Asia-Pacific
Economic Cooperation

# Training Curriculum for Solar PV Installers and System Designers

## FINAL REPORT

APEC Secretariat

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# 1. INTRODUCTION

## 1.1 BACKGROUND

Installations of solar photovoltaic (PV) systems have enjoyed a tremendous and steady growth for over a decade worldwide, addressing the need for renewable sources of energy. Solar PV systems are one of the strategic solutions perfectly adapted to developing economies in order to meet the objectives of reducing emissions of greenhouse gases (GHG) related to electricity production. Solar PV rooftop installation is becoming a viable solution to reduce the burden on electricity grid for households, especially in cities with under capacity and/or growing electricity needs. The adoption of pro-active policies combined with incentives and the development of safety and efficiency standards in this regard are confirming the opportunities and needs for such applications.

This fast and steady growth has however highlighted several problems that start to affect the reliability and efficiency of such systems, especially for rooftop installations. In developing economies in particular, installers and system designers are lacking proper skills which result in: 1) a lower performance (or efficiency) of the system: lower output-efficiency; higher operation and maintenance cost: lower return on investment (ROI) for investors; 2) safety issues during installation (Occupational Health and Safety (OHS) issues) and operatio n (rooftop solar PV systems modify the fire safety conditions of the roof), resulting in increasing numbers of accidents, sometimes fatal, and fires with huge consequences on humans and buildings; and 3) grid-connection issues. This lack of competency in most installers and system designers seriously: 1) reduces the overall performance/output of solar PV systems; 2) increases risks of fire and other safety issues for human and equipment; and 3) make distribution utilities reluctant to connect such systems to their grid.

Addressing the problems mentioned above, the APEC Secretariat would like to develop training curriculums and training materials for installers and system designers for solar PV rooftop systems, as well as for trainers, to map out and conduct evaluation of training institutions in APEC economies, and to transfer of training curriculums and training materials to selected training institutions in APEC economies via capacity building workshop. Castlerock Consulting, in association with Advancing Engineering (AE) Consultants was selected to undertake this “Capacity Building for Installers and System Designers for Solar PV rooftop installations” project.

## 1.2 OBJECTIVES

The long-term objective of this project is to increase the performance/output of solar PV rooftop systems and facilitate connection to the grid for rooftop solar PV systems, as a means to support APEC economies’ efforts in increasing the share of electricity from renewable energy sources. The project is expected to increase the reliability and safety of solar PV rooftop systems.

To contribute to this long-term objective, the project:

- Develop a training curriculum for installers and system designers (as well as for trainers)
- Identify training institutions in APEC developing economies
- Transfer the training curriculums to training institutions
- Design a certification program for installers and system designers
- Create awareness among government institutions in APEC economies on the need for training and certification of installers and system designers

- Build capacity of government institutions on how to establish national certification schemes.

## 1.3 METHODOLOGY

The project is structured into four tasks as delineated below:

- Task 1: Develop training curriculums for installers and system designers, as well as for trainers;
- Task 2: Development of training materials;
- Task 3: Mapping out of training institutions in APEC developing economies; and
- Task 4: Transfer of training curriculums and training materials to selected training institutions in APEC developing economies.

All activities under each task were conducted under the guidance and supervision from the Project Overseer (Pacific Northwest Laboratory/U.S Department of Energy; Mr. Cary Bloyd), and the International Copper Association (ICA; Mr. Pierre Cazelles).

The project team consists of the team leader/project manager, two Solar PV rooftop experts; one has expertise on rural development while the other is having in-depth experience in building solar rooftop, a capacity building expert and a senior analyst.

This report only covers the **Task 1 Develop training curriculums for installers and system designers, as well as for trainers** component and this task is divided into four detail sub-tasks as follows:

***1.1 Review of major training programs***: a review of major training programs for solar PV installers and system designers, including analysis of strengths and weaknesses, was conducted through these two steps: (1) identification of the existing similar training programs worldwide through literature research and internet search; and (2) review and analysis of strength and weaknesses, particularly on the training content, methods, as well as success and failures in organizing these trainings.

***1.2 Training needs analysis and applicability in APEC developing economies:*** the training needs analysis was conducted through several steps, i.e: (1) research on the development level status of Solar PV particularly solar rooftop, in APEC developing economies; (2) research on existing similar training programs in sub task 1.1; (3) training needs analysis for conducting trainings designers and installers of solar rooftop. To provide an objective result in comparing and documenting similar existing trainings worldwide as well as comes up with a recommended training outlines, a training content/curriculum criteria was developed and this criteria is also used in the development of detailed curriculum for installers, system designers and trainers.

***1.3. Draft report on review of training programs and training needs analysis*****:** Results of research conducted in 1.1 and the training needs analysis in 1.2 is documented in this draft report.

***1.4. Develop training curriculums for installers and system designers:*** The results previous work in sub-task 1.1 to 1.3 including the training curriculum evaluation criteria is used as the basis to develop the training curriculum for Solar PV rooftop installers and system designers. This curriculum is designed to fit the existing condition and skills level in the economies being assessed in sub-task 1.2, delineate the most suitable training methods (e.g., classrooms, groups exercises, and demo, etc.), and includes test procedures and test materials.

***1.5 Develop training curriculums for trainers***: Similar to sub-task 1.4, a training curriculum for trainers will be developed. Different for the curriculum for installers and the system designers, the curriculum for trainers will have a pedagogy approach on how to engage the audience/students, evaluation and various skill/and knowledge assessment method in addition to technical knowledge on solar PV rooftop installation.

# 2. TRAINING NEEDS ANALYSIS IN APEC DEVELOPING ECONOMIES

## 2.1 OVERVIEW OF SOLAR PV MARKET IN APEC DEVELOPING ECONOMIES AND SKILLS IDENTIFIED

The implementation of photovoltaic technology has initiated significant employment creation globally at the point of installation (installers, retailers and service engineers) [1]. It has been assumed that 10 jobs are created per MW during production and about 33 jobs per MW during the process of installation. Wholesaling of the system and indirect supply (for example in the production process) each creates 3-4 jobs per MW.

