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

1st April 2012 - 30th June 2013 and 1st January 2014 - 31st March 2015

Final Report

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1 Introduction

The German-Israeli Programme on Cooperation in Vocational Education and Training (Israel Programme) is a bilateral cooperation programme between the Israeli Ministry of Economy and the German Federal Ministry of Education and Research. Since 2013, the National Agency Education for Europe at the Federal Institute for Vocational Education and Training acts as implementing organisation for the Israel Programme.

The programme aims at developing innovative measures in the vocational education and training (VET) field in both countries. For more than 40 years, this programme has been giving vocational training experts from both countries the opportunity to exchange experiences, develop innovative approaches, and test them in their practical work. The programme consists of several forms of cooperation: Study tours, conferences, exchanges of apprentices (since 2012) and projects.

Throughout the projects, Israeli and German experts have the opportunity to cooperate in selected fields for one or two years. In the past, projects in mechatronics, ICT and microsystems technology had been conducted. The projects focus on the exchange of professional experiences and on the development of common products such as teaching material, curricula and other VET-instruments.

This joint project team cooperation has been working in the field of renewable energy. Before starting the project team cooperation, a joint Green Energy Conference was held in Berlin on November 30, 2009, focusing on solar and wind energies. Then two workshops on green energy took place in Germany and Israel in 2009 and 2010. Following these events, in 2011 experts from both countries proposed to the German-Israeli Forum on VET to implement a joint project focusing on vocational training in the field of renewable energy, in particular on solar energy and energy efficiency. At this time there was a tremendous need of skilled workers in the RE sector. Unfortunately, the situation changed during the work period as the photovoltaic (PV) sector has decreased in general.

One of the most significant challenges in the world of the 21st century is confronting the climate crisis, the short and long term consequences of which will affect the future of humanity. Changes in the patterns of energy consumption and production, e.g. improved energy efficiency and the transition to the production of clean energy, are essential in order to reduce greenhouse gas emissions worldwide. Climate change concerns, limitations and effects of non-renewable resources are driving innovation in renewable energy (RE) and RE commercialisation.

In the last years, Germany has been one of the world’s strongest markets for renewable energy. In the field of solar power it used to be a leading PV manufacturer and the third largest PV producer worldwide regarding production capacity and number of employees. Before the crisis, there were around 70 manufacturers of silicon, wafers, cells, and modules, over 200 PV material and equipment suppliers, and more than 100 balance-of-system component manufacturers. These enterprises employed around 64,000 people in the German PV industry before 2012. In total more than 300,000 people were engaged in the German RE sector. Due to the crisis in the PV sector Germany has lost jobs in the renewable energy sector for the first time in more than a decade.

Highly skilled employees are a key feature of the German labour market. This is also true for the RE sector. German universities have introduced full study programmes with different focal areas in the RE field. There are more than 240 university degree courses with a strong focus on RE technologies. At intermediate workforce level the vocational training within the dual system is traditionally very important. However, there are no specified training regulations or programmes in the dual system for occupations in the RE sector. Instead, certain skills and contents relating to RE are integrated in nearly 20 different training regulations or occupations such as electronics, mechatronics or HVAC system mechanics.

In the Israeli context, the energy issue is of tremendous importance. Israel's ability to replace electricity production on a large scale using renewable energy in the short term is limited, and so energy efficiency on the one hand and the use of solar energy on the other are key sustainable solutions that Israel can accommodate at least in short and mid-term.

RE research and innovation is very sophisticated in Israel, too. Research is led by the country's seven top-class universities, as well as a range of academic colleges and government R&D centres. In a sunny country such as Israel, it is no surprise that most of the academic research in renewable energy focuses on solar energy, especially on PV system and solar thermal systems.

In Israel, there are over 100 companies providing RE solutions. Most companies are small, and are not exclusively dedicated to PV. Less than ten Israeli firms are active in the PV field, and they deal mainly with system integration. Lately, a branch of economy has developed for entrepreneurship and construction of home and commercial electricity stations and progress has been made in the direction of deploying medium size systems of large roofs and areas of land. However, the impact on the labour market and the need for qualifications are supposed to be relatively low. There are only a few training programmes in the RE sector.

To conclude, the renewable energy topic is a very important issue for both countries even though strategies, conditions and needs are different. Nevertheless, with respect to qualifications and HRD issues it provides excellent cooperation opportunities in a fast developing technological field. The project team cooperation was working on new practical VET approaches in an innovative technological field: the solar energy and energy efficiency. The project team designed a training programme considering relevant European strategies concerning qualifications and VET issues, new didactic approaches and the different needs in both countries which will be presented in this report.

2 Organisation and Aim of the Project Team Cooperation

2.1 Organisation

Usually, this type of project team cooperation in the German-Israeli Programme on Cooperation in the VET has a duration of 2 years. Twice a year, a bilateral meeting is held. In addition, parts of the project are developed within a series of national meetings a year.

The project team cooperation was started with a kick-off meeting in Bonn in April 2012. The first bilateral meeting was conducted in Berlin in June 2012. The second bilateral meeting in Israel was realised in February 2013 (originally scheduled for November 2012). Due to security problems and changes in the programme administration the project work was interrupted causing a delay of the work flow. The project work stopped in July 2013 with a restart for one year in January 2014. Eventually, the German project team had the opportunity to extend the work for three months in order to finalise the work and test the training concept. In 2014, four national meetings and two bilateral meetings in Germany (Freiburg, March) and Israel (October) were conducted. In the extension stage the German team had the last national meeting in March 2015.

The project team members are provided in the following table:

Germany	Israel
Dr. Waldemar Bauer, University of Erfurt, Professor, Technical Education Sven-Uwe Raess, VET consultant, Gesamtmetall, Federation of German Employers' Associations in the M+E industries, Berlin Wolfram Seitz-Schüle, Coordinator and Head of Zukunftswerkstatt, Chamber of Crafts Freiburg Detlef-Horst Sonnabend, VET Teacher, Richard-Fehrenbach-Gewerbeschule Freiburg Rolf Inauen, Trainer, SMA Solar Technology AG Niestetal Jürgen Neumeier, VET Teacher Berufliche Schulen Korbach (partially replaced Klaus-Michael Peters, Hein-Moeller-Schule, Berlin) Sara Schwedmann, Journalist/university lecturer, Cologne Institute for Economic Research	Dr. Eli Eisenberg, Senior Deputy Director General, Head of Administration for R&D and Training, ORT-Schools Network, Tel-Aviv Maya P. Shaffermann, Ministry of Industry, Trade and Labour (now Ministry of Economics) Yosef Sharvit, Ministry of Education Eddie Bet Hazavdi, Director Department of Energy Conservation, Ministry of Energy and Water Yehuda Haiman, Deputy Director General Marketing & Business Development and Managing Director, Manufacturer´s Association Israel Sarit Ofri, Coordinator of Environmental education, ORT Afridar High School in Ashkelon. ORT Israel Network

Table 1: Project Teams

Figure 1: Project teams and visits (own pictures)

2.2 Aim and Concept of the Project

The overall aim of the project is to develop cooperatively training modules or learning units in the field of solar energy and energy efficiency which follow current didactic concepts and European strategies. The project focuses on these topics because it is a field of application with excellent research in both countries, industrial involvement and a need for qualified workforce. Although, the situation and needs are different in both countries and there have been changes during the project work. For Israel it is assumed that the potential of implementing PV systems (e.g. medium-sized distributed PV systems) is bigger than the actual situations may demonstrate which could increase the demand on qualified workforce. The energy efficiency subject is a broad and transversal issue which is highly relevant for all types of education and training, and a step towards ensuring a sustainability-aware generation.

Regarding the European strategies the most relevant instruments to be considered are the European Qualifications Framework (EQF) or the National Qualifications Framework (NQF), if applicable, and the European Credit System for Vocational Education and Training (ECVET). Both instruments help to make the learning outcomes of certain educational and training programmes comparable, and thus generate more transparency of competences and qualifications which might foster the mobility of experts in the RE field. ECVET shall help to support the idea of accumulating competences, which will be acquired in different countries and ultimately facilitate the recognition of these competences in different educational systems.

The most important didactic concept or learning strategy is the competence-based education and training (CBET) approach which has become a global strategy in the VET field nowadays. Many hopes rest on CBET because it is an outcome-based approach and is seen as a major driver of learning. CBET is focused on outcomes that are linked to workforce needs, as defined by professions. CBET moves education from focusing on what academics believe graduates need to know (teacher-focused) to what students need to know (learner-focused) and be able to do in varying and complex situations (action-focused).

The idea to embed the (occupational) competences into a VET curriculum leads to the necessity of identifying these competences and the requirements of the workplace. Since there is only little knowledge on work activity and occupational tasks in the RE sector available in both countries, some pragmatic occupational analysis has to be conducted in the project in order to identify relevant tasks and competences in the related field. Ultimately, the curriculum and training modules shall be designed using these results and a competence model which is based on the state of the art in both countries.

In any formal VET system educational purposes, learning objectives and contents are somehow systematised in a curriculum. A curriculum is an inventory of activities implemented to design, organise and plan an education or training action, including the definition of learning objectives, content, methods (including assessment) and material, as well as arrangements for training teachers and trainers. Traditionally, a curriculum was based on a knowledge hierarchy of basic science, followed by applied science and then the technical skills of day to day practice. Competence-based learning strategies lead to different curricular concepts where learning contents are derived from the logic of work systems.

In literature the development of a competence-based VET system such as National Vocational Qualification (NVQ) is described with four key stages, which are the identification of competences, the standardisation of competences, the conduction of competence-based training and the certification of competences (cf. Vargas 2004).

Figure 1 illustrates the connection between work, curriculum and learning. This connection should be seen as a cycle and not as a linear process with certain challenges (cf. Bauer 2009). In order to design occupational curricula the relevant occupation and the related work have to be analysed with a proper methodology in the first step. The results of this work or occupational analysis shall be transferred into the VET curriculum. This implies – besides formal requirements – the use of learning theories and developmental concepts. Since a curriculum is usually a normative document it should not only be focused on this mere empiric perspective. Therefore additional objectives (e.g. political, educational, institutional, individual) and contents can be embedded in the curriculum. Following this logic the next step is a didactic transfer. A curriculum has to be implemented in the classroom and workshops. Since the key purpose of CBET is the development of occupational competences it is obvious that learning in VET shall be focused on real problems and tasks of the occupation. Thus, teachers and trainers have to contextualise learning, design meaningful learning arrangements and apply suitable learning methodologies. This is also true for the evaluation, examination and assessment field.

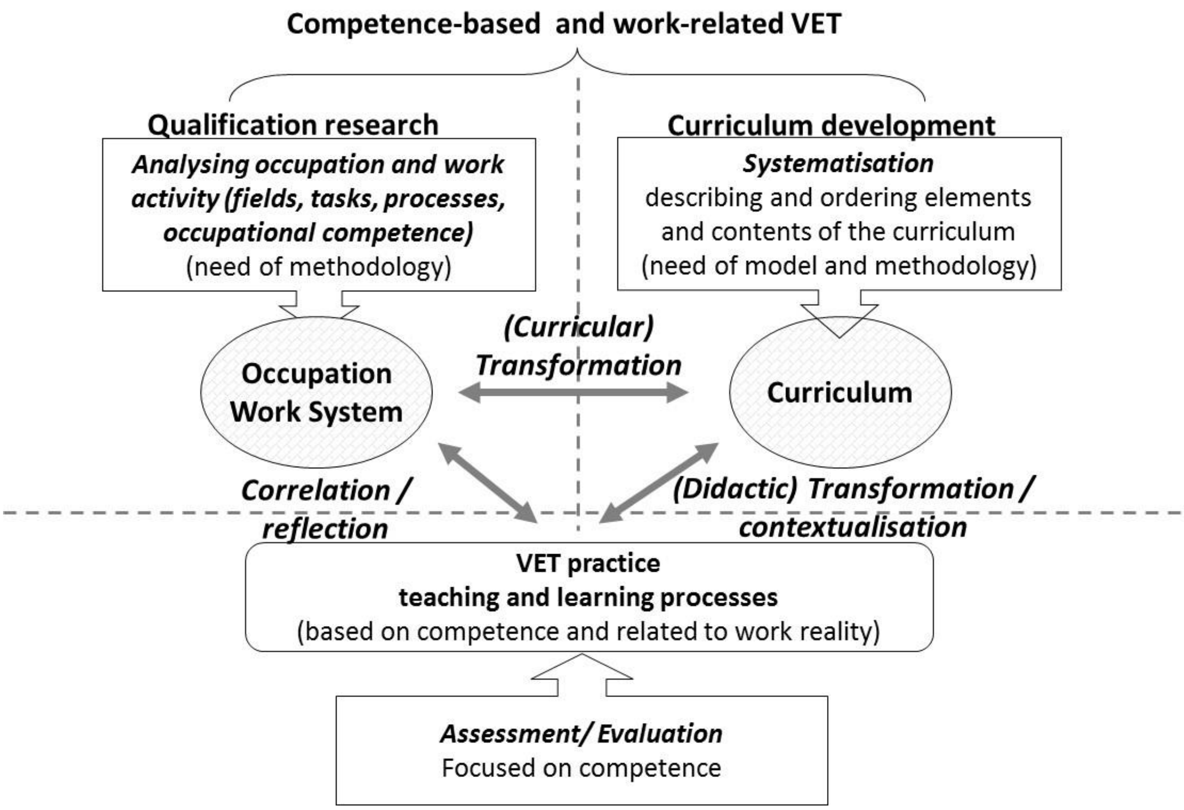

Figure 2: Fields of action and linkages between work analysis, curriculum development and learning practice

Taking into account this cycle challenges occur. First, curriculum developers and VET teachers have to identify meaningful work tasks or problems which are significant for work activity and also have potential for learning or competence development. The transformation from meaningful work problems to learning arrangements entails a complex series of steps beginning with the analysis of work activity and the required competences, followed by the development of a work-related and competence-based curriculum and ending with the design of competence-based and/or work-related learning arrangements. For the development of occupational profiles and VET curricula there are at least three core problems:

- *Problem of analysis*: The analysis of occupational and/or work activity must be focused on developing a VET curriculum. Therefore, a practical and empirical methodology is needed to describe work activity. This methodology must be able to analyse the objective dimension of work (e.g. objects, tools, methods, organisation, standards and regulations) and also the subjective dimension, namely the individual performance of work and applied knowledge and skills. There are many methodologies in place such as DACUM or functional analysis.
- *Problem of transformation:* It is obvious that the empiric findings of occupational/work analysis cannot be transformed directly into a VET curriculum. The transformation process must be conceptualised through the use of educational, pedagogical, psychological and societal models and criteria. This means that the occupational/work analysis must be linked with a curriculum conceptually and methodologically. One can state that the applied transformation concepts suffer from lacking educational and learning models. In addition, new systems such as NQFs have an impact on the design of the curriculum.
- *Problem of systematisation*: A curriculum ultimately describes the purposes of vocational education and training. Insofar, it systematises knowledge, skills, attitudes and behaviour or competences in a pedagogical manner. Thus, the elements and content of a curriculum must be arranged in a way to foster competence development, which requires a specific developmental competence model.

These three steps of analysis, transformation and systematisation finally enable us to develop an empiric based, work-related and pedagogically founded curriculum – provided that domain-specific work studies and competence research in an occupational field is linked with the development of a curriculum.

