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*German-Israeli Programme on Cooperation in Vocational Education and Training*

## **Project Team Cooperation**

# **Competence-based education and training in the field of solar energy and energy efficiency**

Period of Project

1<sup>st</sup> April 2012 - 30<sup>th</sup> June 2013 and 1<sup>st</sup> January 2014 - 31<sup>st</sup> March 2015

## **Final Report**

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June 22, 2015

## 5.2 Examples of Modules

### Module 1: Planning and designing solar energy systems

#### *Description*

The focus of the module is the determination of customer requests, site surveys, provide advisory service, system layout, measuring/estimating energy consumption, use of sizing, design and simulation software; cost calculation and consignment of the material (can be added or treated in module 2). Since it covers a broad work area, the module can be split up into two smaller modules (1 purchasing an order and preparing an offer – 2 design of solar energy system). In this module, it will not be differentiated between photovoltaics and solar thermal systems since the focus is on system planning and customer communication.

This task deals with the planning and the design of solar energy systems (PV and ST systems). The related work tasks are typically the initiation of the work of the solar power installation service. A customer asks for a technical solution and an offer for such a system. In order to begin the planning and to prepare an offer the installer has to identify the customer's wishes. Therefore, the installer has to conduct on-site visits and site surveys. The expert determines the customer requests, identifies the local conditions and circumstances and advises the customer professionally. The installer has to determine the energy use, the size of the system and chooses modules or arrays. The system layout is typically realised with the help of a sizing, design and simulation software.

Module 1 contains the preparation of an offer which also includes a financial planning. Thus, cost calculations (material costs and labour costs) are included. These contents can also be considered in module 2.

#### *Knowledge*

- know the basics of power engineering;
- know general issues of climate change, RE and economic, ecological and political conditions
- explain the functions and components of solar thermal systems and photovoltaic systems, including the different options of construction;
- analyse the characteristics and features of the elements and system components of a solar thermal system and a photovoltaic system;
- know the benefits and operation of different simulation and planning software for solar thermal and photovoltaics systems and choose the most suitable software;
- describe the principles and strategies of communication techniques;
- demonstrate knowledge of principles and processes for providing customer and personal services about implementation of solar systems, including customer needs assessment and evaluation of customer satisfaction;
- know the principles of preparing the offer and functional specifications of a solar energy system;
- know about the different presentation techniques and software.

#### *Skills*

- conduct site surveys and talk to the customer in order to identify wishes, requirements and conditions using suitable tools (e.g. check lists);
- gather the necessary information on the local conditions and evaluate whether or not and how the customer's requests can be fulfilled;
- develop different possible solutions for installing a solar energy system considering technical and economic conditions and individual wishes;
- present different possible solutions to the customer and provides advisory;
- plan a photovoltaic power or solar thermal system according to the determined specifications and requirements;
- use the suitable sizing, design and simulation software;
- write up a calculation of costs for the installation of a photovoltaic power or solar thermal system;
- prepare an offer of a solar energy system.

*(Personal and Social) Competence*

- gather the information necessary for talking to the customer and analysing technical problems;
- make decision on the basis of obtained information and choose an appropriate solution;
- show empathy and a positive attitude to the customer; listen actively and adjust the action in relation to others' action;
- use logic and reasoning to identify the strengths and weaknesses of alternative solutions to problems considering different perspectives (economic, ecological, social etc.);
- prepare independently and correctly functional specifications;
- take responsibility for designing PV system and application process.

## Module 2: Setting up work at the building site

### *Description*

The module focuses on the setting up of the installation site, the organisation of work processes, the commencement of work at the building site, advising the customer, work with other trades, consignment of material and cost and labour calculation.

This module describes the necessary measures for setting up an installation site taking into account the professional storage of material, work flows, flow of material as well as health and occupational safety. The module contains financial planning, cost calculation, labour calculation, consignment of the material and advisory of the client.