### 2.1.1 Indonesia

With its thousands of scattered islands and consequent off-grid photovoltaics demand, it is predicted that almost 1 GW of installed photovoltaic capacity will be added by 2016. A research titled Emerging Solar Market 2012 by IMS Research stated that due to its substantial and quickly growing need for electricity, the small amount of the population that currently have access to electricity, and its reliance on diesel generators on its thousands of islands, PV is a highly attractive solution for providing distributed electricity sources in Indonesia[2].

Currently there are no competency standards and certification systems for PV system designer and PV installer in Indonesia. Therefore, the government encourages the associations of renewable energy contractors and services to develop competency standards and certification scheme, especially for solar power system[3].

Government has issued Ministry of Energy and Mineral Resources Regulation Number 30 Year 2006 concerning the implementation of competency standard for technical workforce in the renewable energy including solar power system and Ministry of Energy and Mineral Resources Regulation Number 05 Year 2008 on the application of competency training standard for technical workforce in the renewable energy including solar power system.

The Technical Education Development Center (TEDC) Bandung, a state education center under the Ministry of Education, has developed four models of Vocational School (SMK) in four provinces that integrating new and renewable energy technology, including solar power system into vocational learning in Indonesia. This step is an effort to prepare trained technicians in the field of renewable energy, including solar power system. The center has produced curriculum, syllabus and module for solar power system with the following outline:

- Electrical Bench Work (Usage and Maintenance of Electrical Equipment)
- Diagram of Electrical Engineering
- Introduction to Solar Technology

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[1] "Solar Generation IV – 2007; Solar Electricity for Over One Billion People and two million jobs by 2020," Accessed August 5, 2014, available at: http://www.greenpeace.org/international/Global/international/planet-2/report/2007/9/solar-generation-iv.pdf

[2] "Indonesia Set to Challenge Thailand in PV Stakes: Pv-Magazine," accessed August 4, 2014, http://www.pv-magazine.com/news/details/beitrag/indonesia-set-to-challenge-thailand-in-pv-stakes_100009035/#axzz38hYdJ9Pa.

[3] "Kementerian ESDM Minta Asosiasi Siapkan Standar SDM | Berita Terkini Nasional," accessed August 13, 2014, http://www.antarasumbar.com/berita/nasional/d/0/350656/kementerian-esdm-minta-asosiasi-siapkan-standar-sdm.html.

- Electrical Measurement
- Solar Power System components
- Installation of Solar Power System
- Operation of Solar Power System
- Maintenance of Solar Power System
- Inspection of Solar Power System
- Making of Solar Power System Applications

**Association Relevant To the Profession**

The relevant association to the profession related to Solar Energy are as follows:

- Indonesia Association of Renewable Energy Contractors and Service Providers (AJEKTI - *Asosiasi Kontraktor dan Jasa Energi Terbarukan Indonesia*)
- Indonesian Renewable Energy Society (METI – *Masyarakat Energi Terbarukan Indonesia*) www.meti.or.id

**Related Training Institutions**

Technical Education Development Centre (TEDC Bandung or *Pusat Pemberdayaan dan Pengembangan Pendidik dan Tenaga Kependidikan Bidang Mesin dan Teknik Industri*) is the most relevant institution that has included solar energy technology at vocational level (equivalent to high school).

Education and Training Center for Electricity, Renewable Energy and Energy Conservation (ETCENEREC) under the Directorate General of New and Renewable Energy and Energy Conservation (DGNREEC).

### 2.1.2 Malaysia

Since Malaysia introduced its renewable energy FiT in 2011, 2,628 applications for 484.03MW of capacity have been approved across all forms of generation. PV for individuals and at a larger scale has proved the most popular form of generation, accounting for almost 40% of approved FiT capacity – a total of 192.26MW. However, completion of approved projects has been slow to happen, with only 11.8.19MW of all FiT-approved projects having commenced operation. Malaysia's Sustainable Energy Development Authority (SEDA) released 1,500 kW of solar PV quota for individuals on September 18 2013 and the response received was overwhelming. The FiT for individuals under Malaysia's Solar Home Rooftop Programme has proved extremely popular since its launch in September last year, with earlier quota releases selling out in similarly short periods to September's. To date SEDA has approved 2,279 applications for individuals totalling 24.43MW, of which 8.98MW has commenced operation[4].

SEDA Malaysia provides training on Grid-Connected Photovoltaic (GCPV) Systems Design, Grid-Connected Photovoltaic for Wireman and Chargeman and Solar PV Installer and Maintenance[5]. Comparison of course outline and participants requirements of these training are as follows is explained in Table 1 below.

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[4] "Malaysia Closes Home Solar Tariff for 2013 after Huge Response - PV-Tech," accessed August 4, 2014, http://www.pv-tech.org/news/malaysia_ends_solar_tariff_after_overwhelming_response.

[5] "SEDA PORTAL," accessed August 13, 2014, http://seda.gov.my/.

**Exhibit 2.1. Comparison of course outline and participants requirements of trainings in Malaysia**

| Type of Training | GCPV Photovoltaic for Wireman and Chargeman | GCPV System Design Course | Solar PV Installer & Maintenance |
|---|---|---|---|
| Course Outline | - Grid Connected Solar PV System<br>- System Installation<br>- Operation and Maintenance<br>- Experiment | - Introduction to photovoltaic systems<br>- Basic solar engineering<br>- Photovoltaic technology<br>- Grid interactive inverter<br>- Connection to the grid<br>- Design and sizing<br>- System performance and evaluation<br>- Installation, operation and maintenance<br>- Lightning protection system | - Occupational Health and Safety Practice<br>- Introduction to Solar Electricity<br>- Preparataion of System Installation<br>- System Equipment and Installation of Electrical Systems<br>- Corrective maintenance |
| Training Participant Requirements | - Age above 18 years of age<br>- have a minimum qualification of "PW2" for Wireman or "A0" for Guardian of Electric Machinery. | - age above 21 years of age;<br>- minimum Diploma in Engineering or Degree in Applied Science (Physics); and<br>- proficient in English. | - Age above 18 years of age<br>- Malaysian Certificate of Education or a qualification recognized as equivalent by the SEDA Malaysia |

The training encompasses both theoretical and practical sessions, ending with a competency examination. Participants who pass the examination will receive a certificate of competency from SEDA.