There is another crucial issue concerning the design of learning arrangements. In CBET the learning strategy has shifted from teacher-centred arrangements to more activity-oriented and self-regulated learning modes. Thus, one key purpose in the project is to develop a didactic concept for implementing CBET or in other words to design competence-based learning arrangements. It is remarkable that the issue of designing learning or a CBET didactic in the CBET context is not very elaborated in the international debate. Quite often it is only focused on frameworks and assessment procedures. Therefore, one key interest of the project team cooperation is to contribute to the didactics in the CBET discussion. The project follows the current trend in German vocational schools known as the *Lernfeld* concept and the didactic approach of learning situations (cf. KMK 1996; 2011). Learning situations are didactically and methodologically planned teaching and learning arrangements which focus on real problems or tasks of the occupation with the purpose of initiating the action-oriented learning process. They are thematic units derived and developed from the training modules. Practically, the modules are broken down into a series of learning situations to achieve the expected competences.

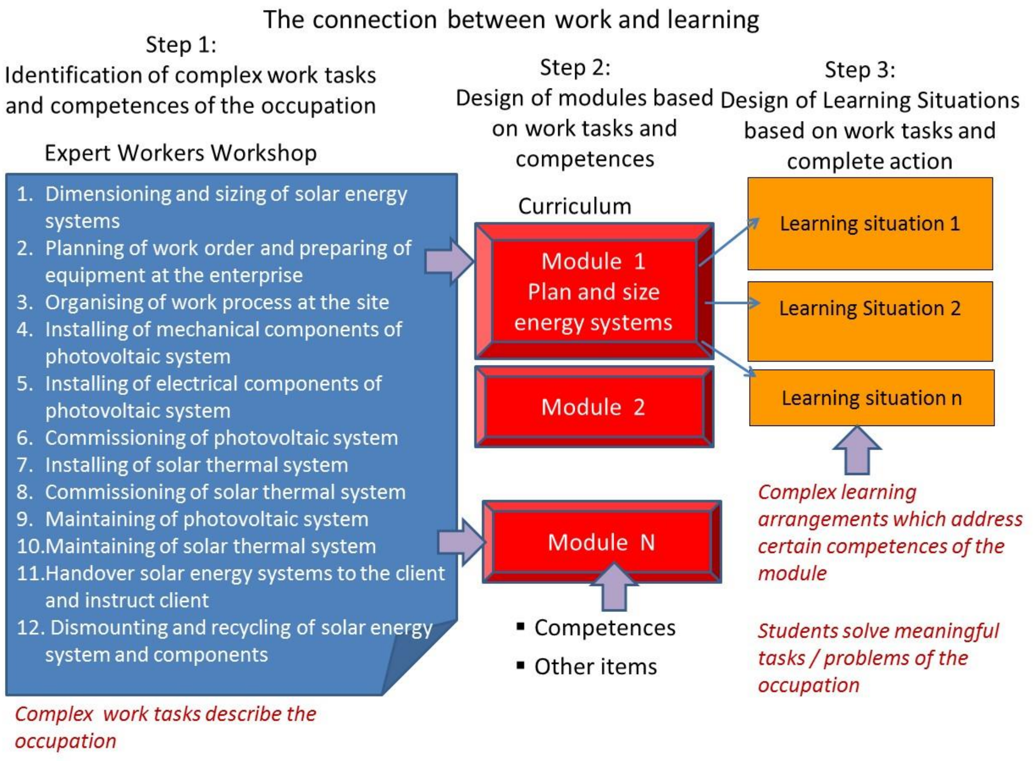

Figure 3: Linkage between work tasks, modules and learning situations

Based on the project concept the main activities shown in the table were realised:

	Activity	Methodology
1	*Expert Profile Development* Develop an occupational or competence profile of experts (intermediate level) in the solar energy sector, in particular in the field of PV and ST systems (e.g. planning, installing and maintaining PV/ST systems and PV/ST components).	*Expert Workers' Workshops* to be conducted with approximately 10 expert workers in order to identify, analyse and describe work tasks and competences of solar energy experts.
2	*Curriculum Development* Transfer the expert profile into training modules or learning units using a competence model (here EQF) for setting up the curriculum.	Participative Development of modules in both project teams in Germany and Israel.
3	*Development of Learning Situations* Didactic transfer of exemplary modules into learning arrangements which are focused on real occupational tasks and promote the development of competences.	Participative Development of learning situations in both project teams in Germany and Israel.
4	*Implementation and evaluation* Testing of selected learning situations.	Conduction of training (only Germany in ST field)

Table 2: Main Steps and Activities of the Project

3 Occupation and Qualification in the Renewable Energy Sector in Germany

According to the Federal Ministry for Economic Affairs and Energy (BMWi) about 371,000 people worked in renewable energies in Germany in 2013 (cf. O'Sullivan et al 2014). The employment numbers resulting from the turnover of the production of renewable energy installations stands at about 230,800 people and decreased by 13 percent since 2012. The employment numbers based on the operation and maintenance of existing installations increased by 6 percent to 63,500 people in 2013. In addition, about 8,300 employees work in publicly funded research and administration.

In the field of photovoltaics, the number of employees has decreased dramatically from 100,300 to 56,000 in 2013. This is mainly a result of fewer investments due to the price decline and the quantitative reduction of the newly installed performance. Overcapacities have led to cutting down the turnover of engine builders and equipment manufacturers by 50 percent in 2012 compared to 2011. The inter-trade organization VDMA estimates that more than 90 percent of the turnover has incurred abroad because most of the German photovoltaics producers have not invested in alternative and enhancing measures due to the unfavourable state of the market. The turnover of the producers of the means of production has nosedived by about 45 percent to 700 million Euro in 2013 compared to the year before.

Figure 4: PV module (own picture)

	Employment due to investments (incl. export)	Maintenance and operation	Fuel supply	Total 2013	Total 2012
Wind onshore	100,800	18,200		119,000	104,000
Wind offshore	17,500	1,300		18,800	17,800
Photovoltaic	45,100	10,900		56,000	100,300
Solar heat	10,100	1,300		11,400	12,200
Solar thermal power stations	1,100			1,100	1,400
Hydropower	8,300	4,800		13,100	12,900
Deep geothermal energy	1,300	200		1,500	1,400
Near-surface geothermal energy	13,300	2,500		15,800	15,000
Biogas	17,200	11,800	20,200	49,200	50,400
Small-scale biomass plant	10,100	3,900	14,600	28,600	28,800
Biomass thermal power station	6,000	8,600	8,400	23,000	22,900
Biomass fuels			25,600	25,600	25,400
Total	230,800	63,500	68,800	363,100	392,500
Publicly funded research/administration				8,300	7,300
Total				**371,400**	**399,800**

Table 3: Employment in the renewable energy sector (source: O'Sullivan et al 2014, p. 7)

The decrease in the solar thermal sector was comparably insignificant to 11,400 employees in 2013. The demand for skilled workers in the field of renewable energies will continue to increase despite the difficult circumstances, further structural changes and cyclical fluctuations.

Especially in the installation and service area skilled workers – mainly with metal fabrication and electrotechnical training in the industry or crafts and trades – are needed. New technologies, products and services from wind and solar energy to electro mobility make it necessary that skilled workers offer different and further competences.

The qualification measures on offer are diverse: starting from internal and external trainings companies provide even for skilled workers from outside the industry to diversified training models reaching as far as different industry-sector-specific degree course.

Even the sector of trainings organized by the government is currently discussing whether or not to create new professions. Due to the already existing number of jobs that require trainings, the heterogeneity of the different fields of activity in the sector of renewable energies and the given flexibility in the trainings regulations a reorganization of special product-oriented professions is at present not recommendable. Nevertheless, the existing professions need to be further adjusted to the new technologies.

The industrial metal and electro professions for example have been basically reformed in 2003/2004 – without creating new and additional professions for certain sectors or products. These new training occupations have been designed for broader occupational fields to be more flexible and enabling companies to focus on their specific business fields and processes. The – at that time – new training structures with their wording open to all types of technology and product neutral have proved to be sustainable. The number of articles of traineeship has increased significantly. The training of skilled workers in the fields of photovoltaic and solar thermal energy has been secured to the greatest possible extent.

As diverse the sector of renewable energies is as diverse are the professions for which trainings are offered. The 12 sectors of technologies include about 40 different professions – including not only the relevant metal and electro professions such as industrial mechanics and electronics technician for industrial engineering but also well builders, chemical laboratory technician and mechanic in plastics and rubber processing. On the background of energy efficiency professions such as the automotive mechatronics engineer (electro mobility) or different building professions (building restoration) have been added.

Table 4: Overview of training occupations with RE components

Technical professions	New training contracts (2013/14)
Mechatronics fitter	7.590
Machine and plant operator	3.657
Mechanic in plastics and rubber processing	2.556
Mechanic in metallurgical industry	549
Well builder	30
Plant mechanic for sanitary, heating and air conditioning systems	11.340
Specialist in water supply engineering	150
Metal professions	New training contracts (2013/14)
Plant mechanic	1.152
Milling machine operator	6.207
Industrial mechanic	13.302
Construction mechanic	2.835
Production mechanic	810
Specialist in metal technology	1.380
Metal worker	6.105
Precision mechanic	2.793

Electronic and IT professions	New training contracts (2013/14)
Electronics technician (crafts)	12.099

Electronics technician for industrial engineering	6.114
Electronics technician for motors and drive technology	429
Electronics technician for automation technology	1.875
IT specialist	10.737

Other professions	New training contracts (2013/14)
Technical product designer	2.598
Chemical laboratory technician	1.659
Chemical technician	2.010
Industrial business assistant	18.321

[Source: Federal Institute for Vocational Education and Training (BiBB), http://www.bibb.de/]

A sufficient offer of jobs that require trainings already exists. Not all companies use the flexibility the training system offers to the same extent. The field of renewable energies is dominated by young, dynamic small and medium-sized enterprises (SMEs). Especially smalls companies are often unable to cope and offer trainings because they are specialized to a high degree and cannot cover all the different training contents.

To only recruit skilled workers on the job market is getting more and more difficult – due to the demographic change. Companies can receive help from the government, chambers and associations when starting to offer job trainings.

In addition to the discussion of contents, accuracy and transparency of the job qualifications image and marketing topics play a major role one should not underestimate. The companies have realized that the topic of renewable energies is an excellent marketing instrument in the competition for young talents. The main producers of wind energy plants for example do not only advertise their names but also their products as a sustainable and ecological energy generation. This leads to the conclusion to also transport this positive image in the job titles. One suggestion for an industry-sector-specific job profile is the “mechatronics fitter for wind turbines”. This attempt is – due to the described image reasons – understandable but results in demarcation problems. Additionally, the jobs that require training are normally not product-oriented but technology-oriented – as described above. Electronics technicians for motors and drive technology for example still produce generators which are used for the product wind energy plant today using a comparable technology.

There are more examples proving that it does not depend on the job titles regulated by the government but that a sufficient marketing by the companies is more important in the recruitment process. For example, the companies of the stamping and metal forming technology sector specifically point to the end products such as premium cars or smartphones for which the products they supply are used in the end.

More and more important for the sector of renewable energies is the topic of further qualifications. Currently, the offer of qualification measures and certificates is overwhelming. So there is a need to establish more transparency and comparability. This is in the interest of the company but also of the employees because their occupational mobility improves.

Examples of existing further qualifications in the field of renewable energies:
• Specialist in photovoltaics • Specialist in solar thermal systems • Solar distribution technician • Distribution technician for renewable energy • Specialist in environmentally friendly energy management • Service technician for wind turbine

Table 5: Examples of continuing training occupations in the RE field

Summing up we can conclude that a main prerequisite for the development of new qualification concepts is the orientation on the actual realistic demand of the companies. The development of process-oriented modules which can be used in qualifications and additional qualifications as well as further trainings is a consistent and reasonable approach. The description of the competences and necessary skills is based on the German and European Qualifications Framework (DQR and EQF).

4 Profile of Solar Energy System Installer

4.1 Methodology

Generally speaking, competence-based learning strategies favour and recommend a self-directed, active mode of learning where the learner has more responsibility for the learning process. There are many different learning methodologies which can be used such as problem-based learning, task-based learning or project-based learning. However, CBET needs more than solely applying a single project or solving a single problem. The problems, tasks or projects must be embedded in a meaningful context and systematised in a broader learning process.

In the VET field learning must be designed so that the novice develops and becomes an expert of his occupation. The stages of development vary not only due to experience but also the commitment to a (work) problem (increasing with expertise), the degree to which knowledge has been internalised, and the degree of awareness of theory behind knowledge. Competence is usually acquired through the successful performance of tasks or solving of problems.

Thus, there might be a logic of development of competence or expertise. First, students shall acquire knowledge of overview, orientation and skills to solve principle occupational tasks (e.g. operation of technical system, manufacturing of (simple) components, simple repair or regular maintenance). Then they acquire coherent knowledge (how are things in the relevant occupation connected and why?) and skills for solving systematic tasks (e.g. connecting subsystems or components, manufacturing or commissioning). In the third stage, they acquire knowledge of functions and details of technical systems and subsystems (how are things working?) and skills for special problem-based work tasks (e.g. dismantling a technical system, functional analysis of a technical system, troubleshooting and fault clearance). In the last stage, they should acquire specialised and advanced knowledge and skills for unpredictable work-based problems (e.g. optimising a manufacturing system, analysis of critical points, special diagnosis, troubleshooting in case of complex not documented failures). These four development stages outline the systematization of tasks, problems and contents of learning and thus a model for the organisation of a curriculum.

The goal of the project is ultimately to develop a training programme which refers to the work activity and the required competences of skilled workers in the solar energy field. For the design of such competence-based learning environments it is very important to identify and describe these typical work tasks of the occupation. This compiles a reference profile for the VET curriculum.

Expert Workers' Workshop

VET experts from the University of Bremen in Germany developed a work analysis method which is similar to DACUM but different in the construct and related theory (cf. Rauner 1999; Kleiner 2002). In the centre of the methodology stands the concept of work task. Compared to DACUM these work tasks are more holistic. They are typical for a meaningful work context in an occupational field. At the same time they have a paradigmatic quality because their successful achievement leads to skill and knowledge acquisition (cf. Benner 1984; Rauner 2007).

Work tasks describe a specific occupation on the basis of significant connections between different aspects of the work and tasks that are both typical of the occupation and provide a complete picture of it. Work tasks cannot be described as a single ability or job, but rather as a complete action that encompasses all aspects of the occupation. A general description of how a work task is carried out contains the specifics of the task, its planning and execution as well as the assessment and evaluation of the resulting work. Thus, a work task always refers to the complete work cycle.

These work tasks of an occupation have different levels: There are work tasks which can be performed by a novice - or more complex ones which only an expert can manage (cf. Dreyfus & Dreyfus 1986). Building on this understanding, it is assumed that competence development can be sequenced empirically based on the complexity of work tasks with its latent variables. Thus, the research task is to identify these developmental tasks of an occupation and its logic of development (cf. Havighurst 1972). According to this method every occupation can empirically be described by a defined number of (developmental) work tasks (12-20) which can be systematized through the logic of development (cf. Rauner 1999).