### *Knowledge*

- knowledge of machines and tools including their designs, uses, repair and maintenance;
- knowledge of material, methods and the tools involved in the construction or repair of houses, buildings or other structures such as highways and roads;
- explain the installation works for the base frame and the modules, name the necessary work steps and put them in a reasonable order;
- consider the relevant regulations and rules to avoid risks occurring at the work site appropriate to the situation;
- know principles of financial planning of solar energy systems;
- calculate the material cost for the system;
- determine the assembly time and the resulting labour costs.

### *Skills*

- provide advisory to the customer concerning the financial planning and costs;
- set up a workplace for the installation of the roof components of a solar thermal or photovoltaic system according to the on-site conditions considering the wishes and requests of the customer;
- evaluate the safety of the on-site scaffolding;
- store the material according to risk prevention and in the correct order of the call avoiding damages;
- handle the personal protective equipment and any devices which serve to ensure the safety at the work site appropriately and professionally.

### *(Personal and Social) Competence*

- show empathy and a positive attitude to the customer; listen actively and adjust actions in relation to others' actions;
- gather and evaluate information on the installation site and adapt it the setting of the work site according to the on-site conditions;
- decide independently how and where on the installation site the material should be supplied;
- work cooperatively with other trades on the site;
- recognise the hazards special to the up-coming installation works and the necessary measures to avoid these hazards.

### Module 3: Installing solar panels (rooftop installation)

#### *Description*

This module focuses on the installation of the mounting system and the solar panels for solar thermal as well as photovoltaic sites on the rooftop. Even though the used media (water and electricity) differ, most of the work steps on the roof are the same.

The module can be enriched with ground mounted systems.

#### *Knowledge*

- distinguish mounting methods for different building types (inclined roofs, flat roofs, facades);
- analyse the different kinds of roof constructions and being able to describe the setup of typical constructions;
- explain the system for connecting the single support profiles to one another and describe how the profiles have to be attached;
- understand how the fasteners have to be attached to the support profiles and evaluate the quality of the connections and the selection of the necessary tools;
- know the necessary tools and what they are intended to be used for;
- know the different joining techniques (e.g. screwing or riveting) and describe the advantages and disadvantages;
- know the setup of the different wires, the valid cable laying guidelines and the different systems of feeding wires through the roof cladding.

#### *Skills*

- use the correct mounting method according to the roof type or installation site;
- expose the fastening points and attach the fasteners according to the technical rules using suitable tools;
- connect the fasteners to the support profiles appropriately and professionally; use and handle the necessary tools;
- connect the single support profiles to one another appropriately and professionally; use and handle the necessary tools;
- conduct the roof penetration according to the technical rules and regulations and feed the wiring through professionally;
- identify how the cables can be fed through the roof cladding in a reasonable way under various conditions and selects an appropriate method.

#### *(Personal and Social) Competence*

- draw decision independently regarding the mounting method, the placement and connection of substructures and fasteners considering the roof construction and conditions;
- work together cooperatively with other trades on the site;
- work professionally on the roof considering health and safety standards.

## Module 4: Installing PV system (inside building)

### *Description*

This task describes the installation (DC side and AC side) of the PV system inside the building from the roof cladding to the inverter and the connection of the PV system to the power grid in the case of a grid-connected PV system. After mounting the PV modules on the roof, the installer runs the string cables through the roof, routes the string wiring installation inside the building, connects the string cables to the terminals of the DC main disconnect/isolator switch or PC combiner/junction box, installs the inverter and the main connections. The commissioning of the inverter is included in this step as well as in the next module. It starts with setting up the meters, then the relevant measurements are taken and entered in the commissioning log.

The module and related competences can be adapted to stand-alone systems, too.

### *Knowledge*

- describe the components, process, steps of a PV installation;
- analyse DC and AC circuits;
- explain the different joining techniques for wiring;
- select the appropriate system/technology to the wall mounting;
- know the different cable routing systems and use the appropriate one with the corresponding fastening techniques;
- explain the relevant technical standards (e. g. IEC 60617);
- read and draw up the corresponding plans;
- know the necessary steps to connect the PV unit and name the correct order;
- know the different tools and its functionality and use them goal-oriented;
- explain the functionality of an inverter and its installation;
- describe regulations on work safely, especially the five safety rules and the relevant accident prevention regulations of the trade association.