**Association Relevant To the Profession**

- Malaysian Photovoltaic Industry Association (MPIA)

**Related Training Institutions**

- Sustainable Energy Development Authority (SEDA) Malaysia
- Universiti Kuala Lumpur - British Malaysia Institute (UniKL BMI), Gombak, Selangor
- Universiti Teknologi MARA (UiTM)
- Selangor Human Resource Development Centre (SHRDC).

### 2.1.1 The Philippines

The Philippines has a high renewable energy resources from solar. A 50 MW installation of solar photovoltaic targeted by end of 2015[6]. In 2013 the solar roof top market in the Philippines is expected to double in size from 2.5MW to 5MW. The passing of the net-metering rules and interconnection standards enabling all on-grid end-users to install a solar roof top will further boost the market as now the regulatory framework has been set[7]. The potential market for solar industry players was estimated at about $450 million, or P19

[6] http://www.irena.org/REmaps/countryprofiles/asia/Philippines.pdf

[7] "Net Metering Website - 5. How Is It Done: Solar Roof Top Installations in the Philippines," accessed August 4, 2014, https://www.doe.gov.ph/netmeteringguide/index.php/5-how-is-it-done-solar-roof-top-installations-in-the-philippines.

billion, yearly. This was based on the 50,000 households (representing 10 percent of the half a million constructions yearly) that can install solar panels with a capacity of 2 kilowatts[8].

Philippines Technical Education and Skill Development Authority (TESDA) has issued competency based curriculum, self-assessment guides, and training regulations for PV System Design, PV Systems Installation and PV Systems Servicing[9]. However, this is limited only to rural solar home systems (SHS) and installation of up to 1 kWp. The program was initiated by and was developed under USAID AMORE (rural electrification) program in Muslim Mindanao. Comparison of course outline and participants requirements of these training can be seen in Exhibit 2.2 below.

**Exhibit 2.2. Comparison of course outline and participants requirements of trainings in the Philippines**

| **Type of Training** | **PV System Design** | **PV Systems Installation** | **PV Systems Servicing** |
|---|---|---|---|
| Course Outline | • BASIC COMPETENCIES<br>- Leading workplace communication<br>- Leading small teams<br>- Developing and practicing negotiation skills<br>- Identifying / determining fundamental cause of problem<br>- Using mathematical concepts and techniques<br>- Using relevant technologies<br>• COMMON COMPETENCIES<br>- Preparing construction materials and tools<br>- Performing mensurations and calculations<br>- Maintaining tools and equipment<br>- Observing procedures, specifications and manuals of instructions<br>- Interpreting technical drawings and plans<br>• CORE COMPETENCIES<br>- Determining customer | • BASIC COMPETENCIES<br>- Participating in workplace communication<br>- Working in a team environment<br>- Practicing career professionalism<br>- Practicing occupational health and safety procedures<br>• COMMON COMPETENCIES<br>- Preparing construction materials and tools<br>- Performing mensurations and calculations<br>- Maintaining tools and equipment<br>- Observing procedures, specifications and manuals of instructions<br>- Interpreting technical drawings and plans | • BASIC COMPETENCIES<br>- Leading workplace communication<br>- Leading small teams<br>- Developing and practicing negotiation skills<br>- Identifying / determining fundamental cause of problem<br>- Using mathematical concepts and techniques<br>- Using relevant technologies<br>• COMMON COMPETENCIES<br>- Preparing construction materials and tools<br>- Performing mensurations and calculations<br>- Maintaining tools and equipment<br>- Observing procedures, specifications and manuals of |

[8] "Use of Rooftop Solar Panels in Philippines Pushed | Inquirer Business," accessed August 14, 2014, http://business.inquirer.net/85370/use-of-rooftop-solar-panels-in-philippines-pushed.

[9] "Downloadable Files," accessed August 13, 2014, http://www.tesda.gov.ph/program.aspx?page_id=29

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|---|---|---|---|
| | requirements<br>- Calculating system components requirements<br>- Specifying components in bill of materials<br>- Preparing installation drawing | • CORE COMPETENCIES<br>- Installing electrical wiring<br>- Performing PV system testing and commissioning | instructions<br>- Interpreting technical drawings and plans<br>• CORE COMPETENCIES<br>- Performing PV systems diagnosis<br>- Repairing PV systems<br>- Monitoring PV system operation |
| Training Participant Requirements | - Have undergone training on PV Installation National Certificate Level II<br>- With good moral character<br>- Can communicate both oral and written<br>- At least 18 yrs old | - With good moral character<br>- Can communicate both oral and written<br>- At least 18 yrs old | - Have undergone training on PV Systems Installation National Certificate Level II<br>- Can communicate both oral and written<br>- Must be physically and mentally fit to undergo training<br>- At least 18 yrs old |

To attain the National Qualification, the candidate must demonstrate all of the competence units. Successful candidates shall be awarded a National Certificate signed by the TESDA Director General.

