter board on a wall in a room that is not normally occupied.

The AC output from the inverter must be connected to an over current device that is rated at 1.25 times the maximum continuous output current of the inverter. Run conduit from the inverter to the AC disconnect switch and to the building's electric panel. The utility may require a separate, lockable utility disconnect switch be installed near the utility's meter. This disconnect switch is for utility personnel use to take the PV system off line when utility work is done in the area. The wire size for these runs is determined by the inverter's AC current output and the distance to the breaker being back-fed in the electric panel.

Turn the electric panel breaker(s) to the off position, check the disconnect switches to ensure they are in the off position, then fish the appropriate wires to each device back to the inverter. Connect the wires securely to the panel breakers, switches, and the inverter. The installation is ready for a final check before the system is turned on.

Although it is probably not possible to check the rooftop connections, check the tightness of all electrical connections and tighten as necessary. In the process of checking the electrical connections, check that the conduit runs are supported according to code, and check the tightness of all mounting screws and bolts used to mount the inverter, disconnect switches, conduit, and the equipment grounding connections.

Use the voltmeter to check the polarity and the open circuit voltage and current of each string coming into the combiner box(es). Write down the open circuit volt and current values for each string. These will be used as reference numbers to check the performance of each string and help in the troubleshooting process. Check the open circuit DC voltage at the inverter when the DC disconnect switch is closed. The open circuit current in this circuit is probably more than can be checked with a digital voltmeter (they usually max out at 10 amps), so use a DC ammeter to determine the current level. Record this value for future reference. Check the utilities line-to-line-and line to-ground voltage at the breakers in the electric panel and label the front of the electric panel and the breakers to identify the solar circuits.

Once the final physical and electrical inspections are complete, follow the inverter manufacturer's instructions to get the inverter turned on. If all is installed correctly, the PV system should start to produce power. Turn off the inverter, the panel breakers, and all the disconnect switches and contact the inspector to schedule the final system inspection.

Finally, you will need to prepare a general electrical schematic to give to the building owner (and the electrical inspector), along with copies of the equipment descriptions, operating and troubleshooting instructions, and warranties. On the electrical schematic, include a drawing of the PV array layout with the specific circuits going to the combiner box(es) labelled.

CONCLUSIONS REGARDING WHOLE JOB MODULE

The severe environmental problems and the fear of depletion of conventional energy supplies in recent years led to the systematic use of environmentally friendly or renewable energy sources. Within the last fifteen years, there has been a strong effort to harness the available solar energy to generate electricity directly through photovoltaic conversion. For end are given by both the European Union and the country us (see, for example, the new Law on Renewable Energy N.3468/06) particularly attractive financial incentives, which include subsidy cost of initial installation and guaranteed market of energy production at preferential prices. The use of photovoltaic conversion of environmentally clean electricity from the sun occurs at an accelerating pace in most EU member states and has recently started an intense activity in the domestic market

Solar photovoltaic's can and should play an important role within a sustainable energy system of the future. Solar photovoltaics (PV) is one of the key technologies to generate decentralised electricity for private households around the world, and the technology is on its way. The market has grown by more than 40 % each year for almost one decade now and the industry is investing large sums for building more production facilities each year.

Numerous qualitative analyses about the potential market development of solar photovoltaics have been published in the past. The aim here has been to compile a detailed quantitative knowledge base, coupled with clearly defined and realistic as-sumptions from which extrapolations can be made on the likely development of the solar electricity market up to 2025 and beyond. The results which have emerged from this extensive analysis point to a technology that is going to have a significant future impact on the everyday lives of the population born today.

Clearly, this transformation will not happen by itself. It will require the far-reaching commitment of consumers and industry, as well as significant political will. The level of commitment needed, however, has already been demonstrated in those countries which show the greatest growth in their solar electricity industries. We must learn from them and adapt and de ploy the corresponding catalysts at global level if solar electricity is to fulfil the potential that we need it to.

Therefore, the training in solar installation gives us a confident position in the labour market.