### *Skills*

- determine the type of wire and cross section taking into consideration the surrounding temperature, the number of wires and laying procedure;
- identify the wall mounting and conduct professionally the necessary breakthroughs using appropriate tools;
- lay the wires using appropriate tools and mounting material (where necessary including the installation of a cable trunking);
- tie-in the PV modules in the existing electric installations taking into account the valid technical standards, regulations and accident prevention regulations;
- determine the assembly site of the inverter in terms of accessibility, setting etc. – while at the same time taking into account the wishes and ideas of the customer;
- install the inverter professionally at the designated site using appropriate tools and mounting material;
- conduct necessary measurements of the PV system;
- select and determine the reasonable measures to prevent accidents.

*(Personal and Social) Competence)*

- obtain information on how to enter the premises and on the time frame set for the realisation of the work;
- define independently the order of the different work steps and coordinates the work with the other trades involved;
- advise the customer about the installation considering the use of the rooms and energy;
- obtain information on the prevailing technical standards and regulations and extract the valid ones;
- develop the necessary plans (wiring diagram, installation plan etc) independently and professionally and explain them to others;
- take care of the compliance of occupational health and safety of the installation team and other trades.

## Module 5: Commissioning and operating PV system

### *Description*

This work task describes the start-up of a PV installation including the steps visual inspection, necessary measurements, testing of the installation and compilation of the commissioning report which serves as a proof to the operator that the PV system is functioning and safe to operate. The tasks starts with the commissioning of the inverter. After installing the inverter and setting up the meters, the relevant measurements are taken and entered in the commissioning log. For the commissioning of a PV system, the system constructor must issue a commissioning certificate. The certificate documents technical information and registers electrical measurements, before switching on the PV system electric measurements defined in proper standards have to be taken (e.g. ground/earth resistant, isolation resistance of the PV generator, isolation resistance of the DC main cable, short-circuit current for each string, open-circuit voltage of the generator, string-open voltage for each string). After switching on the PV system other measurements are taken and logged (e.g. operating current for each string, voltage drop above each diode, voltage drop above each safety device). Further measurements are conducted with an active system (with short-circuiting the generator, IEC 62446; and possibly without short-circuit).

In case of a grid-connected PV system an application to the responsible mains operator has to be presented including the documents (e.g. outline of PV system, description of safety system, type of inverter, declaration on conformity etc.). The mains operator usually assembles and connects the meters. Normally the first commissioning is carried out by a certified electrician usually in presence of an expert from the mains operator.

### *Knowledge*

- know the procedure and formal requirements of the commissioning of a PV system, in particular for grid-connected systems;
- know all relevant technical standards and the procedures for compiling commission reports;
- explain the type and significance of electrical measurements to be conducted;
- explain possible faults in the measurement setup and name methods to eliminate these faults;
- describe testing procedure and criteria for PV systems;
- prepare the application process and compile the necessary documents, in case of grid-connected PV system for the responsible mains operator.

### *Skills*

- conduct a visual inspection professionally and document it;
- conduct the relevant measurements and enter the data in the commissioning log before switching on and after switching on the PV system in accordance with technical standards;
- conduct further measurements with active system, if necessary;
- test the PV system;
- compile an immaculate documentation and the commissioning report of the PV system;
- hand over the PV system appropriately to the customer and instruct the customer professionally.

### *(Personal and Social) Competence*

- gather information on common procedures and measurements for the commissioning of PV system;
- prepare relevant documents with the use of suitable language and writing skills;
- collaborate professionally with other experts, in particular with representatives from the mains operator;
- advise the customer in commissioning and operation of PV system considering relevant regulations;
- demonstrate attendance for supporting the customer in future queries.



## Module 6: Installing solar thermal system

### *Description*

This module describes the installation of a solar thermal system which includes collectors on the roof. The installation work of solar collectors on the roof is similar to the installation of PV panels including the health and safety regulations. The main focus of this module is the internal installation of pipes from ST collectors to hot water storage, the solar-controller and the pump station. It includes the connection of the ST system with existing or new sanitary installations. Procedures of work orders, technical documents (e.g. installation plan) and safety regulations are considered.