**Association Relevant To the Profession**
- Philippine Solar Power Alliance (PSPA)
- IIEE Institute of Integrated Electrical Engineers (Association of Electrical Practitioners)
- ACMEEE Association of City and Municipal Electrical Engineers and Electricians

**Related Training Institutions**
- Technical Education and Skill Development Authority (TESDA)
- UP NEC University of the Philippines National Engineering Center

### 2.1.2 **Thailand**

In July 2013, the National Energy Policy Council decided to implement a regulation as well as the inherent procedure for the development of a solar PV rooftop support scheme for Thailand. Already in September 2013, the official opening of the first call for solar PV rooftop projects was publicly announced. Thailand's government has announced plans to support a major expansion of the country's solar rooftop sector on both domestic and commercial buildings. Thailand's alternative energy development strategy has been put in place since 2008. This covers all renewable energy sectors, including large-scale solar projects. However, until now there has been no rooftop policy in place, either for large commercial and public buildings or the domestic sector. A working group had been tasked with producing a financial framework covering a feed-in tariff and other supporting measures. The group is also expected to recommend the abolition of current restrictive regulations that require homes or offices wishing to install solar panels to apply for licences from the government's Industrial Works Department. The government is proposing to support the installation of 100,000 domestic rooftop systems and 1,000 commercial systems. The total capacity installed is expected to be approximately 800MW. As well as a FiT, the government is understood to be looking at a system of tax breaks and soft loans to financially underpin the policy. The policy is expected to encourage a lot of home owners to participate in the solar energy sector[10].

The Thai solar PV rooftop program includes certain aspects generally addressed in more mature markets, such as highlighting the importance of certified solar PV installers for installation of solar rooftop systems. In addition, the encouraging initiatives of several Thai public authorities, in first line of the Energy Regulatory Commission (ERC) are to emphasize, which proactively initiated an analysis of the existing regulations and procedures for the development of solar PV rooftop in Thai land to identify excising challenges and issues in order to streamline procedures for a smoother implementation of solar PV projects in the future[11].

The Regulation of Energy Regulatory Commission (ERC) on Power Purchase from Solar PV Rooftop 2013 define "Installer" as a juristic person with appropriate qualifications who has been listed as a recommended solar PV rooftop installer. The regulation classify installer into 2 types as follows:

- Type A is a juristic person with paid up share capital not less than 2,000,000 baht (two million baht), 1 contract generating value of work not less than 1.0 million baht, and personnel according to Clause 11 who is qualified as solar PV rooftop installer with the installed capacity not exceeding 10 kilowatts (<10 kWp).
- Type B is a juristic person with paid up share capital not less than 10,000,000 baht (ten million baht), 1 contract generating value of work not less than 5.0 million baht, and personnel according to Clause 12 who is qualified as solar PV rooftop installer with the installed capacity not exceeding 1,000 kilowatts (<1,000 kWp).

The 2013 ERC regulation requires the installer to have the manager and operating employee with qualifications listed in Table 3 below[12].

**Exhibit 2.3. Installer qualification requirements under 2013 ERC Regulation**

| Type A installer | Type B installer |
|---|---|
| (1) Manager who controls and is responsible for works performed by operating employees in relation to area inspection, design and install solar PV rooftop system, and coordination among relevant persons. The Manager must have the following qualifications:<br>a. Graduated at least with Bachelor Degree from educational institutions approved by the Office of the Civil Service Commission in:<br>i. Engineering or equivalent in the fields of electrical | (1) 1 Manager who controls and is responsible for works performed by operating employees in relation to area inspection, design and install solar PV rooftop system, and coordination among relevant persons. The Manager must have the following qualifications:<br>a. Graduated at least with Bachelor Degree from educational institutions approved by the Office of the Civil Service Commission in:<br>i. Engineering or equivalent in the fields of electrical |

[10] "Major Boost for Thailand Rooftop Solar Sector - PV-Tech," accessed August 4, 2014, http://www.pv-tech.org/news/major_boost_for_thailand_rooftop_solar_sector.

[11] "Major Boost for Thailand Rooftop Solar Sector - PV-Tech," accessed August 4, 2014, http://www.pv-tech.org/news/major_boost_for_thailand_rooftop_solar_sector. http://www.thai-german-cooperation.info/download/20140408_pdp_th_report_pv_regulations.pdf

[12] http://www.thai-german-cooperation.info/download/20130918_giz_translation_solar_rooftop.pdf

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|---|---|
| engineering, or civil engineering, or structural engineering, or energy engineering, or construction engineering;<br>ii. Science in the fields of energy technology or energy management;<br>iii. Architecture or equivalent.<br>b. Performed works or have experiences in managing projects related to building/installing solar energy power generating system or power system or power plant or power distribution system not less than 5 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br><br>(2) Operating employees are responsible to inspect areas, design and make model of installation, install, monitor the installation, and test solar PV rooftop system. The operating employees comprise of:<br>a. At least 1 electrical engineering with the following qualifications:<br>i. Graduated at least Bachelor Degree in Engineering or equivalent in the field of electrical/power engineering from educational institution approved by the Office of the Civil Service Commission and received License for Professional Practice from Council of Engineers that is valid on the date of signing the relevant documents;<br>ii. Performed works or have experiences in designing or installing solar energy power generating system or power system or related works on power electricity not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>b. At least 1 civil engineering with the following qualifications:<br>i. Graduated at least Bachelor Degree in Engineering or equivalent in the field of civil engineering or structural engineering from educational institution | engineering, or civil engineering, or structural engineering, or energy engineering, or construction engineering;<br>ii. Science in the fields of energy technology or energy management;<br>iii. Architecture or equivalent.<br>b. Performed works or have experiences in managing projects related to building/installing solar energy power generating system or power system or power station or power distribution system not less than 5 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br><br>(2) Operating employees are responsible to inspect areas, design and make model of installation, install, monitor the installation, and test solar PV rooftop system where it is required that the operating employees must sign no the documents under their own responsibilities. The operating employees comprise of:<br>a. At least 1 electrical engineering with the following qualifications:<br>i. Graduated at least Bachelor Degree in Engineering or equivalent in the field of electrical/power engineering from educational institution approved by the Office of the Civil Service Commission and received License for Professional Practice from Council of Engineers that is valid on the date of signing the relevant documents;<br>ii. Performed works or have experiences in designing or installing solar energy power generating system or power system or related works on power electricity not less than 5 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>b. At least 1 civil engineering with the following qualifications:<br>i. Graduated at least Bachelor Degree in Engineering or equivalent in |