The structure of the expert workers' workshop is similar to the DACUM workshop, however, the elements and proceedings are different in some parts. The identification and description of work tasks presume the following objective dimensions which constitute an occupation (cf. Rauner 1999; Kleiner 2002): the object of work (contents emanating from the functional use and the technical functions), the methods, the tools and the organisation of the work activity, and the entrepreneurial, social and subjective requirements of the work task and technology (requirements resulting from legislation, standards, technical regulations, employers' regulations, customer claims etc.).

The identification and analysis of work tasks and related occupational competences in the solar energy sector was realised by two 1-day expert workers' workshops in Germany. The results are described in the following section.

4.2 Results of Expert Workers' Workshops in Germany

The following table outlines the conducted expert workshops in Germany:

Data and Place Expert Workshops	1. Workshop in Berlin (June 6, 2012) 2. Workshop in Freiburg (Sept 13, 2012)
Participants	First Workshop: 4 participants from 3 enterprises in the PV field Second Workshop: 5 participants from 5 enterprises in the PV and solar thermal field (including a SE trainer)
Agenda	1. Workshop layout and introduction of participants 2. Collection of work tasks of experts in solar energy (group work) 3. Presentation and discussion of work tasks 4. Systematisation and validation of work tasks
Results – List of work tasks	First Workshop: 1. Planning of PV system 2. Building of support structure for PV system on roof 3. Mounting of PV modules 4. Installing wiring and feeding-in 5. Installing of inverter 6. Setting-up of PV system 7. Maintaining of PV system 8. Documentation of data of PV system 9. Disassembling of PV system and recycle components 10. Optimising of PV system Second Workshop: 1. Analysing work order 2. Purchasing and checking of work material and equipment 3. Organising of work process at building site 4. Mounting of PV system and components 5. Installing of PV system 6. Installing of solar thermal system 7. Commissioning of PV system 8. Commissioning of solar thermal system 9. Maintaining of solar energy systems 10. Recycling of components of solar energy systems

Table 6: Results of the German Expert Workers' Workshops

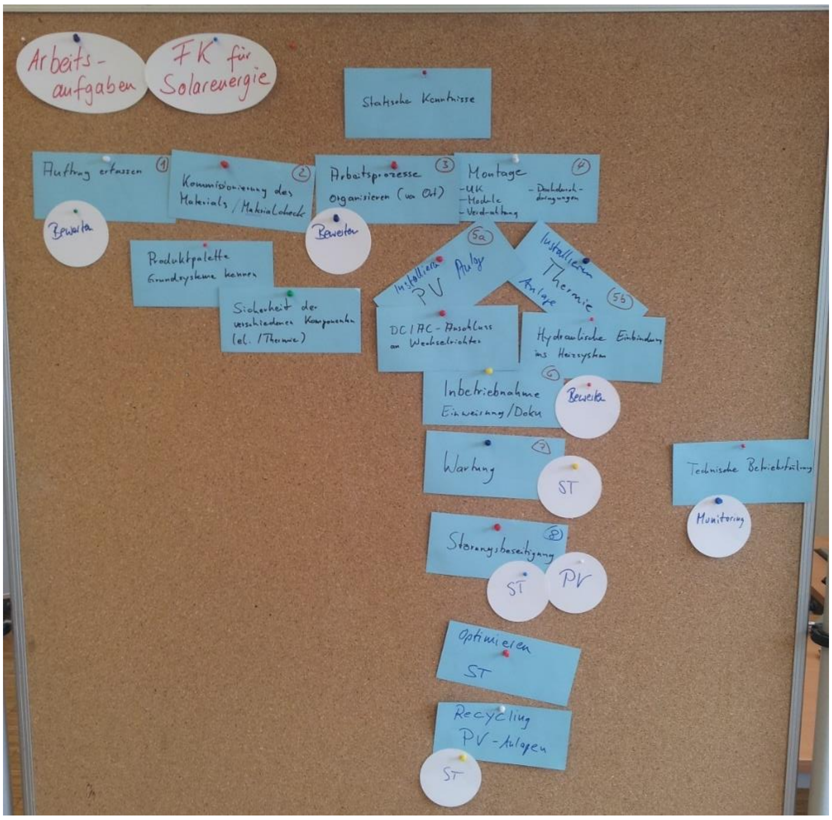

Figure 5: Example of the identification of work tasks (own picture)

Note: The Israeli project team has conducted similar expert workshops and presented their results in a bilateral meeting in February 2013. It was agreed to use the German profile and merge the Israeli results. The following profile and description of work tasks represent the joint outcome of the first work package.

4.3 Occupational Profile – Work Tasks of Solar Energy System Installer

The first workshop in Germany was focused on solar photovoltaic (PV) systems whilst the second workshop also included the installation of solar thermal (ST) systems. Solar energy systems can be designed to heat water or living spaces as well as to provide electricity. There are two basic types of PV systems which produce electricity. First, grid-connected or net-metered PV systems are connected to the utility grid through a special meter that turns backwards when the PV generator produces more electricity than is needed in the house. The utility grid serves as storage eliminating the need for batteries. Second, off-grid or stand-alone systems are completely independent of the utility grid and other electric systems. They are commonly used for remote power or backup applications. Since off-grid systems generally provide electricity for the entire home they require storage batteries and usually have some kind of backup generator. They may use other power generators additionally.

Regarding solar water heating systems there a basically two types with different technologies: active solar water-heating systems (direct-circulation systems or open systems, indirect-circulation systems or closed systems and drainback systems) and passive solar water-heating systems (integral-collector storage systems and thermosyphon systems).

Furthermore, the ST system can be differentiated according to the temperature of the collector (low, medium and high).

The profile shall represent all types of work activity with the different technical systems hence an expert in the solar energy field must have the skills to handle different work situations. Planning, sizing and installing solar energy systems depend on different factors. One of the most crucial factors is the size of the system which mostly determinates the requirements of work organisation and work activity. This document focuses rather on small and medium-sized systems (e.g. grid-connected PV systems on residential buildings up to 30 kWp). Nevertheless, some features of larger systems are also been discussed in the following work tasks.

The results of both workshops can be clustered into the following work tasks which a skilled worker in the field of solar energy has to conduct in the various business sectors and enterprises:

1. Dimensioning and sizing of solar energy systems
2. Planning of work order and preparing of equipment at the enterprise
3. Organising of work process at the site
4. Installing of mechanical components of photovoltaic system
5. Installing of electrical components of photovoltaic system
6. Commissioning of photovoltaic system
7. Installing of solar thermal system
8. Commissioning of solar thermal system
9. Maintaining of photovoltaic system
10. Maintaining of solar thermal system
11. Handover solar energy systems to the client and instruct client
12. Dismounting and recycling of solar energy system and components

Note: Experts of the trade suggest to include an optimising task for solar energy systems. In the following list of work tasks and modules we do not describe such a task because details of the tasks have not been clarified yet. A corresponding task is not included in the training modules.

4.4 Description of the Work Tasks

In this section the work tasks are described in detail.

Work Task 1: Dimensioning and Sizing of Solar Energy Systems

The installation of solar electric power and solar thermal systems is usually based on a customer order. It is the client who asks a solar firm to plan and install a residential solar PV or solar thermal system or a stand-alone or larger contributed systems. The expert might have responsibilities in this consulting and planning process depending on the size and organisation of the solar enterprise.

In case of an expert being engaged in the customer consultancy the first activity is to find out the customer’s needs. The expert must have a well elaborated customer focus enabling him to demonstrate a concern for the needs and expectations of customers and to make them a high priority. The communication skills are used to understand the customer's needs and to provide technical advice which are the basis for decision making. The expert conducts site visits and field surveys at the customer's place in order to analyse the situation and collect relevant data for the new solar energy system.

In the following step the expert evaluates the situation and data of the field visit and customer conversation in order to find the best solution for the customer's needs.This is the linkage to the design of the solar energy system. In some enterprises the design of a solar energy system is part of the responsibility of the skilled worker. In other firms the design is prepared by specialists in proper design departments providing all technical documents and the work order for the installer. In this case the work process of the solar expert starts with the analysis of the work order and the system design. The expert has to control all documents, to verify the size planning of the system and all components and to check the feasibility with regards to deadlines, costs and technical realisation. If the expert detects some incorrect planning or has any doubt about the feasibility, further communication with the planning unit or other colleagues such as vendors is necessary.

In this project approach the expert profile requires design skills in dimensioning and sizing solar energy systems in order to provide a holistic profile. For designing purposes the expert has to examine the energy consumption demands in a building (e.g. thermal or heat energy, electrical energy, and refrigeration) as well as the local weather and working conditions of the system in order to find the most suitable system. The planning of a (grid-connected) PV system depends on the following features: the conditions of the roof (size, alignment, inclination), shading conditions, the instructions of manufacturers regarding the PV modules, inverters and other components, aesthetical requests of the customer and the financial framework. The planning steps encompass the estimation of the roof space considering the financial framework, the selection of the PV modules (type and amount) and inverters (type and number), the configuration of the system and the compilation of the parts list (solar arrays, generator junction box, wiring, switches, inverters, chargers etc.), forecasting/ simulating the output of the system (usage of a dimensioning programme) and considering the local weather conditions. Also supplementary parts (e.g. lightning protection) must be considered.
Larger PV systems such as free standing plants or solar power plant (e.g. 5 MWp) require specific planning due to higher technical requirements which cannot be described completely in this document.

The planning of simple solar thermal systems for water heating is conducted in a similar way. Basically, the system type and building size – which for example depends on the water consumption - determine the collector size and other components. Furthermore, the type of building such as a new building or a modernisation of an existing energy system has an impact on the system design and installation. Systems are principally divided into drinking water heating and space heating or combined systems. A special but not often used technology of solar thermal energy is solar cooling - which may become very important in a variety of applications as the prices for the collectors have been decreasing notably.

In Europe, most systems are closed two loop systems. Very often the solar thermal system is integrated in an existing space and water heating system. Some manufacturers define the system size according to the collector size (e.g. medium-size systems to 30 m²), others according to the number of housing units. The planning of large-scale solar thermal systems requires specialised knowledge which will not be covered in this profile. The design contains all important components including the collector field, collector arrangement, pipe dimensions, solar pumps, expansion tanks, in-line vessels, heat exchangers, storage tanks, preheating tanks and regulators.

Once the customer order is translated into requirements specifications the expert has to develop the technical specifications of the system. Typical contents to be described are approval specifications, product features, component lists, assembly and applications.

To summarise, this work task requires the following competences to perform the work:

- Complete understanding of solar energy systems (PV and ST) and of all system components and its functions and operations as well as the awareness of the need to constantly being up-to-date on new systems and components.
- Skills in dimensioning and sizing PV and ST systems on the basis of field studies using typical software.
- Knowledge in basic cost calculation and basic pay off and profit analysis methods.
- Skills in analysing geographical and constructive situations for the purpose of the installation of solar energy systems.
- Knowledge for selecting a geographical location suitable for a system that blends in with the architecture of the building and has a sturdy surface upon which the system can be installed - bearing in mind lift force and the constant need for proactive protection against lift force.
- Skills in reading and preparing technical documents and drafts such as construction diagrams and detailed schematics as well as electrical schematics according to the required standards.
- Communication skills and a well elaborated customer focus.

Work Task 2: Planning of Work Order and Preparing of Equipment at Enterprise

The installation of a solar energy system is usually based on a technical specification and a work plan. The work plan is the guiding document for the activities to be carried out during that time period. In most cases, the expert has to develop the work plan and arrange all activities at the construction site.

In such documents the necessary components, material and equipment are described either by planning units or by the solar energy specialist. In any case, the expert has to check the list of material and equipment and verify if the material is available and complete. If not, he or she might purchase missing parts. This work process includes the commissioning of material in the depot.

The expert has to collect all necessary documents for the energy system such as manufacture’s instruction, diagrams, data sheets and the documentation of the planning process (work task 1). The work place in the company has to be arranged according to company regulations as well as ergonomic and safety aspects.

Depending on the scope of responsibility and the solar project the solar energy expert might need managerial skills and knowledge of project management. For example in larger projects the team leader has to plan, monitor and control the project which requires the application of project management tools (e.g. work breakdown structure, Gantt chart or a network diagram, PERT) and simple cost calculation. This includes estimating time and cost for activities, developing the schedule and risk planning. Team leaders also need communication skills. In large companies this work might include the use of vehicles such as forklift trucks.

This work task requires the following competences to perform the work:

- Understanding/familiarity of organisational structure and functions of solar energy enterprise and involved labour force such as management, installer, team leader, maintenance and repairman.
- Knowledge in planning work activity, project management and the use of relevant tools (e.g. project schedule, work breakdown structure Gantt chart or a network diagram, PERT).
- Knowledge in analysing technical specifications and documents as well as translating them into a project plan and work activities.
- Knowledge in performing cost and risk calculations.
- Knowledge in reading/amending contracts, warranties and professional insurance.
- Broad knowledge in the field of work safety.
- Knowledge in purchasing required parts, material and tools and testing their integrity.
- Skills in checking parts, material and tool availability as well as prices according to the proposed schedule.
- Skills in preparing and packaging of appropriate parts, material and tools (in a compact manner to prevent damage) for transportation to the system installation site.

Work Task 3: Organising of Work Process at the Site

The work in the field of installing solar energy systems is usually done at a customer's site which can be a small private building, a multi-storey building or on a floor space. Therefore, the organisation of the work process at the site is a necessary skill of a solar energy expert. In any case, the expert has to survey the site and communicate with the client.

In bigger projects the installation might be conducted by a crew which requires further communication between team members. In such projects (e.g. multi-storey buildings) the experts have to ask the building administration for access permission. Depending on the size of the building and the installation further equipment such as cranes is necessary for the use of which proper licences might be necessary.

At the building site the expert(s) check again the equipment, tools, material, the technical specifications, manufacturer's instructions, drawings and diagrams and other documents.

At scaffolding work and electric work safety regulations have to be considered. In general, safety is of the utmost importance. Standard health and safety practice and conventional electrical installation practice must apply to the installation of a PV system. Issues such as working on roofs or standard domestic AC wiring are covered thoroughly in technical standards or juridical documents. The dimensioning specification of the system must be designed according to statics which the expert must follow strictly.

If a team conducts the solar installation, a safety meeting is recommended. This meeting should include safety issues on specific regulations when installing solar water-heating or PV systems (e.g. setting up and using ladders correctly, wearing gloves and safety glasses and being careful to not drop tools or equipment, electric shock and its potential danger when working around PV systems). Everyone should be trained in basic first aid.

This work task requires the following competences to perform the work:

- Knowledge in purchasing and testing required general/special safety equipment.
- Knowledge in creating an appropriate and implementable site safety programme including marking of problematic areas.
- Broad knowledge in the field of work safety, in particular for working on roofs; ‘working at height’ certification is mandatory.
- Skills in scaffolding.
- Knowledge for selecting a geographical location suitable for a system that blends in with the architecture of the building and has an appropriate place for the system, bearing in mind the additional load and forces.
- Knowledge in the accurate recording of the parts and material required for all systems.
- Knowledge in the field of material including safety devices and/or specific dedicated work tools.
- Communication skills and ability for team work.

Work Task 4: Installing of Mechanical Components of PV system

PV modules are either added to existing buildings, integrated into new buildings or installed as free-standing structures in a field. In existing buildings PV systems are retro-fitted to buildings, either on tilted or flat roofs. They can be integrated in or attached to the building roof. They may be mounted in the same place on the roof or may be inclined relatively to the roof surface. There are also PV systems which are installed in facades which requires specific features. Most residential and small commercial PV systems (to 30 kWp) are mounted to roofs and are fixed in place.