USEFULL RESOURCES

Links:

1. Centre for Renewable Energy Sources (CRES) www.cres.gr/kape/index_eng.htm

2. Objectives and Task Analysis for the Solar Photovoltaic System Installer, North American Board of Certified Energy Practitioners®: www.nabcep.org

3. Code of Federal Regulations, Chapter 29 Part 1926 - Safety and Health Regulations for Construction, Occupational Safety and Health Administration: www.osha.gov

4. Electrical Safety in the Workplace, NFPA 70E, National Fire Protection Association: www.nfpa.org

5. Photovoltaic Systems, 2007, by Jim Dunlop. ISBN 978-0-8269-1287-9, National Joint Apprenticeship and Training Committee and American Technical Publishers: www.jimdunlopsolar.com

6. Photovoltaic's Design and Installation Manual, 2007. ISBN 978-0-86571-520-2, Solar Energy International: www. solarenergy. org

7. Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices, February 2005, by John Wiles. SAND2005-0342, New Mexico State University/Southwest Technology Development Institute and Sandia National Laboratories: www. sandia. gov/pv

8. Roofing Construction and Estimating, 6th Printing, 2006. ISBN 978-1-57218-007-9, Craftsman Book Company: www. craftsman-book. com

9. Photovoltaic Systems Engineering, 2nd Edition, 2004, by Roger Messenger and Jerry Ventre. ISBN 0-8493-1793-2, CRC Press LLC: www.crcpress.com

10. Soares Book on Grounding and Bonding, 10th Edition, 2008, ISBN 1-890659-47-9. International Association of Electrical Inspectors: www.iaei.org

11. A Guide to Photovoltaic System Design and Installation, by Bill Brooks. California Energy Commission Consultant Report 500-01-020, June 2001: http://www.energy.ca.gov/reports/2001-09-04 500-01-020.PDF

11. Battery Service Manual, 12th Edition, Battery Council International: www.batterycouncil.org

12. Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices, SAND87-7023, Sandia National Laboratories: http://www.sandia.gov/pv/docs/PDF/Stand%20Alone.pdf

13. Maintenance and Operation of Stand-Alone Photovoltaic Systems, Sandia National laboratories: http://www.sandia.gov/pv/docs/PDF/98TLREF13.pdf

14. Working Safely with Photovoltaic Systems, January 1999, Sandia National Laboratories: http://www.sandia.gov/pv/docs/PDF/workingsafely.pdf

15. Solar America Board for Codes and Standards: www.solarabcs.org

16. National Renewable Energy Laboratory Website: www.nrel.gov

17. Sandia National Laboratories Photovoltaics Website: http://photovoltaics.sandia.gov/

18. Southwest Technology Development Institute, PV Codes and Standards Website by John Wiles: http://www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html

19. Interstate Renewable Energy Council Website: www.irecusa.org

20. IAEI News, International Association of Electrical Inspectors, http://magazine.iaei.org

21. PHOTON International Magazine : www.photon-magazine.com/

22. Home Power Magazine: www.homepower.com

23. Solar Pro Magazine: www.solarprofessional.com

Organizations

Ministry of Development	www.ypan.gr
General Secretariat for Research and Technology	www.gsrt.gr
Regulatory Authority for Energy	www.rae.gr
Public Power Corporation	www.dei.gr
Hellenic Transmission System Operator	www.desmie.gr
Public Gas Corporation (DEPA)	www.depa.gr/
Hellenic Petroleum	www.hellenic-petroleum.gr/
3rd Community Support Framework Programme	www.3kps.gr/
National Statistical Service of Greece	www.statistics.gr/
Greek Solar Industry Association	www.ebhe.gr/
Ministry of Environment, Physical Planning and Public Works	http://www.minenv.gr/4/41/e4100.html
The Photovoltaic's Market in Greece	http://www.helapco.gr/index_en.htm
Greek Association of RES Electricity Producers	www.hellasres.gr

European

1. **EERA** European Energy Research Alliance www.eera-set.eu/
2. **TREN** The Directorate - General for Energy and Transport europa.eu/comm/dgs/energy_transport/index_en.html
3. **Eurostat** europa.eu/comm/eurostat/
4. **ADEME** Agence de l'Environnement et de la Maitrise de l'Energie www.ademe.fr
5. **ADENE** Agencia para a Energia www.adene.pt/
6. **DEA** Danish Energy Agency www.ens.dk
7. **Enea** Ente per le Nuove Tecnologie l'Energia e l'Ambiente www.enea.it
8. **EVA** Energieverwertungsagentu www.eva.ac.at
9. **FES** Future Energy Solutions www.future-energy-solutions.com
10. **IDEA** Instituto para la Diversificacion y Ahorro de la Energia www.idae.es
11. **IEC** Irish Energy Centre www.irish-energy.ie
12. **IFE** Institute for Energy Technology www.ife.no
13. **NOVEM** Netherlands Agency for Energy and the Environment www.novem.nl