| | |
|---|---|
| approved by the Office of the Civil Service Commission and received License for Professional Practice from Council of Engineers that is valid on the date of signing the relevant documents;<br>ii. Performed works or have experiences in designing or constructing buildings or construction, installing solar energy power generating system or construction of power plant or power generating system not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>c. At least 1 electrical technician as follows:<br><br>Graduated with high vocational certificate from educational institution approved by the Office of the Civil Service Commission in the field of power electricity with experiences in installing solar energy power generating system or power generating system not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>d. At least 1 civil or construction technician as follows:<br><br>Graduated with high vocational certificate from educational institution approved by the Office of the Civil Service Commission in the field of civil or construction with experiences in construction or structure not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences. | the field of civil engineering or structural engineering from educational institution approved by the Office of the Civil Service Commission and received License for Professional Practice from Council of Engineers that is valid on the date of signing the relevant documents;<br>ii. Performed works or have experiences in designing or constructing buildings or construction, installing solar energy power generating system or construction of power plant or power generating system not less than 5 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>c. At least 3 electrical technicians as follows:<br><br>Graduated with high vocational certificate from educational institution approved by the Office of the Civil Service Commission in the field of power electricity with experiences in installing solar energy power generating system or power generating system not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences.<br>d. At least 3 civil or construction technicians as follows:<br><br>Graduated with high vocational certificate from educational institution approved by the Office of the Civil Service Commission in the field of civil or construction with experiences in construction or structure not less than 3 years by providing, for consideration, evidence of qualification, performed works, and experiences. |

**Association Relevant To The Profession**

- Thai Photovoltaic Industries Association (TPVA)

**Related Training Institutions**

- School of Renewable Energy Technology (SERT), Naresuan University, Phitsanulok

### 2.1.3 Vietnam

Vietnam is among the countries with sufficient potential in solar energy in South East Asia Region. According to a survey on solar radiation, there were from 1,800 to 2,100 sunny hours in a year in the Northern provinces, and from 2,000 to 2,600 sunny hours in a year in southern provinces. Solar radiation in Northern provinces is 20% less than in central and southern provinces because in winter and spring, drizzling rain can continue for days. In southern provinces and Ho Chi Minh City, the sun shines all the year round, stable even in rainy season[13].

Managers and scientists proposed a strategy which include a detailed objectives of the programme, including effectively exploiting solar power to ensure national energy security in every situation (250 MWp = 456,25 tỷ KWh/year), and supplying power to all Vietnam's territory by 2025 together with the national network. Now, the programme has drafted four major projects, including the project on 10,000 solar power houses, the project on solar power plant connecting 2MWp-5MWp partial net, the project on 10,000 public lighting sources by new energy collective technology, and a project on new energy performance of Vietnam and the world. In addition, there are also other projects such as the project building solar cell slab and solar module factory and the project on solar powered taxis[14].

The solar power industry in Ho Chi Minh City has created several production foundations such as first industrial scale Module PMT factory in Vietnam, and the Solar Materials Incorporated which has the possibility to provide mono and multi-crystalline to use for solar cell production. Several outstanding products such as module solar cell, inverter peripherals, and smart machines have expanded in the regional and global market[15]. Photovoltaic (PV) modules are generally imported while some balance-of-system components are locally manufactured. The national telecommunication company (VNPT) and EVN own subsidiaries for the design and installation of solar electric systems for their own internal needs[16].

Vietnamese household and rural solar PV installations are rapidly growing, while utility scale PV projects are still at an early stage of development. Not being subject to government FiT, these projects can benefit from negotiated PPAs with the electricity end-users, or are built and financed directly by those end-users for their own use[17]. Vietnam's total solar power capacity to date is estimated at from 1.6-1.8 megawatt peak (MWp). Of the figure, between 25% and 30% is installed at households, 35% developed by the

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[13] "Vast English," accessed August 4, 2014, http://www.vast.ac.vn/en/index.php?option=com_content&view=article&id=1191:building-vietnam-solar-power-industry-along-with-global-trend&catid=28:national-science-and-technogory-news&Itemid=34.

[14] Ibid.

[15] Ibid.

[16] "GIZ - Solar Energy," accessed August 17, 2014, http://www.renewableenergy.org.vn/index.php?page=solar-energy.

[17] "Solar Power System | Wind Power System | Solar Panels | Wind Turbines | Solar Power in Vietnam | Wind Power in Vietnam | Solar Energy in Vietnam | Wind Energy in Vietnam Wind and Solar Power Opportunities in Vietnam," accessed August 17, 2014, http://en.solarpower.vn/vi/bvct/id66/Wind-and-solar-power-opportunities-in-Vietnam/.

telecommunications industry and 35% by the waterway traffic industry. Separate solar cell systems are installed at households in mountainous and remote areas[18].

There are four types of systems that define the Vietnamese solar energy market individual home systems, individual business systems for hotel, restaurant, hospitals, army and service centers, village facilities for lighting, audio, television and energy centers for recharging batteries[19]. A 10,000 solar roofs from 1 kWp to 100 kWp, using SIPV technology with total capacity of 10 MWp will be built across the country. The project aims to effectively use solar electricity to balance the national grid supply in urban areas and to electrify remote inland, island and border areas. This project will lay a foundation for the development of solar electricity in Vietnam. Technologies and human resource for solar industry will be also developed through the project[20]. Investment in solar energy is considered profitable only for solar water heating. While household scale solar power is economically negative because of high cost but low generation quality[21].

**Association Relevant to the Profession**

- Solar Energy Association of Ho Chi Minh City
- Vietnam Energy Association

**Related Training Institutions**

- Renewable Energy Research Centre (RERC), Hanoi University of Technology
- Solar Laboratory of Institute of Physic (Solarlab), Vietnam Academy of Science and Technology
- Institute of Energy in Hanoi

## 2.2 IDENTIFICATION OF TARGET GROUP, JOB DESCRIPTION AND REQUIRED COMPETENCY

### 2.2.1 PV System Designer Job Description Analysis

*Job Title and Proposed Professional Title*

Position title for the job containing the functions of photovoltaic system design, which may include commercial/sales function, may differ from one company to another. It can be a “design engineer”, “renewable energy engineer”, “PV system designer” or “residential PV system designer”. For consistency purpose, the proposed title for this professional term used throughout this assignment is "photovoltaic system designer" or "PV system designer".