In Europe, most systems on residential buildings are mounted parallel to a pitched roof on a support structure with a standoff of several centimetres for cooling purposes in a 25-35° angle. Sometimes - such as with flat roofs - a separate substructure with a more optimal tilt angle is mounted on the roof.

The installation of PV modules on a roof needs to be realised on a support structure which is usually built by the PV specialist and thus requires roof work. Working on the roof is mostly defined by certain standards which regulate work and safety (e.g. in Germany BGR 203 and

BGV C 22). Furthermore, the functionality (e.g. protection against rain, dust, dirt etc.) of the roofing must be ensured when working on the roof structure (especially flat roofs). This work might require a cooperation with other qualified workers (e.g. roofer).

PV mounting systems consist basically of rails carrying rows of modules. Most modules are mounted vertically or horizontally. The rails are connected to the roof and/or its substructure by means of fastening elements. The solar modules are held to the rails by middle and end clamps. In case of roof-mounted systems the composition of the roof and statics will dictate how the mounting rails or rack should be installed. It must be verified that the roof is capable of handling the additional weight of a PV system; it must withstand the load and forces (e.g. wind, snow etc.).

The expert has to choose the proper area on the roof where the rafters for the PV array must be put. It could be done on the principal rafter or on the roof batten. If rafters cannot be arranged on the roof, the fixing must be done in the attic space but this should be verified in order to ensure the functionality of the roof construction. There are several approved ways to mount PV modules to a support structure (according to IEC 61730-1 clause 12.4). The installation is always based on the manufacturer's instructions using installation requirements and procedures from the manufacturer's specifications.

Before attaching the modules or sub-arrays to the mounting rack the modules, the frame and other components should be checked visually. Depending on the mounting technique a group of modules can also be assembled into a sub-array on the ground and electric parameters can be checked before being moved to the roof as a unit.

While mounting the PV arrays it is necessary to connect the modules electrically. The modules are connected to strings in series or in parallel. The electric connection depends on the size of the system, the type and number of inverters and the shading conditions. Mostly PV modules are connected in series to a string because it is fast and easy and it reduces the wire cross-section. Then, in larger systems, two or more strings are connected in parallel.

The strings will be put through the roof. The electric wiring must be labelled carefully in order to identify the strings and circuits going to the inverter and for future troubleshooting purposes.

Lightning arresters are not necessarily required by technical standards, however, electric shock can occur. For that purpose most manufacturers and some local electrical codes recommend grounding the mounting rack. Therefore, the frame ground wire needs to be attached before the module or sub-array is attached to the mounting rack on the roof.

In the mechanical mounting process first measurements of electric parameters have to be conducted. Below the roof cladding the PV string open circuit voltage, the PV string short circuit current and the PV array insulation have to be measured and documented. The earthing conductor must be low resistant. After the mechanical mounting the installation of the electrical components can be started.

The installation of large systems (more than 30 kWp), especially free-standing systems or solar parks, need specific measures regarding the design, organisation, site work, safety issues and the permission of operation (grid-connection).

The mechanical installation requires the following competences:

- Knowledge in positioning solar panel collectors such as geographical positioning, tilting and azimuth. Knowledge and use of accepted permissible tolerances, use of correction coefficients as required in the event of deviation from acceptable permissible deviations.
- Knowledge in structural analysis.
- Skills in metal working, joining technology and plumbing.
- Skills in system anchoring such as stands, collectors etc.
- Skills in measurement and testing including electrical measurements.
- Knowledge in electrical circuits and electrical installation technology.
- Knowledge in electric protection measures.
- Communication skills and ability for team work.

Work Task 5: Installing of Electrical Components of PV system

The electrical installation of the PV system might be a separate task as it could be executed by other specialists such as an electrician. Of course, a completely trained PV specialist who is allowed to perform electric work can conduct the mechanical as well as the electrical installation. The electrical installation contains wiring, conduits, junction boxes, switches, controllers, inverters and energy meters. Depending on the system other components might be necessary (e.g. chargers or batteries).

The PV installer must always follow and observe all appropriate regional and jurisdictional electric codes. The international standard IEC 60364-7-712 'Electrical installations of buildings - Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems' is of particular significance since it usually provides the basis for such national or regional standards. It sets out rules for ensuring that solar photovoltaic power systems are safe and supply a number of the definitions used in this profile.

The work process contains the installation at the DC side (PV generator and generator junction box to the inverter) and the AC side (inverter to AC installation and grid box as well as energy meter). The electrical installation requires the determination of cableway and preparing the cable routing (slots and wall recess, conduits), sizing cabling, installing inverter, connecting electric wiring to the generator junction box, the DC main switch, the grid box, and installing electric equipment at the energy or utility meter.

The conduits between the generator junction box, DC disconnect switch and the inverter must have the capacity to accommodate the size and number of cables passing through them. The cables used for wiring the DC section of a grid-connected PV system need to be selected to ensure that they can withstand the environmental, voltage and current conditions at which they may be expected to operate. The wiring must be connected securely and tightly to the distribution board, switches and the inverter. The ground needs to be joint to the common DC equipment ground bus.

In case of grid-connected PV systems, the grid operator may require a separate, lockable utility disconnect/isolator switch to be installed near the utility's meter. This disconnect switch is for utility personnel use to take the PV system offline 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 to the electric panel.

Inverters are installed before conducting the complete electric wiring. For service and maintenance purposes, the inverters must be easily accessible. The inverter must be treated as a standard electrical apparatus and is usually earthed as defined in local regulations. The programming must ensure that the automatic protection system operates at defined conditions. Most PV inverters have a display on each unit or a data port for connecting to a computer. These are used during commissioning and to monitor the long term performance of the system if the computer data-logging system is installed. Devices for remote indication of data are often used which can be installed in other rooms and operated by radio communication or power-line.

In grid-connected PV systems the electrical installation ends with the connection of the utility meter to the main switchboard in the building. For metering the gross input of grid-connected PV systems the main switch for the PV installation has to be installed on the main switchboard. For residential installations this is usually the meter box which is normally located outside of the residence and is thus accessible. Most technical standards require that the main switch for the grid-connected inverter enables a complete isolation.

The installation of a PV system must be reported to the grid operator who confirms the operation if the system is installed according to the legal basis. Usually, certain regulations or guidelines have to be considered (e.g. BDEW: Technical Conditions for the Connection to the medium voltage network in Germany).

The electrical installation requires the following competences:

- The formal permission (certificate or licence) to perform electrical work.
- Knowledge in electrical circuits and skills in electrical installation technology.
- Knowledge of PV system, its components and functions.
- Knowledge in operating electrical measuring instruments including voltmeters measuring up to 1,000 volts and a current of up to 200 amperes.
- General knowledge of electrical work safety measures and electric shock protection methods in accordance with the relevant regulations such as an Electricity Act.
- Knowledge in electric protection measures. For example, knowledge of grounding requirements in open air electrical installations in accordance with the relevant regulations.
- Use of safety equipment during the performance of electrical work, including the use of insulated gloves and mats as well as periodic testing of the equipment in accordance with the relevant regulations.
- Skills in insulation testing including insulation requirements up to 1,000 volts.
- Skills in installing inverters and connecting them to the utility grid in accordance with the relevant regulations and procedures.

Work Task 6: Commissioning of Photovoltaic System

The commissioning of the complete system to the requirements of certain technical standards (e.g. IEC and building regulations) must be carried out and documented by the expert. The standard IEC 62446: Grid connected photovoltaic systems – Minimum system documentation, commissioning tests and inspection requirements (DIN EN 62446 or VDE 0126-23:2010-07) describes the minimum operation tests, inspection criteria and documentation expected to verify the safe installation and correct operation of the system. The document can also be used for periodic retesting. It is written for grid-connected PV systems only and not for systems that utilise energy storage (e.g. batteries) or hybrid systems. Additional technical standards can refer to electronic equipment such as inverters which are essential for power installations. Also an interface to the electricity network and the permission to connect the metering are necessary. Although the meter might be installed by the PV specialist, the commercial arrangements need to be made by or on behalf of the client.

The standards have an impact on the commissioning of PV systems as well as the connection to a public grid. The electric utility company providing service to the residence plays a very important role in this process since it may require certain procedures and regulations. Therefore, interconnecting a PV system to the utility grid is not a trivial undertaking. Fortunately, most manufacturers or other professional organisations provide well developed sets of utility interconnection standards making the process fairly easy.

Typically, the competent PV installer verifies that the system has been installed according to the manufacturer’s instructions and related standards. Once the system is installed the PV specialist will run a series of tests to make sure the system is up and running properly. Usually, competent installers use a checkout procedure or an installation checklist to ensure an efficient and complete installation and to carry out the system acceptance test. Later, the installer provides this documentation of the system and the commissioning record and hands them both over to the user or owner.

The inspection and testing of electric circuits is comprehensively covered within the above mentioned technical standards and supporting technical guides, and typically comprises an installation certificate which includes a schedule of items inspected and a schedule of test results. A common commission test sheet contains an installation checklist with the following item: general electrical installation (according to IEC 60364-6-61), general mechanical installation, protection against overvoltage/electric shock, DC system, AC system, labelling and identifications.

Measurements which are necessary at the AC side contain a protective earth conductor, insulating resistance of the wiring at the AC side of the inverter, protection automatic disconnection of supply and grounding resistance. At the DC side the measurement contains these parameters: insulating resistance of PV generator and DC conduction, open circuit voltage of generator and strings, short-circuit current at strings and potential difference.

PV array/string performance tests are recommended to verify performance as a check for faulty modules. These will entail additional tests over and above those set out in the electrical test based on standards. This may require a means of measuring solar radiation for larger installations if radiation levels change during testing.

Once the final physical and electrical inspections and measurements are completed the PV system should start to produce power. A functional test of the solar energy system should be conducted.

Finally, a general electrical schematic must be prepared in order to give it to the building owner (and the electrical inspector) along with copies of the equipment descriptions, operating and troubleshooting instructions and warranties. The electrical schematic includes a drawing of the PV array layout with the specific circuits. At the end of the process the expert will inform and advise the customer on possible uses.

The commissioning task includes the following competences:

- Knowledge of PV system and all components and its functions and operations.
- Knowledge of relevant technical standards and regulations for installation and operation of PV systems.
- Knowledge of electric work safety measures including electric shock protection methods.
- Knowledge in operating electrical measuring instruments including voltmeters up to 1,000 volts and a current of up to 200 amperes.
- Use of safety equipment during the performance of electrical work and periodic equipment testing.
- Skills in inspecting and testing of electric circuits in accordance with the relevant technical standard.
- Knowledge in applying commission reports.

Work Task 7: Installing of Solar Thermal System

Different solar thermal system types exist which can be classified according to the collector types that help produce solar thermal energy for water or space heating or to produce electric power. This includes low, medium and high temperature collectors. Low temperature collectors are those that make use of flat plates which, for example, are used to heat pools. Medium temperature collectors are most commonly applied to heat water for homes and buildings. High temperature collectors involve lenses and mirrors which are often used by solar thermal power plants to generate electric power. The applications, buildings and users of such systems are different. Places and climate are important issues for the operation of solar thermal systems. In colder regions one needs freeze-protected fluid (e.g. propylene glycol). Some systems will include a heat exchanger (in or outside storage). The mounting on the roof is also part of the work process (work task 4). Similar to PV systems the installation has to be clarified if a removal of plaster or sheet rock is necessary. Thus, a lot of variables have to be considered in installing solar thermal (water or space heating) systems. In addition, the components of such systems vary from manufacturer to manufacturer.

Generally speaking the following basic steps for installing a closed-loop solar water (or space) heating system are necessary:

1. Mounting the solar collectors on the roof according to the manufacturer’s instruction (similar to work task 4). Protect the system from overheating; the collectors may have to be covered until the glycol has been filled in.

2. Installing the solar storage tank (including the solar heat exchanger) in addition to or instead of the conventional drinking water storage tank and the boiler. The type of the storage tank depends on the usage of warm water and, for example, possible support of the heating system (multiple-purpose storage). The tank's electrical system shall be installed in accordance with the requirements of the relevant technical standards (e.g. Israeli standard 579/4 - appendix A, sections 49 through 53).
3. Installing the piping and solar pump station for the glycol loop, assembling the entire glycol loop without soldering it and then solder the entire loop afterwards; alternatively you can use a certified press-fitting system. The pump should be installed at the lowest part of the glycol loop. The pump outlet is plumbed to the piping leading to the solar collectors on the roof.
4. Installing the piping for drinking water (pwc, pwh).
5. Installing the control; the differential temperature control must be installed to sense the temperature difference between the water at the bottom of the solar storage tank and the glycol temperature at the top of the solar collectors; optional equipment includes bypass valve, tempering valve, high-temperature radiator loop and rotational speed regulation of the solar pump.
6. Filling and flushing the system (covered collectors or in the darkness) by using a high speed pump above an open container and continue until no air remains in the collector system; open any installed shut-off gates or valves by hand.
7. Observing the permissible operating pressure.
8. Checking system for leaks.
9. Checking the function of the safety equipment (manometer union, safety valve a.s.o.).
10. Checking the expansion vessel and the system pressure; pre-charge pressure has to be calculated (0.7 bar + 0.1x static head in m); top-up heat transfer medium until the system pressure is 0.3 to 0.5 bar higher than the set pre-charge pressure of the expansion vessel (that there is a minimum of 3 litres in the expansion vessel).
11. Checking the electrical connections; checking the tightness of the electrical plug in connectors and cable grommets; checking also cables for damage.

The installation of a ST system requires the following competences:

- Knowledge of ST system and all components and its functions and operations.
- Knowledge of relevant technical standards and regulations for installation and operation of ST systems.
- Formal permission to perform plumbing work and electrical work (installer/electrician).
- Knowledge in health and safety regulations.
- Skills in metal working, joining techniques and plumbing including insulating and sealing plumbing in accordance with relevant technical standards (e.g. Israel 579/1, 2).
- General knowledge of electric work safety measures including electric shock protection methods.

- Skills in testing and measuring ST systems including roof construction, piping systems, water storages, heating systems and electric/electronic devices.
- Knowledge of the need for fair treatment and building a reliable relationship with the customer and awareness to provide the customer with complete and accurate information.

Work Task 8: Commissioning of Solar Thermal System

The commissioning of solar thermal systems is the final part of the installation of this system. This is the point where the system is first operated and checked whether or not it operates safely. As important as the commissioning is a regular maintenance which is also necessary for optimizing the solar thermal system regarding efficiency and reliability. It is also helpful to adapt the conditions of use as an individual setup to the customer's overall system. The process can be described as follows:

1. Starting the system; observing operating instructions of installed components.
2. Venting the solar thermal system (adjust pump for maximum speed, switch it on and off several times); repeat venting process after the system has been in operation for several days.
3. Checking the switching function (via relay test) of the solar control unit (difference temperature switch-points a.s.o.).
4. Setting the required flow rate via pump rate as it has been calculated (high-flow or low-flow).
5. Examining the terms of stagnation (system-pressure, temperature).
6. Prevention of gravity circulation (checkout of backflow preventer).
7. Insulating the water and glycol lines, valves and solar-station (usually as a unit included pump, thermometer and valves).