### *Knowledge*

- know the fundamentals of designing the system size and the process of a solar thermal system installation, name and describe the necessary steps and put them in a reasonable order;
- distinguish installation techniques and mounting methods for different roof types (flat, pitched, steep, facade) and collector fields;
- analyse the different kinds of roof constructions and describe the setup of typical constructions;
- explain installation techniques for pipe installation (cutting, connecting, fixing, sealing) and sheet metal work and the use of appropriate tools;
- explain connecting techniques for the installation of the solar circuit and the use of appropriate tools;
- explain different fittings in solar circuit, domestic hot water piping and heat system;
- distinguish sensor types and controllers;
- read the valid symbols and draw up the necessary plans (hydraulic schematic, control scheme);
- plan the professional connection of the solar thermal system to the existing heating system;
- know the work safely, especially the relevant accident prevention regulations of the trade association.

### *Skills*

- determine the assembly site in terms of accessibility, setting etc;
- plan the necessary steps of the solar thermal installation;
- install all components at the designated site using appropriate tools and mounting material;
- conduct the necessary breakthroughs using appropriate tools;
- lay the pipes using appropriate tools and mounting material as well as connect them hydraulically;
- install the store considering requirements of the installation place (store weight, strengthen ceiling etc.);
- install the pump considering requirements of the installation place;
- install sensors and controllers;
- tie-in the solar thermal system in the existing drinking water system and heating system taking into account the valid technical standards, safety regulations and accident prevention regulations.

### *(Personal and Social) Competence*

- analyse independently contract documents, technical specifications and other documents for the planning of the installation;
- draw decision independently regarding the installation technique and mounting method, the placement of the collectors and store considering the roof construction and conditions;
- work cooperatively with other trades (e.g. roofer) on the site and define the work steps of involved craftsmen;
- provide technical advice to the customer considering local conditions and the wishes of the customer.

## Module 7: Starting up solar thermal system

### *Description*

This task describes the start-up of a solar thermal installation including the steps visual inspection, necessary measurements, safe and successful operation, testing of the installation and compilation of the commissioning report. The necessary steps for starting up a thermal solar system are flushing out the solar circuit, check for leaks, filling with solar liquid and set pumps and controller.

### *Knowledge*

- describe and justify the different steps necessary to start up the solar thermal system and its order;
- know the necessary spots for a visual inspection and describe them;
- describe the necessary measurements considering manufacturer's instructions and technical standards;
- explain possible faults in the measurement setup and name methods to eliminate these faults;
- explain the extent to which the installation should be tested;
- prepare the documentation of the solar thermal installation completely and meaningfully;
- know the procedure of the handover of the system to the customer and instruction techniques.

### *Skills*

- conduct a visual inspection professionally and document it;
- start up the thermal solar energy system considering the typical steps (flush, check, fill, set up);
- conduct measurements appropriately in the correct order and document the data;
- test the installation for functionality and safe and operation;
- compile an immaculate documentation of a solar thermal installation;
- hand over the solar thermal system appropriately to the customer and instruct the customer professionally.

### *(Personal and Social) Competence*

- work professionally, carefully and goal-oriented considering the regulations in this field, technical standards, health and safety regulations;
- determine independently necessary steps for the start-up and the documentation;
- communicate clearly and emphatically to the customer.

## Module 8 Maintenance of PV System

### *Description*

This task describes the maintenance of a PV system. Albeit the need of maintenance of PV system is a rare event, it has to be considered in the profile and training. The task is focused on periodical maintenance and inspection of PV systems for a secure and immaculate performance as well as fault diagnosis in case of severe faults, fault correction and recommissioning and the compilation of a maintenance report.

The aspects of visual inspection, measurements, testing and documentation are also described in the commissioning module.

### *Knowledge*

- explain different maintenance types and relate to PV systems;
- explain the maintenance needs and procedures of different PV installations;
- evaluate the current state of PV system;
- identify fault clearance strategies and explain structured troubleshooting;
- explain typical faults and their effects in PV systems;
- know the necessary software tools that support the recording and evaluation of malfunction.