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[18] “Vietnam Plans Bright Future for Solar Energy | News | Eco-Business | Asia Pacific,” accessed August 17, 2014, http://www.eco-business.com/news/vietnam-plans-bright-future-for-solar-energy/.

[19] “GIZ - Solar Energy.”

[20] Trinh Qung Dung, Photovoltaic technology and solar energy

development in Viet Nam, TECH MONITOR, Nov-Dec 2009, page 35, accessed August 17, 2014, http://www.techmonitor.net/tm/images/6/63/09nov_dec_sf3.pdf

[21] “GIZ - Solar Energy.”

*Job Description*

A PV system designer usually act as a first point of technical support, who is responsible for verifying the most appropriate technical and material solutions per site conditions, client design parameters, or other variables to optimize the clients' solution. Depending on the size of the company, often the PV system designer combined with the sales function. The exact job description also differ a bit from company to company. Table 4 shows the Sample of PV System Designer Job Description in Several Companies.

**Exhibit 2.4. Sample of PV System Designer Job Descriptions in Several Companies**

<table>
<tr><td>Company</td><td>SunPower Philippines Ltd[22]<br>The Philippines Company</td><td>Clean Energy Malaysia[23]<br>Malaysian Company</td><td>One Roof Energy[24]<br>US Company</td></tr>
<tr><td>Job Position Title</td><td>Design Engineer I</td><td>Renewable Energy Engineer</td><td>Residential PV System Designer</td></tr>
<tr><td>Job Description</td><td rowspan="2">1. Adhere to specific instructions provided by Design Product Lead<br>2. Use basic design request platform ( Sales Force) operation<br>3. Use PV Specific Design Tools basic operations ( PV Home, PV Fast, PV SIM, Design Calculator, Google Earth, Pictometry and others )<br>4. Apply complete solar design guidelines specific to a particular product assigned<br>5. Perform actual design tasks specific to a solar product assigned to include the following :<br>a. Client Files Extraction (CAD Files, Excel Files, PDF references and others)</td><td rowspan="2">• Discuss power systems requirement and constraints with stakeholders in a consultancy<br>• Participate in site assessments for solar PV projects, when appropriate.<br>• Responsible for solar power system design and solution development.<br>• Provide safe, timely and high quality PV systems design utilizing state of the art modeling and design skills.<br>• Prepare, present and promote solutions for power system requirement to stakeholders<br>• Interface with local officials and utility engineers to design the best system configuration.<br>• Maintain awareness of new product technology and communicate</td><td>Design Preliminary and Final Plan Sets for Residential Solar Installations in compliance with AHJ, Building, Utility, and NEC Code requirements within Arizona, California, Hawaii, Massachusetts, New York, and emerging market areas as required.</td></tr>
<tr><td>Responsibilities</td><td>• Create preliminary designs for outside sales reps to confirm upon homeowner visit.<br>• Create, enhance, and use design templates.<br>• Use AutoCAD 2D software and custom software tools to design residential photovoltaic roof top systems.<br>• Establish and incorporate design specifications per company policy.<br>• Incorporate Site Inputs to facilitate changes at time of site visit to create final design integrating:</td></tr>
</table>

[22] http://jobs.jobstreet.com/ph/jobs/4944669?fr=23&src=12

[23] http://jobs.jobstreet.com.my/my/jobs/2358353?fr=23

[24] https://www.ziprecruiter.com/job/Residential-PV-System-Designer/dbc24ef2/?source=cpc-simplyhired-sfs

| Company | SunPower Philippines Ltd[22] **The Philippines Company** | Clean Energy Malaysia[23] **Malaysian Company** | One Roof Energy[24] **US Company** |
|---|---|---|---|
| | b. Solar array layout<br>c. Solar shading analysis<br>d. Electrical three-Line diagram<br>e. Incorporation of Standard structural details<br>f. Review completed work for accuracy, and quality prior to submission<br>6. Perform standard drawing tasks and procedures to include the following :<br>a. Create design drawing using basic AutoCad ( 2009, 2010 version)<br>b. Compile to sheet sets<br>c. Plot to PDF all final drawings<br>d. Send to printer (for Permit Packs) operation<br>e. Save to shared drives as instructed<br>f. Revise drawings per reviewers comments ( as a required)<br>7. Handle medium scale solar design projects<br>8. Participate in regular design team meetings as required | pertinent developments to colleagues.<br>• Interact with electricity utility companies and regulatory authorities with regard to solar projects.<br>• Liaise with headquarters about logistics of supplying component for large solar projects.<br>• Provide implementation and technical support.<br>• Provide assistance to the Business Development Manager. | 1. System output to define production guarantee for the life of the system<br>2. Establish system design considering cost, reliability, and safety factors.<br>3. Site plan, Roof layout, Equipment Elevation, single line, Signs and Placards.<br>• Generate specifications for parts and equipment data sheets.<br>• Define System Energy Production to incorporate into sales proposal.<br>• Output final designs for AHJ submission.<br>• Create required design utility interconnection and rebate documents (single line and 3-line).<br>• Work cross functionally with sales, project management and installation teams to ensure clients' needs and internal deadlines are met.<br>• Work with project managers to submit plans and drawings to building departments.<br>• Track permitting process through approval.<br>• Perform additional duties as assigned and/or directed. |
| Essential Knowledge, Skills, Abilities And Qualifications | • BS in Architecture, Structural, Mechanical, or Electrical Engineering. | • A Bachelor degree in Electrical Engineering and/or Structural Engineering, or | • Proficient with NEC Code, Authority Having Jurisdiction Requirements, International Building |