Usually a functional test is conducted in which key safety and performance parameters are confirmed as operational on a checklist. This signed commissioning report which certifies that the equipment is safe, legal and fit for use in its intended purpose is handed over to the user. Such a commissioning report shall contain the following items: general commissioning (flow and return pipes connected and earthed, pressure test air vent closed, charge pressure of the expansion vessel checked, solar system verified to be free of air, pH level of solar fluid checked, replace solar fluid, frost protection), inspection of the collector array (visual inspection, collector temperature sensor correctly positioned, visual inspection of the mounting structure, visual inspection for leaks carried out at points where mounting structure meets roofing, visual inspection of pipe insulation carried out, wet cleaning of collectors carried out), the solar cylinder (maintenance on solar storage cylinder carried out), programmer (operating hours of solar pump, pump functioning, activation/deactivation temperature difference of solar pump, temperature indicated by all temperature sensors, temperature sensors correctly positioned, maximum cylinder temperature for solar storage cylinder, backup heating is functioning properly), heat meter (period, temperature sensors correctly positioned).

Work Task 9: Handover Solar Energy System to the Client and Instruct Client

The documentation of data and functions of solar energy systems has already started in the inspection and test phase, thus it is part of other tasks. However, the documentation will be described as a proper task in the profile as the handover requires a complete documentation of the system. When the work has been accomplished, the system should be fully checked and tested. Any test results will be recorded on a commissioning record and handed over to the client together with relevant conformity certificates and guarantees. As with other major systems in a home it is essential that the owner has a complete documentation of the system including operating and maintenance instructions. A complete documentation package is an essential part of ensuring the safe and reliable long-term performance of any system installation.

Regarding PV systems the international standard IEC 62446:2009 (equivalent to EN 62446:2009) describes the requirements of the system documentation which a user must receive from the PV installer. At a minimum this documentation should include: system specifications (e.g. date of initial operation, place, and involved firms), electrical schematics and mechanical drawings, parts, material and source lists, data record sheet of the modules and inverter. The documentation should also include installation (description of mounting system of PV generator) and checkout procedures, user/operator training for operation, maintenance, troubleshooting and tools and equipment required to perform these tasks.

This work task finishes off with the instruction of the client. The PV specialist explains the system and its usage. Some manufacturers and organisations provide guidelines for this instruction. They typically encompass the following issues: demonstration of the installation place and the operation and function of the principle components (modules, inverter, utility meter, junction boxes, switches etc.); service telephone numbers; explanations of operational modes (regular and malfunctions); maintenance; inspection and service tests and monitoring of the system.

This work task requires the following competences:

- Knowledge in complete solar energy systems and operation.
- Communication skills and a well elaborated customer focus. In particular ability to explain system and technological processes and operations in an understandable manner.
- Knowledge in preparing and presenting all technical documentations and drafts for the customer
- Ability to train the customer in the operation of the system.

Work Task 10: Maintaining of Photovoltaic System

IEC 60364-6 requires initial and periodic verifications of electrical installations. Specificities of photovoltaic installation (outdoor, high DC voltage, unsupervised installation) make periodic checking very important, albeit maintenance steps and periods are not regulated properly. If the efficiency of the whole system is usually checked in order to ensure the maximum production, manufacturers also recommend performing a periodic maintenance of the equipment. PV system operating conditions involve various environmental stresses such as wide temperature variations, humidity and electrical stresses.

Manufacturers recommend to conduct an annual inspection of the PV modules, array and balance of system (BOS). Since homeowners usually do not have the necessary instrumentation and the electrical knowledge, they might consider contracting with a professional PV installer (or electrician) to maintain and inspect the PV system.

The following items and modules should be checked periodically to keep the PV system functioning correctly in the long run: (1) the mechanical connection between the PV module and the mounting structure should be checked for corrosion and loose components be tightened to specified torque settings. An inspection of any roof penetration and weather sealing should be conducted. (2) The PV modules must be clean and free of dirt and dust. Dirty modules can cause reduced current output. Sources of shade and accumulated dust, dirt and other debris on the array should be removed. Water and a soft sponge or cloth should be used for cleaning. (3) All electrical connections should be checked for corrosion and separation on PV modules (connectors, cables, and grounds). Damaged wires must be replaced. The junction box(es) also needs to be checked for any dirty, loose or broken connections, and needs to be corrected if necessary. Switchgears operating condition and integrity should be reviewed. Functional tests of equipment and auxiliaries might also be necessary.

Maintaining the inverter might also be part of the process. The inverter should be checked for dirty, loose, or broken wires, connections (very important!) and ground faults. The inverter's operating DC input voltage and current level as well as on the AC side the inverter's output voltage and current levels are to be controlled and recorded by using a voltmeter and a DC ammeter. Data might be compared with the data of the last inspection.

In case of any malfunction a troubleshooting of the PV system is necessary. This usually means that a load does not operate properly or not at all, that the inverter does not operate properly or not at all or that the array has low or no voltage or current. The various problems require different actions on the system. For example a lack of power output from the inverter could be caused by a blown fuse, tripped breaker, a broken wire, a ground fault or any of the inverters internal disconnects.

The maintenance task includes the following competences:

- Complete understanding of the PV system and all components as well as functions and operations.
- Knowledge in maintenance concepts and troubleshooting strategies.
- Skills in performing maintenance work in accordance with the requirements of relevant technical standards and safety issues.
- Diagnostic knowledge required in the event of a malfunction – identification and diagnosis while providing reasonable efficient and cost-effective solutions.
- Ability to describe malfunctions orally and in writing.

Work Task 11: Maintaining of Solar Thermal System

Solar thermal systems are almost maintenance free, however, manufacturers recommend having an annual inspection and maintenance every 3 to 5 years. For the inspection and maintenance process the same checklist as for the commissioning process might be used.

During a maintenance or inspection the following items should be checked:

- the collector glazing (cleanness, damages etc.),

- the roof fixings and covering,
- the function of the safety equipment,
- the expansion vessel and the system pressure,
- the electrical connections,
- the switching function of the solar control unit at operation,
- the flow rate at operation,
- the gaskets and seals,
- the frost protection temperature and the pH value of the heat transfer medium,
- the thermal insulation of the pipes and
- the circulation pumps.

The anti-freeze solution should be checked at a 5 years interval and possibly replaced at 5-10 year intervals. Regular de-scaling may be required for the heat exchanger surfaces.

The maintenance task includes the following competences:

- Complete understanding of the solar thermal system and all components as well as functions and operations.
- Knowledge in maintenance concepts and troubleshooting strategies.
- Skills in performing maintenance work in accordance with the requirements of relevant technical standards and safety issues.
- Diagnostic knowledge required in the event of a malfunction – identification and diagnosis while providing reasonable efficient and cost-effective solutions.
- Ability to describe malfunctions orally and in writing.

Work Task 12: Disassembling and Recycling of Solar Energy Systems and Components

Disassembling solar energy systems is the reverse process of mounting the system. With respect to work safety all required standards for roof work and electrical work have to be considered. Up to now, it is not clear which future tasks might have to be performed by the solar energy specialist but it is assumed that solar energy enterprises will be engaged in the disassembly of solar energy systems and selling the scrap material (metal, PV cells and semi-conductors, glass, electronic devices, batteries and other equipment) to the recycling market.

Recycling involves a complex matrix of operational and material-specific systems which include collection, transporting, storing, recycling/producing in (commercial) recycling centres and material recovery facilities as well as marketing, selling and disposal. The various waste material (e.g. electronic waste, metal scrap, glass and semi-conductors) are recycled or disposed of in community-owned or private facilities in a national and international market.

PV modules, for example, contain substances such as glass, aluminium and semiconductor material that can be successfully recovered and reused, either in new PV modules or other products. However, the recycling of solar panels is more complicated than the recycling of other products because of the decades-long intervals between installing and discarding modules, their low concentration of valuable material (e.g. semi-conductors) and their geographical dispersion. An issue with potential environmental implications is the decommissioning of solar cells at the end of their useful life.

Trade in waste material and disposal is - in accordance to legal provisions - subject to the rules of an international market. And despite the presently small waste volumes there are organisations such as PV CYCLE (European voluntary PV recycling initiative) which recommend starting the collection and recycling of PV panels as soon as possible to be prepared for the increase in volume over the next decade.

5 Training Modules

5.1 Methodology

Learning units or training modules are specific standardised learning packages and didactically founded constituent elements of the curriculum. The modules encompass relevant fields of activity related to the identified work tasks within the respective occupational profile. They are complete statements of the competences required for performing the related work tasks including any requirements relating to health and safety, technical standards, work organisation as well as behaviour, communication and collaboration. Hence, they describe what learners should be able to do after completing the module.

In the German case promoting action competence is the key idea of vocational training. Typically, action competence is classified into four broad categories: technical competence, personal competence, social competence and methodological competence - manifesting the scholar curriculum in the dual system (cf. KMK 2011). Firstly, individuals need to be able to use a wide range of tools for interacting effectively within the context of the task and the environment. This includes physical tools of the respective trade as well as information technology and knowledge of technical standards and regulations. They need to understand such tools well enough to use them interactively and to adapt them to the context. Secondly, individuals need the motivation and readiness to use their abilities and skills in various situations successfully. They must be able and willing to take responsibility for managing the task on hand as well as their own development and life autonomously. Thirdly, individuals need to be able to engage positively with others. Since individuals encounter people from a variety of backgrounds in work and life situations, it is important that they are able to interact appropriately and responsibly with heterogeneous people in the broader social context. Fourthly, individuals need to internalise methods which support the self-determined acquisition of further knowledge, skills and competences in order to maintain their employability, to pursue their professional career and to engage in self-development and lifelong learning.

A curriculum and its elements (such as modules) can be designed by different components and criteria. In the project the competence format of the European Qualifications Framework is used because of the international nature of the project cooperation. This means that the module description is realised with three competence dimensions which are knowledge, skills and competences (understood as personal and social competence). Hence, the modules consist of a description of these elements which are related to the work tasks.

Based on the EQF terminology (cf. EU 2008) 'learning outcomes' are statements of what a learner knows, understands and is able to do after completing a learning process which are defined in terms of knowledge, skills and competence. The learning outcome can be understood as the end of training performance expected by the student (learners' competence). Knowledge means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. The glossary of the European Qualifications Framework divides knowledge into theoretical and factual knowledge. Skills means the ability to apply knowledge and use know-how to complete tasks and solve problems. In the model of the European

Qualifications Framework skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, material, tools and instruments). Competence in the EQF language stands for the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations as well as in professional and personal development. In EQF model competence is focused on responsibility and autonomy.

Besides the components of competence other European models can be used for the module development that are the EQF levels and a credit point system (ECVET). Thus, each model can be aligned to a level of the EQF as well as a number of credit points. Since ECVET points shall be determined for a unit of learning outcomes in accordance with the relative value (cf. BMBF n.y.), it requires further measurements and assessment. Originally, it was intended to realise this in the project but due to the limited personnel resources it turned out to be not possible. In addition, the alignment of learning outcomes needs proper instruments at content level enabling the comparison of specific competences with the general competences of the EQF levels. This is a broader research task and cannot be realised in such a practical project team cooperation. Hence, the alignment of modules and learning outcomes can only be done formally. This means that the type of occupation or qualification is formally related to individual levels as in most European countries exist.

Apart from these European tools there are other considerations for the curriculum development. Formulating the modules offers the opportunity to include educational objectives into the technical competence or subject matter description. Usually, any type of VET system and programme is embedded in specific educational strategies and purposes. These educational objectives might refer to all system levels and types of VET. As they set up general objectives, they are usually linked to social and human competences.

Modules can be enriched by other items such as learning contents, assessment tools, learning material and methodology. For example, learning contents provide a good orientation for the teacher and the learner. They are linked to specific technology, technical standards and regulations, health and safety standards, work documents, work organisation and methodology. Usually, they are part of the formulated competences. The recommended contents do not have to be described for each competence but can be combined.

Recommendations on assessment of the competences (methods, tools and criteria) can set out standards against which students must be assessed and provide a clear guide to the student and the teachers/instructors. They must always be derived from the competences as they indicate the outcome of learning and explain the essential quality of performance. The assessment instruments are therefore developed in a way that the students can demonstrate the required competences. It should be possible to assess the competences described in the module using one assessment tool which however can be separated in different parts (e.g. practical work and related theoretical test).

Due to the limited research possibilities in the project, team members decided to design simple modules and focus on the formulation of learning outcomes using the competence model of the EQF. Nevertheless, these modules can easily be used for further elaboration. The most suitable approach for determining the modules is the simple transfer of the identified work tasks as one into a module using the three elements. Every title of the work tasks can be used as a module if the identified complex work tasks of the experts' workers workshops are well elaborated in terms of representing clear selective tasks with a defined beginning and end. However, there might be some doubts in single cases. In principle, there are two alternative ways: Firstly, two or more work tasks can be combined to produce one module. This can be the case when some work tasks are too small. Secondly, one complex work task can be split up into two or more modules. This can make sense if the complex work task covers many sub-tasks or work activities and is very demanding and time-consuming.

The modules developed in the project are described in the following section. A complete description of all possible training modules is not provided. Moreover, the selection and formulation of skills, knowledge and competence is a result of the discussion of the project teams and therefore can be designed differently.

Note: The concept of modules or learning outcomes and some examples listed below were presented to the Israeli team in bilateral meetings in Germany and Israel. The Israeli team has designed some examples of learning units that were focused more precisely on the current conditions of curricula in Israel. In the final stage new expectations, in particular from the responsible ministry, were communicated. It was expected that the project team cooperation shall design a complete curriculum taking into account the requirements in Israel. Therefore, the curriculum shall entail learning objectives, contents, equipment and learning material, statements on assessment, requirements for teaching and learning and a teacher profile for solar energy. This approach has not been discussed before and not agreed. As a consequence, the training modules have not been merged as a further clarification of curricular concepts and time for elaboration is required. The examples of the modules only represent the work of the German team.

It was discussed to design the training modules in accordance with the new structure of *Lernfelder* (cf. KMK 2011). Due to the international approach the teams decided to formulate learning outcomes using the EQF model. The following modules can be transferred to the *Lernfelder* format.

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 ▪ have knowledge of machines and tools including their designs, uses, repair and maintenance; ▪ have 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 to 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 decisions 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 on 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 coordinate 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 start 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 decisions 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 decisions 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.

6 Learning Situation

6.1 Concept and Methodology

The main work tasks of the occupation have been identified, described and transferred to training modules (or learning units) using the elements of the EQF. In the next step, modules had to be transferred into learning arrangements. The German project team used the didactic approach called learning situation which is nowadays common in vocational schools in Germany (cf. KMK 1996; 2011).

Learning situations are didactically and methodologically planned teaching and learning arrangements which focus on real problems or tasks of the occupation with the purpose of initiating the action-oriented learning process. They are thematic units derived and developed from the modules. Thus, the modules are broken down into a series of learning situations to achieve the expected competences. The sum of learning situations developed for each module should cover the competences and contents of the entire module.