### *Skills*

- clean the solar panels professionally;
- conduct a visual inspection of the PV system;
- determine faults in the system, in particular which were not shown in fault reports;
- correct and eliminate the located fault appropriately and professionally;
- compile fault reports for a solar installation using appropriate software tools professionally;
- conduct the necessary measurements (see module 5) and restart the system;
- hand over the repaired system to the customer and explain the faults and their effects and - where applicable - instruct the customer how to avoid such faults in the future.

### *(Personal and Social) Competence*

- plan independently the troubleshooting and maintenance of PV system;
- arrange maintenance and inspection appointment with the customer;
- take decision on suitable steps for the fault clearance;
- advise the customer on technical and economic effects of maintenance and malfunctions.

## Module 9: Maintaining solar thermal systems

### *Description*

The output of solar thermal systems depends on the adjustment of all components and its optimal operation. Solar thermal systems require little maintenance, however, a regular check is recommended. This module focuses on the maintenance task of solar thermal systems. It includes visual inspection, the monitoring of system parameters, the detection of assembly errors and the exchange of aged or damaged components.

### *Knowledge*

- explain different maintenance types related to ST systems;
- describe the maintenance needs and procedures of different ST systems;
- evaluate the current state of the system;
- explain the effects of worn, aged and damaged components in a ST system and know how to replace them;
- identify fault clearance strategies and explain structured troubleshooting;
- explain typical faults and their effects in ST systems;
- select the necessary software tools that support the recording and evaluation of malfunction.
- know the valid symbols and add facts, read and draw up the corresponding plans and documentation;
- know the necessary steps to put the system into operation and name the correct order;
- understand the manufacturer's checklist and process it step by step;
- know work safely, especially the relevant accident prevention regulations of the trade association.

### *Skills*

- deduce necessary steps of maintenance;
- monitor system parameters;
- check all components for the function using appropriate tools;
- check the wear and normal ageing of all relevant components using appropriate tools;
- replace worn, damaged and aged components using appropriate tools;
- restart the solar thermal system taking into account the valid technical standards, regulations and accident prevention regulations.

### *(Personal and Social) Competence*

- read contract documents, working documents and plans for maintaining the system, usually based on checklists;
- plan independently the troubleshooting and maintenance of ST system;
- procure, select and provide the necessary documents;
- arrange maintenance and inspection appointment with the customer;
- decide on suitable steps for the fault clearance;
- advise the customer on technical and economic effects of maintenance and malfunctions;
- add facts to the customers documentation, complements, develops and constructs the necessary plans (hydraulic schematic, control scheme);
- plan the professional steps to put the system into operation of the solar thermal system according to the manufacturer's specifications.

## Module 10: Dismantling solar energy system and recycling

### *Description*

This task describes the professional decommissioning, the dismantling and the professional recycling of solar system.

### *Knowledge*

- describe procedures and regulations for dismantling the solar energy system;
- explain the procedures for decommissioning the solar energy system;
- analyse the structure of walls, ceilings and roofs;
- explain the regulation of recycling solar panels and other components.

### *Skills*

- plan the removal of the solar energy system;
- set up the site for dismantling and remove the solar system;
- put the solar energy system out of operation keeping in mind the health and safety regulations;
- dismantle the solar energy system appropriately and professionally;
- remove the equipment (e.g. wires, collectors), disassemble if necessary and prepare for removal trying to avoid pollution and demolition of building fabric;
- seal any modifications in wall, ceiling and roof penetration appropriately and professionally, restore surfaces of walls and ceilings;
- remove tools and material, clean the tools and prepare them for the next operation;
- dispose of or recycle the discarded components and resources provided by the customer environmentally sound.

### *(Personal and Social) Competence*

- coordinate the work with other trades, integrate and order external services such as the scaffolding;
- inspect the on-site circumstances and discuss the installation details with the customer (e.g. point of time, access to the building);
- adjust the order of the necessary work steps independently;
- establish communication with recycling companies;
- provide advice to the customer on recycling issues.