| Company | SunPower Philippines Ltd[22] **The Philippines Company** | Clean Energy Malaysia[23] **Malaysian Company** | One Roof Energy[24] **US Company** |
|---|---|---|---|
| | • Minimum 1 year in design using AutoCAD<br>• Good analytical and problem solving skills<br>• Must have the ability to work independently with minimal supervision.<br>• Must be detail oriented.<br>• Knowledge of CRM an ERP systems (SFDC, Oracle, SAP or Equivalent) an advantage.<br>• Experience with Microsoft Office ( Word, Excel, Outlook and PowerPoint ) is required.<br>• Experience with AutoCad or equivalent is required.<br>• Willingness to work on Night Shift Schedule.<br>• Required Skill(s): AutoCad.<br>• At least 1 year(s) of working experience in related field is required for this position.<br>• Applicants must be willing to work in Laguna | higher degree.<br>• A minimum of 5 years' experience performing designs of solar PV systems and products.<br>• Successfully completed the SEDA Grid-Connected Photovoltaic (SGCP) Systems Design Course.<br>• Experienced with solar PV system design, inverters, wiring, grounding, utilities interface and performance monitoring.<br>• Technically proficient in the field of photovoltaic conversion, direct current circuits and protection designs with a working knowledge of solar PV system modeling.<br>• Familiar with Malaysian Standards for solar systems & other relevant international standards.<br>• Self-motivated, high energy, original thinkers, with project management skills, able to assume increasing responsibility in a highly successful global organization.<br>• Excellent verbal and written communications skills with internal and external customers.<br>• Solid general knowledge of computer technology and be proficient with 2D and 3D | Code, and Utility Requirements for photovoltaic systems.<br>• Proficient in AutoCAD and similar PV system software programs.<br>• 1 years of residential solar experience.<br>• Ability to work effectively with developing technology, Microsoft Word, and Excel.<br>• Ability to work swing shift as required.<br>• Site Surveying and Solar installation Experience preferred.<br>• BS in Engineering (EE, ME) is preferred. AS in Engineering Discipline (EET, MET, etc.) would be considered based on experience.<br>• All levels of experience will be considered.<br>• NABCEP Certified.<br>• Familiar with the new product development process, which includes inception, feasibility, project planning, detailed design, manufacturing, field implementation, testing, product launch and field Problem resolution.<br>• Familiarity with Mechanical and Structural Engineering concepts are beneficial. |

| **Company** | SunPower Philippines Ltd[22] **The Philippines Company** | Clean Energy Malaysia[23] **Malaysian Company** | One Roof Energy[24] **US Company** |
|---|---|---|---|
| | | modeling software such as Solid-work, PV System, and AutoCAD (training will be provided for inhouse ezDesign sytem).<br>• Experience in project implementation, such as for stand-alone power systems and electrical engineering projects.<br>• Experience in a consultancy role.<br>• Project management experience.<br>• Proficient in Bahasa Malaysia and English languages.<br>• Have a passion for renewable energy and want to ensure a future for the environtment. | |

*Job Responsibilities*

The PV system designer responsibilities are:

- Conducting a site assessment
- Design and draw plan for solar PV installations
- Generate specifications for parts and equipment data sheets.

*Required Knowledge and Skills*

The PV system designer are expected to have the technical and non-technical knowledge and skills. The technical aspects include civil and electrical installation, understanding of civil/mechanical and electrical plan and diagrams, using design software and solar pv system modelling, interpret mechanical and/or electrical circuits and system, solar power system installation, applicable standard for solar system. While the non-technical aspects include the ability to work with teams as well as to work independently, project management, good communication skill and strong analytical abilities.

*Field of Work and Types of Companies*

PV system designer can work in energy services companies (ESCO's), power utility companies or companies retailing PV systems.

*Job Task Analysis*

The job task is listed in Table 5 below.

**Exhibit 2.5. Job task of system designer**

| | |
|---|---|
| **1.** | **Conducting a Site Assessment** |
| 1.1 | identify tools and equipment required for conducting site survey for PV installation |
| 1.2 | demonstrate the appropriate skill to use tools and equipment for site survei |
| 1.3 | determine suitable location with proper orientation, sufficient area, adequate solar access, and structural integrity for installing PV array |
| 1.4 | determine suitable locations for installing inverters, control, batteries, and other balance of system components |
| 1.5 | illustrate possible layouts and locations for array and equipment, including existing building or site features |
| 1.6 | identify and assess any site-specific safety hazards associated with installation of the system |
| 1.7 | obtain and interpret site solar radiation and temperature data for use in electrical system calculations |
| **2.** | **System Sizing and Design** |
| 2.1 | Measure the peak load demand and average daily energy use for the purpose of sizing equipment |
| 2.2 | Determine requirements for installing additional subpanels and interfacing PV system with electrical supply network |
| 2.3 | Determine the design currents and voltage for any part of a PV system electrical circuit |
| 2.4 | Determine the capacity of system conductors, and select appropriate sizes based on design currents, voltages and safety factors |
| 2.5 | Determine appropriate size, ratings, and locations for earthing, surge suppression, lighting protection and associated equipment |
| 2.6 | Identify a mechanical design, equipment (including fixing and mounting brackets) to be used |
| 2.7 | Identify installation plan that is consistent with the environmental, architectural, structural, code requirements, and other conditions of the site |
| 2.8 | Identify appropriate module/array layout, orientation, and mounting method for ease of installation, electrical configuration and maintenance at the site |
| 2.9 | Identify and select major components and balance of system equipment that meet the sizing requirements |
| 2.10 | Estimate annual energy performance of proposed system |

### 2.2.2 PV Installer Job Description Analysis

*Job Title and Proposed Professional Title*

Position title for the job containing the functions of photovoltaic installation, may differ from one company to another. It can be a “technician”, “solar energy technician”, “photovoltaic engineer” or “solar system engineer”. For consistency purpose, the proposed title for this professional activity is "photovoltaic installer" or "PV installer".