The development of learning situations is based on the competences which are itemised in the work tasks. These tasks are translated into competences setting up the modules. Each learning situation focuses on the accomplishment of a real task or problem of the occupation. The phases of each complete learning cycle are similar to the phases in work situations and actions in real life. Each complete action requires solving a characteristic problem of the occupation, commonly a typical work order, customer request (e.g. “a customer requests the maintenance of his car”), manufacturing task, maintaining tasks or other service. In accordance with similar models in Germany, the complete action was structured with the elements shown in the following figure:

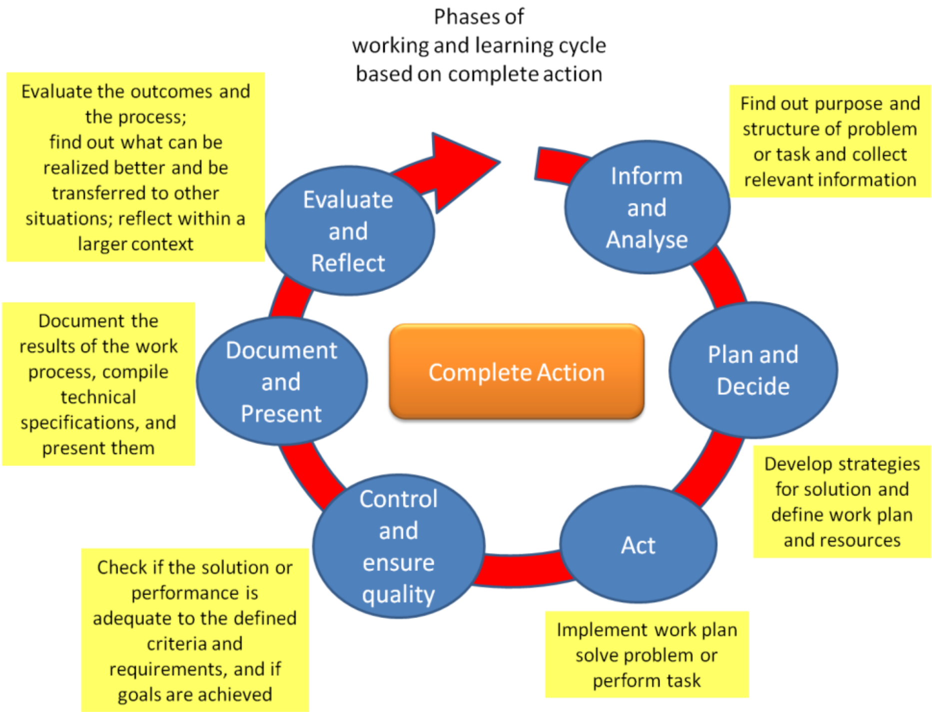

Figure 6: Cycle of complete action

While performing the complete action from the beginning to the end, the phases of the above described working and learning cycle have to be passed through. The inner process of learning situations follows these phases and supports the learner methodically in building the necessary competences to successfully perform the task: the required professional (technical) knowledge and skills together with the necessary human (personal), social and methodological competences.

Learning situations have the aim to support not only the development of knowledge and skills of learners. They also promote the necessary competence to transfer and apply knowledge and skills to work and life situations: to be willing and capable to take adequate actions. Achieving the competence to take action should be one important goal in every type of vocational education and training as it is the core of vocational competence.

To summarise, learning situations typically applied in German VET schools are the didactic concept for implementing a competence-based training approach. It has the following main benefits:

- Correspond to occupational situations and work tasks or problems (labour market relevance and practice orientation);
- promote active learning strategies;
- combine theoretical with practical learning;
- refer to the complete working and learning cycle (holistic process);
- offer the flexibility to consider local school specifics and company specifics (e.g. resources, regional demands, business fields, work processes) and thus foster cooperation;
- promote learning in groups and teams and the required social competences (cooperative learning);
- empower self-organisation, self-reliance as well as responsibility and incorporate self-evaluation and reflection (personal competence);
- offer the flexibility to respond to individual learning needs (different learning styles);
- develop the whole person and prepare the student for lifelong learning (educational objectives);
- combine specific vocational objectives with general educational objectives;
- consider issues which are significant for life and the society.

The project team developed a format in order to systematise and make the didactic planning explicit. In the format we use the following items:

- The title of the learning situation representing the work task or problem.

- The description of the learning situation which focuses on the task or problem and provides more information for teachers and learners.
- Selected competences specified in a matrix which contextualises the more general competences of the modules.
- Learning contents which support the scope of learning for teachers and learners.
- A methodological reference based on the cycle of the complete action and considering learning methodologies and aids.
- Key questions representing the fundament of knowledge to be generated.
- Evaluation or assessment tools and criteria.

The following section shows some examples of learning situations developed by the German team. Due to the fact that this took place at the end of the project a joint German-Israeli development of learning material and a more profound discussion about competence-based learning arrangements was not possible.

Figure 7: Analysing an existing PV system (own picture, example from a vocational school in Germany)

6.2 Examples of Learning Situations

Module 1: Designing and sizing a solar energy system

Module No 1	**LS No 1**	Time Frame: 5 hrs
LS Title: Analysis of an energy supply system considering current economic and ecological factors		

Description of the learning situation:

To prepare the students for the complex study content “photovoltaic”, it is necessary to give them the following information at the start:

- illustration of the nationwide energy supply (energy mix)
- description of the problem of the current climate warming due to extensive CO_2 emissions and the resulting global economic and ecological effects
- current number of jobs in the sector of renewable energy and explanation of future job prospects
- educational objectives of the unit “photovoltaic”
- structure and content of the single lessons
- performance requirements and assessment criteria

Competence Matrix for LS

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- Basic knowledge of the energy supply of the country and the percentage of RE sources - Knowledge of the potential to supply the country based on RE sources - Awareness of the personal CO_2 footprint and the global effects of climate warming - Recognition of future job prospects if the students have knowledge of renewable energies	- Compiling own CO_2 footprint with the use of an online programme - Gathering of necessary information on climate warming, energy consumption, energy mix and current labour market statistics - Analysis of the facts and drawing of the conclusion that an energy transition is necessary -	- Sharing current data, facts and figures - Assessing the necessity of the course “photovoltaic” in terms of their job prospects, economic and ecological challenges and the necessity to think globally and to act locally

Contents:

- Potential to secure the energy supply of your own country ecologically and sustainably
- The country’s energy consumption, energy mix, types of energy supply and their prospects
- Political, economic and ecological challenges to fulfil the climate agreement according to the Kyoto Protocol
- Current labour market in the energy sector
- Information on course structure, contents, methods, assessment and educational objectives

Methodological Reference:

Steps of complete action	*Description*	*Methodology*	*Resources*
Inform and analyse	- Obtain an overview, e.g. energy consumption, energy demand, energy mix - employment figures and job prospects - students shall realise the necessity to act - job security	- teacher-centred lecture - teacher shows short film clippings illustrating the environmental problems caused by CO_2 emissions.	- internet for underpinning statistics on the labour market situation of the energy sector, the energy consumption, energy mix etc. - sources: e.g. environmental agency, ecology groups, energy suppliers, central bureau of statistics - movie „An inconvenient truth” (Al Gore) on global warming

Plan and decide	- students collect and check relevant data as well as search for online tools to determine their individual CO2 emission - searching for methods to reduce the CO2 emissions	- Online research	- computers and internet access
Act	- students determine their own CO_2 footprints. - students prepare a short presentation of the (energy) data) they have collected	Individual work: - Student determines his/her own CO2 footprint - Research in small groups	Onlinetool: http://www.fussabdruck.de/
Control and evaluate	- within the small groups the gathered results will be questioned critically and – if necessary - revised	- work in small groups	
Present, reflect and document	- the small groups present the researched data to the whole class. They show methods of how to reduce the CO_2 emissions. The results will be discussed and reflected in class. - afterwards, the students begin to compile a project folder	Individual work: - every student starts to compile a project folder. - filing of the gathered data and information - record first results	Brochures and further information

Key questions: - What are the means of energy supply in our country? - How high is the potential to supply our country with renewable energy? - What is necessary to reduce the amount of CO_2 emissions? - What can every one do to contribute to reduction of emission? - Which competences can I gain from participating in the course „photovoltaic"? - What are the advantages for my company when I pass this course?
Evaluation/assessment criteria and tools: - Active participation in lessons - Compilation of a project folder

Figure 8: Analysing the situation at the customer's site (own picture, example of a VET school in Germany)

Module No 1	**LS No 2**	Time Frame: 5 hrs
LS title: The customer meeting – recording customer requests professionally using the example „specialist counselling and support planning a PV unit		

Description of the learning situation:
This learning situation focuses on simulating a customer order as authentically as possible. The customer order is used as a learning carrier to which the technical learning contents on photovoltaic are connected.

Competence Matrix for LS

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- knowledge of the functional principle of photovoltaic system - command of the basic rules of communication - connecting the students' previous knowledge gained from their operational experiences and transferring these to a new learning situation	- compiling a questionnaire to be able to respond to individual customer requests - taking notes documenting the customer meeting (or recording the customer meeting on film) - getting a general idea of the scope of an order - founding dummy companies to work in small groups as a team - analysing the customer order	- empathy – the students enter the customer request and order - in case of queries, the students ask further questions to make sure the collected customer information is correct - ability to reflect – the students evaluate the customer meeting and realise that they do not have the necessary expert knowledge to process the order

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform and analyse	- the teacher informs the students about the upcoming meeting with the customer	- short introduction/ information phase by the teacher	
Plan and decide	- discussing possible questions on entering an order - compiling a list of questions	- Brainstorming: compiling a list of questions – „which information do we need from the customer?“	- Blackboard or whiteboard to compile a mind map
Act	- client interview/ determination of the customer's requests - a fictitious but authentic customer comes to class and asks the students to draw up an offer for the installation of a photovoltaic site on his/her apartment building; this offer should be written out by the end of the week to be presented to the customer - the customer provides information on: - the location of the house - the nature of the roof (types of roof tiles, interior insulation etc.) - shadowing of the roof area - size of the roof area, the slope of the roof and the north-south alignment of the building - the customer's budget - the customer's motivation to buy a photovoltaic site - interconnection point of the energy supplier, location of the commercial academy - location of the power distribution panel - possible wire routes	- role play "customer meeting" - notice: the customer must be chosen carefully and needs to be provided with the necessary information. - the teacher changes his/her role: from lecturer to moderator	- pictures of the building - building plans - video camera to record the customer meeting

Control and ensure quality	- adjustment of recordings/ answers in the questionnaire - clarification of (diffuse) information given by the client - developing a concrete project order - compiling a specification sheet and an offer due at a specific date	- discussion in class *methodological advice:* - at this point, the founding of dummy companies, competition is recommended - a healthy competitive behaviour boosts the performance of the students	
Document	- securing of intermediate results - analysis of the order/customer requests are written down	- work in small groups (dummy companies)	- 1-2 computers per group
Evaluate and reflect	- vote in the plenum, „what are the next steps?“	- plenary session	

Key questions:

- What does the customer exactly want?
- What is the budget for the realisation of the (fictitious) photovoltaic project?
- What are the framework requirements (roof area, slope of the roof, alignment etc)?
- Are there any complications that should be anticipated (kind of roof type – slate?, monument conservation, shadowing…)?
- What can every single student contribute to make the project a success? Which team member has already gained some operational experience?
- Who is responsible for which task and when will she/he present the results to the group?
- Which knowhow do the students need? Which theoretical contents do they need to learn to be able to compile a professional offer?

Evaluation/assessment criteria and tools:

- Active participation in lessons
- Compilation of a project folder
- List of questions

Module No 1	**LS No 3**	Time Frame:12 hrs

LS title: Technical analysis of a PV system

Description of the learning situation:

Some students have already gained experiences in the photovoltaic sector, others have not. In addition, there are different types of photovoltaic installations. Some operators use the generated electric power only for their own personal need (isolated operation), others sell the electric power completely. And other installations are run in hybrid forms. The students shall explore these existing installations and use the experiences gained for the customer offer.

Moreover, this learning situation focuses on the acquiring of the physical basics. The students shall not only write up an offer, they should also be able to advise the potential customer on expert knowledge as well as technical interrelationships and the functional principle for the generation of energy.

The students shall gain the knowledge in practice lessons (activity-orientated, hands-on learning) and be able to transfer and use the gained knowledge to generate energy with a functioning photovoltaic installation.

Competence Matrix for LS

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- knowledge of the three kinds of possible applications of photovoltaic installations (isolated operation, system with full feed-in, hybrid system/mixed mode) - command of the basic rules of communication - connecting previous knowledge and transferring it into the new learning situation (types of circuits, laying methods, electrical grounding…) - recognising the used components (photovoltaic modules, inverter, fuses, meter, sub-distribution…) - asking the operator about the planning processes and official regulations - knowledge of the physical principle of photovoltaic - knowing that the location is an important fact for the calculation of the cost-effectiveness - knowledge of the single components which are necessary for a photovoltaic installation and ability to explain their functional principles	- compiling a questionnaire for the exploration and inspection of a site - taking notes (or recording on video) while exploring the site and evaluating them afterwards - getting a general idea of the functional principle, installation possibilities and general requirements for the installation of a photovoltaic unit - carrying out the transfer, e.g. the students are able to use the newly gained knowledge for their “order” - students are able to estimate the economic dimension - students are able to start-up a small isolated operation or a small photovoltaic unit correctly and to feed energy into the public grid	- in case of queries, the students ask further questions and make sure to have all the necessary and correct information from the operator - reflecting ability – they evaluate the inspected installations taking into account cost effectiveness, technical execution, quality of the used components - they inform each other about newly gained knowledge. - recognising that the students themselves are responsible for their own learning progress; they experience self-efficacy and learn to learn independently

Contents:

- Exploration and inspection of the site; professional behaviour towards customer
- Compiling a questionnaire, clarifying interests and needs
- Official (governmental) authorisation procedure
- Types of photovoltaic installations: isolated operation, system with full feed-in, hybrid system/mixed mode (own use possible)
- Quality and extent of the installation works (DIN/VDE compliant, aesthetics, present utilization value, etc)
- Physical functional principle of the transformation of light into electrical energy
- Effects on the output of the photovoltaic module due to the North/South alignment, slope of roof, outside temperature, shading
- Efficiency of different module types
- Connection and circuit types (series and parallel connection)

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform and analyse	- planning and exploration and inspection of a site - compiling of a list of questions - clarification of rules of conduct - students find appropriate means to record the results (minutes, audio or video documentation) - exploration and inspection of the site - operator of the photovoltaic site provides information on – for example: - location of the building, - condition of the roof (kind of tiles, interior insulation etc.), - cost effectiveness (compensation for electricity fed into the grid), - size and costs of the installation, - authorization procedure and official constraints/regulations, - motivation for buying a photovoltaic installation, - interconnection point of the energy provider, location of the commercial academy - location of the electric circuit distributor, cableways - planning, construction and start-up of the installation - complications and problems that might occur during the assembling	- teacher gives a short introduction/ information phase. - work in groups: compilation of a list of questions or an exploration worksheet respectively - exploration and inspection of the site including interviewing the owner in small groups	- teacher has contacted 3-4 different operators of photovoltaic installations and has arranged an appointment for a visit - blackboard or a shared whiteboard for drawing up a mind map - a competent operator on the site - pictures of the installation(s) - construction plans of the installation(s) - video camera to record the interview with the operator
Plan and decide	- assessing the site visit: - students analyse their newly gained knowledge and check how useful it is for their “customer order”. - during the assessment off the site exploration new technical questions can arise; these technical problems can be solved by experimental simulations	- work in teams - discussion of problems in class	- classroom with multimedia equipment
Act	- solving technical problems by practically setting up and commissioning sub-systems: - basics of photovoltaic; conversion of solar light into electrical energy via photovoltaic cells (series connection of photovoltaic modules, parallel connection of photovoltaic modules, shading of modules, efficiency of modules due to the inclination	- “station cycle”: in small groups the students carry out little experiments at different stations the teacher has set up	- prepared worksheets for the experiments - ammeter, voltage meter, photovoltaic modules, inverter, battery to store electrical energy for isolated operations, charge controller, compass, blanket - location: outside, e.g.

	and North/South alignment) - structure of a small battery-buffered isolated operation - start-up of a 1 kWp photovoltaic unit including the connection of all necessary components, followed by the feeding of photovoltaic electricity into the public grid		schoolyard
Control	- students adjust the measured data to the information gained from the site visit and check the plausibility. They prepare a short	- work in small groups	- classroom - completed worksheets with the correct solutions
Present and document	- small groups of students present their measured data in front of the entire class; the group can discuss the explanations, functionality and the reference to existing installations	- presentation of the group results in front of the whole class - correction of the first results if necessary	- PowerPoint presentation
Feedback	- students shall give feedback on the purpose and practical value of the experiments	- individual work	- prepared feedback worksheets (sighting disk or similar)

Key questions:

- Which types of installations exists?
- Which official constraints/regulations need to be taken into account?
- Was the operator able to answer all of the students' questions sufficiently?
- Were there any problems when the installation was built?
- What can every single student contribute to make the project a success?
- Which knowhow are the students missing after visiting the installation site? Which theoretical contents need to be learned so that the students can write up a technically first-class offer?
- How can solar light be used to produce energy?
- How do the modules perform in a series connection and in a parallel connection?
- What effect does the correct alignment of the modules have on their performance?
- Why do you have to consider even the smallest shading or contamination of the modules when planning a photovoltaic installation?
- Which role does the outside temperature play in reference to a top performance?
- Which components are necessary for the different installations and how do they need to be connected?
- Which fuse elements are essential?

Evaluation/assessment criteria and tools:

- Active participation in lessons
- Quality of the questionnaire
- Quantity and quality of the experiments (commissioning of sub-systems)

Module No 1	**LS No 4**	Time Frame: 16 hrs

LS title: planning and calculation of the installation, consignment of the material, placing an order

Description of the learning situation:

This learning situation focuses on the planning of the customer's site. The students have the technical knowledge and access to the necessary object descriptions. With the help of a simulation software and current information from the internet (price listings, datasheets of the modules and inverters) they plan the customer's unit. The students determine the installed PV performance, choose the appropriate inverter and the total effectiveness of the PV unit. The following step focuses on the procurement of the customer's site. The students choose the appropriate sub-quantities and products from the assortment for a fictitious order. After a rough planning the students will record the necessary material and list them systematically. During this learning situation, the students are expected to hand in a complete list of material. Afterwards they shall assess the economic feasibility.

At the end of the learning situation, the worksheets completed so far will be collected, the order written up and presented to the customer. As a conclusion, a comprehensive reflection and evaluation of the learning situations of modules 1 and 2 will be conducted including the procedure, contents and circumstances.

Competence Matrix for LS

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- students know that for different performance levels and appliances appropriate types of conductors/cables and cross sections have to be calculated - they are aware of the appropriate technical components which are necessary to operate a PV unit. - students ask the mains operator about the current compensation for electricity fed into the grid - they know which components and systems they need for their offer - they know how to compile a list of material - they know the wage per hour which their employer usually uses for calculations - they know the contents and parts of an offer	- according to the module data sheets and the area at hand, the students determine the maximum performance of the PV generator - they determine the number of modules and inverters necessary for operating the system - they simulate „their system" with the help of simulation software - they determine the length of the conductors/wires and the cross-sections - using catalogues and websites (e.g. of wholesalers), students determine the numbers, components, data, order numbers and the final price/volume that they need for their PV unit. - presentation of the offer, explanation of the different offer sections, answering questions of the customer	- students assess the choice of PV components and optimise the first drafts by running another computer simulation using different components - in small groups, students discuss possible solutions and find compromises together - they assess the choice of PV components and determine the scope of delivery for the planned PV unit. - they discuss the price-performance ratio as well as the economical and ecological use of their PV unit - they present their offer to the customer including explaining all ideas involved; the offer will be handed over to the customer in a folder

Contents:

- Using of the simulation software, e.g. PV*SOL of the company Valentin or Sunny Design by SMA
- Calculating the area at hand for the PV unit
- Determining the possible performance of the PV generator
- Calculating the number of modules which can be installed on the area at hand
- Calculating the number of inverters appropriate for the system
- Simulating different module-inverter-combinations
- Calculating the length of conductors/cables and cross-sections of the cables
- Determining the total effectiveness
- Calculating the annual energy quantity [kWh/a]
- Compiling a list of material
- Calculating the cost of components
- Calculating the employment costs (including set-up time, drive to the location, value added tax)
- Calculating the total sum / cost estimate of the PV unit
- Determining the number of inverters appropriate

- Writing up an economic efficiency calculation – taking into account the current costs for loans
- Putting all of the compiled documents together as a final offer and presenting it to the customer in a personal talk
- Feedback after the customer has assessed the offer
- Evaluation and reflexion

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform	- The teacher informs the students about the content of this learning situation - the teacher introduces the students to the simulation software - the teacher explains the major parts and components of an offer	- short introduction / information phase by the teacher - presentation of the simulation software with the help of a beamer	- projector, at least two notebooks per student group (dummy company) with an internet access - simulation software, e.g. PV*SOL of the company Valentin OR Sunny Design by SMA
Plan and decide	- students begin to develop their working strategy; they compile a to-do-list and divide up the different tasks among the group members	- work in small groups	
Act	- students start to determine the size of the roof according to the data the customer has provided; they calculate the possible solar performance and the PV generators performance according to the data sheets of the different PV modules - they run a simulation of the PV unit using the simulation software (on basis of the components chosen from the internet) - they determine the total effectiveness and calculate the annual electrical energy generation - students discuss the labour input and determine the hours of work which are necessary for the journey times, planning, set-up time, installation, inspection and acceptance and preparation of all documents	- the teacher supports group work and answers questions;	- websites of well-known producers of PV modules and inverters - information and daylight hours to be expected as listed on the website of the meteorological service - book of tables or formulary to determine the kind of conductors /cables and conductor cross-sections, also formulas to calculate the total effectiveness - laptops or computers - websites of well-known producers, assembly robotics (rails, roof bolts, screws, fasteners…), wires, automatic cut-out, lightning arrester, distribution box, meter… - catalogues including price lists, e. g. of wholesalers - telephone for calling a producer, if necessary
Control and ensure quality	- students present their first calculations to the teacher and discuss costs and earnings/ returns; rough miscalculations can be corrected at this point - the concrete commissioning of the needed material for the PV	- work in teams / groups - the teacher gets an overview of the learning progress of the students	- classroom - computers with standard software (Word, PowerPoint, Excel)

	unit follows - further economic efficiency calculation will be done. - (compare to „fine-tuning“)		
Document and present	- compilation of a presentation folder with the offer: - cover letter - electric circuit plan - list of material - assembly time and costs - economic efficiency calculation - data sheets	- work in teams / groups	- a sufficient number of computers - printer - presentation folders
Evaluation/ reflection	- students hand over their presentation folder with the offer to the customer; they explain their ideas and accomplishments promptly and are available for further enquiries - together with the teacher the customer checks the written offer; afterwards, they give their feedback - evaluation „extension of professional competences“ - at the end, the whole course shall be reflected, the students also give constructive feedback; possibilities for improvements are derived to ensure a continuous high quality and to optimise PV courses that will follow	- Presentation given by the student(s) / conversation with the customer - feedback on the offer, given by the teacher and the customer - written exam, taken individually. - reflexion round (writing and/or orally); possible contents: - organisation - material - expert contents - behaviour and methods of the teacher	- visual inspection and control of the offer - prepared final written exam - prepared reflexion/ feedback sheets - keeper of the minutes who records the oral contributions and inputs

Key questions:

- What is the size of the available (roof) area?
- How much energy can be produced with the available area?
- What size do the single modules have and how many of them are needed?
- Which inverter is appropriate for these modules and how many are needed?
- What are the distances between the solar modules and the inverter? What are the conductor / cable lengths?
- Which voltage, electric currents and output can be expected?
- Which laying system, kind of conductors and cross-sections should be used?
- What should the dimensions of the conductors between the inverter and the point of the terminal port/main distributor be?
- Which total effectiveness will the unit reach?
- How many full load hours of the PV unit can the customer expect?
- Can the PV unit be optimised – e.g. by an improved alignment of the modules/inverters?
- How many of the components/modules/… are really needed?
- What are the costs for the entire material and where can it be bought for the best and lowest price?
- How many working hours should be expected and what do they cost?
- Which costs should be taken into account additionally (scaffolder, costs imposed by the energy provider for accepting the produced energy into the grid,…)?
- Which other costs can the customer/operator encounter (insurance, tax charges,…)?
- When would the PV unit be written off / amortized?
- Which conclusions can be drawn from an economic and ecological point of view?

Evaluation/assessment criteria and tools:

- Active participation in lessons

- Quantity and quality of the commissioning - Quantity and quality of the offer (written assessment) - Quality of the presentation of the offer (oral assessment) - Final exam (written assessment)

Module 6: Learning situations for installing a solar thermal (ST) system

Module No: 6	**LS No: 1**	Time Frame: hrs
LS Title: Solar thermal system for drinking water heating		
Description of the learning situation: A client has asked for advice and counselling on a solar thermal system for drinking water heating. He needs further explanation on the basic functions of a solar thermal system, its components and on potential energy savings taking into account the energy-efficiency of relevant parts.		

Competence Matrix for LS

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- knowledge on radiant flux and sunshine duration depending on the customer-specific conditions - knowledge on installation, mode and method of operation of the components and the entire system - knowledge on layout/ dimension of ST system - knowledge of energy and operating costs	- selection and analysis of technical literature and manufacturer documents - compilation/ filling-in of checklists - use of simulation software	- independent obtaining and use of the necessary information via the instructor, school and media - independent request of information - presentation skills - advisory skills - self-contained compilation of predetermined checklists - guided use of software

Contents:

- Occupational safety: knowledge of how to safeguard solar thermal systems (pressure/temperature)
- Accident prevention: fitting on roofs / frontage of the building – protective clothing, construction of the scaffolding, anti-fall guard
- Automatic control technique: sensors, actuators, function of the controller - if possible a continuous-action controller.
- Legal rules and standards - for example EnEV (decree on energy saving): minimal insulation thickness of plumbing (and heat storage), the application of high-efficiency pumps

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform and analyse	- naming of technical possibilities for using solar energy - gathering of the relevant data on the actual situation (technical basic condition, energy consumption and costs)	- use of information, advertising folders, brochures and other documents for a better visualization	- manufacturer‘s documents
Plan and decide	- selection of technical auxiliary material (brochures, checklists, software) - listing of the advantages and disadvantages of the components depending on the use and the given basic condition - compilation of a cost	- counselling of the client - giving of a recommendation - reaching a mutual decision	- plan, photos, drawings - apprenticing company - manufacturer’s instructions and techncial standards

	estimation		
Implement	- networks (your company) - manufacturer documents - accident prevention regulations - EnEV (*decree on energy saving)*		- apprenticing company - manufacturer‘s instructiopns and technical standards
Control and evaluate	- considering of prospective problems (conditions of space and installation) - checking of all the relevant layout criteria - budget and cost level - feedback	- composition of a requirement specification (if applicable checklist) and carrying out of the listed duties	- plans - assessment of costs - price list
Document and present	- project report including a presentation	- - project presentation and handing in of the documentation (project folder)	- brochures - project folder - slides, power point file etc.
Reflect	- feedback (self-reflection, learner and instructor feedback) - evaluation (of the presentation and the documentation)		

Key questions:

- How does the use of solar energy for the heating of drinking water work?
- Which components and parts do you need and how are they used in a solar thermal system for drinking water heating with consideration of the energy efficiency?
- How and in which parts do the types of collectors and accumulators differ and what are the advantages, disadvantages and the possibly applications of every single one?
- Does the state provide any subsidies and are there any legal restraints on the use of solar heat?
- Which other application fields for the use of solar heat (next to its use for heating up drinking water) are currently technically possible?

Evaluation/assessment criteria and tools:

- completeness of the action and the finished task
- structure and design of the documentation including the presentation
- naming of all sources and auxiliary material (checklists, software, websites etc.)
- self-reflection and feedback given by learners and co-learners

Module No. 6	**LS No.: 2**	Time Frame: hrs
LS title: Installation of a solar thermal system for drinking water heating		
Description of this learning situation: The client is pleased with the advice you have given and asks for the installation of a solar thermal system for drinking water heating as well as if applicable the processing of the application for support to receive local or government-funded subsidies.		
Competence Matrix for LS		

Professional / Technical Competence		Personal and Social Competence
Knowledge	Skills	
- knowledge base on applying for support for the system layout the client asks for (system size and function) - skills and safety regulations for working on roofs - parts list	- compiling and filling in of applications for support - selection and analysis of specialist literature and manufacturer’s documentation on functions and installation of the components	- obtaining/using the necessary information on process planning and execution through the instructor, school, manufacturer and media - training of presentation

- list of tools needed including safety-related functional testing - order of installation • installation of the substructure and the collectors (OR: thermo photovoltaic device) taking into account the specifics (module for roof mounting/roof integrated, flat plate collector/vacuum tube collector) • installation of the storage unit for solar energy, the solar station (including pump and safety fittings) and the interconnection to the collectors • installation of the solar controller and sensors - implementing of the system • purging of the solar circuit including a leakage test • filling with solar fluid (glycol mixture) and professional airing of the facility • setting of the operating pressure (including the primary pressure of the diaphragm type expansion tank MAG) • setting of the volume flow rate (pump) • setting of the controller - thermal insulation of the tubing	- accident prevention regulations - knowledge of minimal insulation thickness (according to the Energy Saving Regulation) and choice of insulating material	and consulting skills and techniques - compiling of given applications for support, check lists, measurement sheets independently

Contents:

- Occupational safety: knowledge of how to safeguard solar thermal systems (pressure/temperature)
- Accident prevention: fitting on roofs / frontage of the building – protective clothing, construction of the scaffolding, anti-fall guard
- Automatic control technique: sensors, actuators, function of the modulator
- Legal rules and standards - for example EnEV (decree on energy saving: Energy Saving Regulation): minimal insulation thickness of plumbing (and heat accumulators)
- Handling of the heat transfer medium and its disposal (glycol mixture)

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform and analyse	- naming the possible sources of funding of solar energy - specifications due to the accident prevention regulations - specifications of the components (weights and measures, time of delivery)	- internet research - handling of applications for support - use of information in the manufacturer's documentation and from documents of projects which have already been conducted - contact to the manufacturer (via telephone or internet)	- Internet - manufacturer's documentation - revision documents - planning documents - manufacturer's distribution channels
Plan and decide	- determination of the necessary work steps - consideration of the local conditions and	- compiling of check lists - working with manufacturer's documentation and	- templates / model examples - plans / photos / drawings

	circumstances (roof height and slope, power supply, entrance width etc.) - organising the necessary tools / safety procedures - ordering /delivering the necessary material	planning documents - contact to the manufacturer (via telephone or internet)	- training company - manufacturer - standards
Implement	- networks (own company) - manufacturer's documentation - accident prevention regulations - Energy Saving Regulation	- e-learning / use of an internet platform (e.g. moodle)	- training company - teacher and classmates - manufacturer - standards
Control and evaluate	- considering problems that might arise (available space and installation conditions) - completeness of the material and tools - alignment of plans and actual installation regarding complexity and costs	- working off a specification sheet (if applicable a check list) - calculation / comparison of the planning (offer) and the actual cost of material and expenditure of time	- offer / actual cost of material and expenditure of time
Document and present	- adding the presentation to the documentation or plans	- role play: presentation of the project and handing over a documentation (project folder)	- brochures - project folder - slides/PowerPoint presentation (or similar)
Reflect	- Feedback	- self-reflection, student and teacher feedback - evaluation (of both the presentation and documentation)	- project folder - slides/PowerPoint presentation (or similar)

Key questions:

- Which sources of funding exist? How can a client receive the funding?
- Which components and parts are necessary for a correct, fail-safe, reliable and durable functioning of a solar thermal system? And how can it be integrated into a new or an already existing heat supply system?
- In which ways does the installation of the different types of roof-mounted or integrated collectors and the different storage types differ?
- How can you avoid gravity circulation in the solar circuit?
- Which insulation material is suitable for solar thermal systems (inside a building/on the roof)?

Evaluation/assessment criteria:

- completeness of action and order (structure and sequence)
- consideration of the possible sources of funding and legal regulations
- presentation (visualization and content)
- structure, content and illustration of the documentation
- naming of the sources and auxiliary material (check lists, software, URLs…)
- self-reflection and feedback given by the classmates and teacher

Module No: 6	**LS No: 3**	Time Frame: hrs
LS title: start-up of a solar thermal system for heating drinking water		
Description of the learning situation: The successful installation of the solar thermal system is followed by the start-up of the site as well as the handover to the customer and his/her instruction.		
Competence Matrix for LS		

Professional / Technical Competence	Personal and Social

Knowledge	Skills	Competence
- skills and safety regulations for working on roofs - parts list - list of tools needed including safety-related functional testing - start-up of the system: • purging of the solar circuit including a leakage test • filling with solar fluid (glycol mixture) and professional airing of the facility • setting of the operating pressure (including the primary pressure of the diaphragm type expansion tank MAG) • setting of the volume flow rate (pump) • setting of the controller - customer instruction (function of the components and information on operational and safety-related data such as pressure, temperature and volume flow rate) including maintenance requirements and necessary post ventilation	- selection and analysis of specialist literature and manufacturer's documentation on functions and installation of the components - accident prevention regulations - knowledge of minimal insulation thickness (according to the Energy Saving Regulation) and choice of insulating material - energy optimization (pumping rotation speed / volume flow gauger) - knowledge of the ideal operating range of solar fluids (pH value, antifreeze protection, boiling point / vapour pressure curve)	- obtaining/using the necessary information on process planning and execution through the instructor, school, manufacturer and media - training of presentation and consulting skills and techniques - instruction of the customer (including a record/protocol) - compiling of check lists, measurement sheets independently - compiling of a start-up record/protocol independently compiling of a presentation independently (instruction)

Contents:

- Occupational safety: knowledge of how to safeguard solar thermal systems (pressure/temperature)
- Accident prevention: fitting on roofs / frontage of the building – protective clothing, construction of the scaffolding, anti-fall guard
- Automatic control technique: sensors, actuators, function of the modulator
- Legal rules and standards - for example EnEV (decree on energy saving: Energy Saving Regulation): minimal insulation thickness of plumbing (and heat accumulators)
- Handling of the heat transfer medium and its disposal (glycol mixture)

Methodological Reference:

Steps of complete action	Description	Methodology	Resources
Inform and analyse	- considering specifications and recommendations of the manufacturer and specifications due to the accident prevention regulations - specifications of the components (measures, weights and time of delivery)	- internet research - use of information in the manufacturer's documentation and from documents of projects which have already been conducted - contact to the manufacturer (via telephone or internet)	- internet - manufacturer's documentation - revision documents - planning documents - manufacturer's distribution channels
Plan and decide	- determination of the necessary work steps - organizing the necessary tools / safety procedures - consideration of the default settings according to the planning measures and recommendations of the manufacturer	- Filling out of check lists - working with manufacturer's documentation and planning documents - contact to the manufacturer (via telephone or internet)	- templates / model example - plans / photos / drawings - training company - manufacturer - standards

Implement	- networks (own company) - manufacturer's documentation / installation, setting and maintenance recommendations - accident prevention regulations	- e-learning / use of an internet platform (e.g. moodle) - manufacturer's documentation	- training company - teacher and classmates - manufacturer - standards
Control and evaluate	- alignment of plans and actual installation regarding complexity and costs - information on possible irregularities of planning and implementation	- working off a specification sheet (if applicable a check list) - calculation / comparison of the planning (offer) and the actual cost of material and expenditure of time	- Plans - Check lists - manufacturer's documentation
Document and present	- instruction (start-up and handover of the system including a project report) in form of a presentation	- role play: presentation of the project and handing over a documentation (project folder)	- brochures - project folder - slides/PowerPoint presentation (or similar)
Reflect	- Feedback	- self-reflection, student and teacher feedback - evaluation (of both the presentation and documentation)	- project folder - slides/PowerPoint presentation (or similar)

Key questions:

- Which specifications have to be considered for the setting of the controller?
- How can you avoid gravity circulation in the solar circuit?
- How is the system correctly purged and aired?
- Which operating conditions have to be considered regarding pressure, volume flow and temperature (especially control parameters which have to be set) when starting up a system?
- How do you prepare and conduct a customer instruction?
- Which details and advice do you have to give the customer in order to secure an operating system that runs smoothly and therefore is satisfying in the long term?

Evaluation/assessment criteria and tools:

- completeness of action and order (structure and sequence)
- consideration of the possible sources of funding and legal regulations
- presentation (visualization and content)
- structure, content and illustration of the documentation
- naming of the sources and auxiliary material (check lists, software, URLs…)
- self-reflection and feedback given by the classmates and teacher

6.3 Implementation

Originally, it was planned to test one module for the ST field and one for the PV field. Due to the project conditions only some learning situations were tested in the vocational school Richard-Fehrenbach-Gewerbeschule in Freiburg in the last stage of the project (September 2014 till March 2015). The training was conducted in three different courses. In the dual training of plant mechanic for sanitary, heating and air conditioning systems, in the integrated full-time vocational college (*Berufskolleg*) and in a class of Master Craftsmen training.

The subject of solar thermal systems is part of the framework curriculum for vocational schools of the plant mechanics in the first and third year. The Master programme for the solar expert includes this subject, too.

All programmes in the tested vocational school are attended by male students. The age range in the full-time college and the part-time school is between 16 and 19 years. The students in the Master training are older. Most students have the German citizenship and have no language problems (even though more than 50 percent of the students have a migration background). However, cognitive skills and comprehension vary. Most students are motivated and engaged in learning, therefore the implementation of the learner activating method works well.

The following table shows the classes in which the learning situations were tested:

Type of school/training	Class / Course	Number of students
Part-time vocational school in the dual system	Plant mechanic for sanitary, heating and air conditioning systems (3 classes)	65
Full-time vocational college	Integrated course with dual training plant mechanic for sanitary, heating and air conditioning systems	12
Master Craftsmen programme	Expert Craftsmen in Solar Technology	23

Table 7: Courses of tested learning situations

The evaluation was conducted in February and March 2015 in two classes of the dual training (third year) and one course of the vocational college (second year), based on the first learning situation (solar thermal). The results of the learning situations were evaluated in terms of competence acquisition and occupational contents with a self-evaluation tool by the students. The figure on the next page illustrates the evaluation results from one course of the dual training. Based on these results conclusions regarding the learning outcome and indications for the improvement can be derived. Generally speaking, the test of the learning situations was successful. There are some problems with time management since this type of learning requires more time and a different organisation of instruction. Regarding the contents the teacher realised that the subject requires more details in the use of solar simulation software, energy and cost calculations.

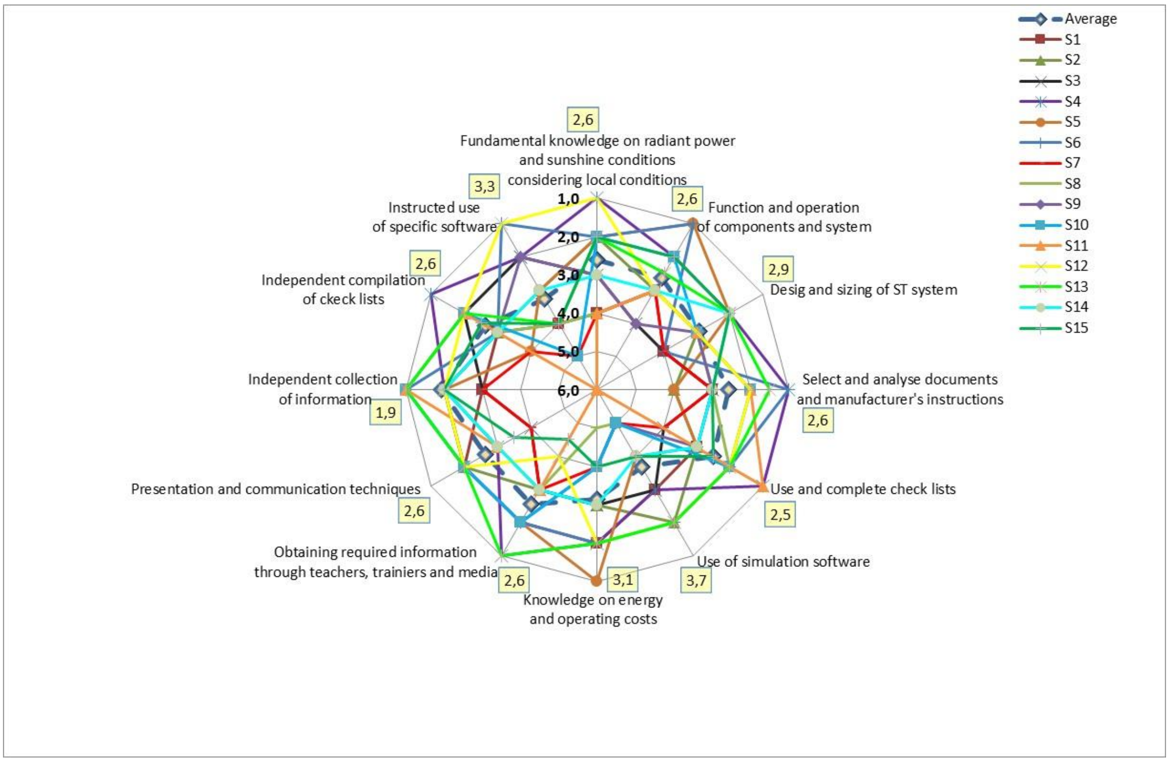

Figure 9: Evaluation results of one class and one learning situation

The training content of the first learning situation that was evaluated includes the following competences:

Knowledge

- knowledge base on radiant flux and sunshine duration depending on the customer-specific conditions,
- installation, mode and method of operation of the components and the entire system,
- layout/dimension.

An almost constant gain of specialist professional knowledge has been noted as the practical implementation as well as the knowledge gained during the hands-on training in a specialist company made it possible to successfully deepen the so far theoretical training.

Skills

- selection and analysis of technical literature and manufacturer documents,
- compilation/filling-in of checklists,
- use of simulation software,
- knowledge of energy and operating costs,

The use of specialist literature and manufacturer documents proofs to be difficult for some students as they are often not used to reading books and especially not such trade literature and rather spend their leisure time with media for entertainment on their mobile phones and similar devices.

Auxiliary means like checklists and media as for example simulation software were used by almost all students. Though some students were not able to handle and operate the software and given tools so that the teacher had to make time for an extensive instruction – which should be considered for future lesson planning.

Personal and Social competence (incl. autonomy)

- obtaining/use of the necessary information via the instructor, school and media,
- practice of presentation and advisory skills,
- independent request of information,
- self-contained compilation of predetermined checklists,
- guided use of software.

Especially in terms of autonomy and team work great differences in performance of the individual students were recorded. The different social backgrounds and standing in society as well as unreadiness to work in a team illustrate a further demand for exercises and make it necessary for the teacher to use a variation of methods.

The evaluation shows that some competences were achieved on a good level, while other items were more challenging for the students. The range of different learning achievements highly depends on the general dispositions or learning requirements of the students. In particular weaker students require more support in using software for dimensioning and simulation. Another critical constraint is the very limited time for each topic.

7 Conclusion

The aim of the project team cooperation was to design a competence-based training programme and didactic concepts in the field of solar energy systems and to test exemplary learning arrangements. The concept is based on three development packages. The German project team analysed the work of PV and ST system installers and prepared an occupational profile of these experts. The profile is designed in form of tasks that describe the work of such experts. The Israeli team has conducted similar expert workshops. Both results were merged to a joint profile. Thus, the first result of the project team cooperation is a joint occupational profile of such an expert who can be found in the labour market but not in the VET system. In both countries there are no specific initial training programmes for this type of solar energy expert.

Regarding the issue of energy efficiency which is highly relevant in this field, it has to be stated that the profile does not contain a specific task related to energy efficiency since it is a transversal topic. This can be redesigned if the profile will be enriched by energy consultation tasks. Furthermore, this topic must be placed in any module or learning unit and learning situation.

The second outcome of the project team cooperation is the framework for a curriculum based on a modular structure and competences (or learning outcomes). The German team used the EQF model. Due to the fact that curriculum design highly depends on the requirements and expectations in the individual VET system it is not trivial to design a joint curriculum. In Israel stakeholders expected a full curriculum that respects traditional structures. This expectation could not be fulfilled in the project work. It would require more time for discussion and elaboration. Nevertheless, the modules and the competences can easily be transferred to other curricular models and be enriched by required components. This is also true for the German situation. The modules can act as an input for the design of new *Lernfelder* for a new occupation or additional courses for existing programmes.

The third outcome is related to the micro level of learning. The German project team prepared exemplary learning situations as a didactic tool for the implementation of competence-based training. Some learning situations were tested by a team member in different courses in a vocational school in Germany. Generally speaking, this test was successful and the teacher gained further experiences regarding his everyday work such as the design of learning situations. The project team will develop the modules and learning situations further and will make them available to the public.

In bilateral meetings both teams discussed this didactic level and exchanged experiences. As this took place during the last stage of the project, time was too short to elaborate a joint learning arrangement. In addition, the approach used in German vocational schools is new and has not been implemented on a large scale in Israel. Taking this into account, it might be an idea to focus other projects on the micro level of VET – or in other words on teaching and learning.

To conclude, the joint project was engaged in the important field of renewable energy in the VET sector. Reflecting the global development, climate change, energy consumption and other factors this issue will be of high priority anywhere in the world. The project team cooperation offered the opportunity to get to know the policies, research, industries, VET institutions and stakeholders of both countries. The project work supported the understanding of the project members of the situation in each country, in particular in the energy sector, and in the use of renewable energy, and it was a good opportunity to learn intensively about the VET system in Israel and Germany. Last but not least, the project members from both countries formed new friendships. From a professional and a social perspective we highly recommend the continuation of this type of cooperation.

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