The exact job description also differs a bit from company to company, but the job generally has the functions to professionally configure, install, and maintain photovoltaic system in compliance with applicable codes and standards. Table 6 show the sample of PV system designer job description in several companies.

**Exhibit 2.6. Example of PV System Installer Job Description in Several Companies**

| **Company** | First Philec [25] **The Philippines Company** | IThera Consulting[26] **Indonesian Company** | Green Innotech[27] **Malaysia Company** |
|---|---|---|---|
| Position Title | Technician | Solar Energy Technicians / Photovoltaic Engineers | Solar System Technician |
| Responsibilities | • Responsible for the installation of PV systems at customers' site/location.<br>• Troubleshoot and/or repair system installations.<br>• Coordinate with the install team on project implementation, updates, and changes. | • Review and calculate the total power for clients<br>• Design and built PV systems<br>• Supervise installation at the site | N/A |
| Essential Knowledge, Skills, Abilities And Qualifications | • Candidate must possess at least a Vocational Diploma / Technical Course Certificate, in Civil Technology, Electrical/Electronic Technology, Mechatronic/Electromechanical Technology, or equivalent.<br>• Required skill(s): Civil and electrical installations, understanding of civil, mechanical, and/or electrical plans and diagrams.<br>• Able to analyze, interpret, and troubleshoot mechanical and/or electrical circuits and systems.<br>• Able to work and coordinate with project teams and contractors.<br>• At least 3 year(s) of working experience in civil and electrical installation is required for this position.<br>• Applicants must be willing to work in Ortigas Center but mostly on field projects.<br>• Preferably 1-4 Yrs | • Knowledgeable on system, control & wiring, troubleshooting, repairing, installation of electrical system<br>• Experience in PLN project is a clear advantage<br>• Preferably at least 1 year of working experience in relevant field<br>• A self-starter who is able to work independently<br>• Willing to work flexible hours and travel overseas when required<br>• Able to work hard under tight schedules<br>• Strong analytical abilities and professional office experience needed.<br>• Good communication skill, highly motivated and excellent logical thinking are | • Candidates must be PW4 Certified.<br>• Deep knowledge in wiring and connection.<br>• Able to troubleshoot and rectify problems related to Solar system installation.<br>• Candidates with knowledge of Autocad or any other drawing tools are an added advantage<br>• Must possess own transport to conduct site inspection and roof measurement.<br>• Able to work independently |

[25] http://www.jobstreet.com.ph/jobs/2010/3/default/80/2333057.htm?fr=c

[26] http://www.jobstreet.co.id/jobs/2012/8/default/40/584446.htm?fr=R

[27] http://www.greeninnotech.com.my/job-vacancy.html

| Company | First Philec [25] **The Philippines Company** | IThera Consulting[26] **Indonesian Company** | Green Innotech[27] **Malaysia Company** |
|---|---|---|---|
| | Experienced Employees specializing in Engineering - Electrical or equivalent. | required | |

*Job Responsibilities*

The PV installer responsibilities are:

- Install PV systems at customers' site/location.
- Troubleshoot and/or repair system installations.

*Required Knowledge and Skills*

The PV installers are expected to have the technical and non-technical knowledge and skills. The technical aspects include civil and electrical installation, understanding of civil/mechanical and electrical plan and diagrams, interpret and troubleshoot mechanical and/or electrical circuits and system, solar power system installation and troubleshooting. While the non-technical aspects include the ability to work with teams as well as to work independently, good communication skill and strong analytical abilities.

*Field of Work and Types of Companies*

PV Installers can work in energy services companies (ESCO's), power utility companies or companies retailing PV systems.

*Job Task Analysis*

The job task analysis is listed in Table 7 below.

**Exhibit 2.7. Installer job task**

| | |
|---|---|
| **1.** | **Working Safely with Photovoltaic Systems** |
| 1.1 | maintain safe work habits |
| 1.2 | demonstrate safe and proper use of required tools and equipment |
| 1.3 | demonstrate safe and accepted practice for personnel protection |
| 1.4 | identify and implement appropriate codes and standard concerning grid system, installation and operation |
| 1.5 | identify and implement appropriate codes and standard concerning safety and maintenance of PV system and equipment |
| 1.6 | identify personal safety hazards associated with PV installation |
| **2.** | **Applying the electrical and mechanical design during the installation** |
| 2.1 | install module array interconnect wiring |
| 2.2 | label, install, and terminate electrical wiring |
| 2.3 | use appropriate and correctly labelled D.C junction boxes and isolation switches |
| 2.4 | verify continutiy and measure impedance of earthing system |
| 2.5 | program, adjust, and configure inverters-controls for desired set points and operating modes |
| 2.6 | utilise drawings, schematics, instructions and recommended procedure in installing equipment |
| 2.7 | assemble module, panels, and support structure as specified by design |
| 2.8 | complete final assembly, structural attachment, and weather sealing of array to building or other support mechanism |
| 2.9 | visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship |
| 2.10 | check system mechanical installation for structural integrity and weather sealing |
| 2.11 | check electrical installation for proper wiring practice, polarity, earthing, and integrity of terminations |

| | |
|---|---|
| 2.12 | demonstrate procedures for connecting and disconnecting the system and equipment from all sources |
| 2.13 | explain safety issues associated with operation and maintenance of system |
| **3. Maintaining and Troubleshooting a System** | |
| 3.1 | Analyse the technical documentation/manual of PV installations, determining actions and resources required for the maintenance process |
| 3.2 | Identify maintenance needs, to design a typical periodical maintenance plan and to select the appropriate required tools |
| 3.3 | Analyse the past production report and potential fault reports |
| 3.4 | Identify typical installation mistakes/failures, perform diagnostic procedures and to interpret results |
| 3.5 | Measure system performance and operating parameters; compare with specifications and assess operating condictions |
| 3.6 | Visually inspect entire installation, check mounting systems, ventilation, cable runs and connections/junction boxes |
| 3.7 | Check system mechanical installation for structural integrirty and weather sealing |
| 3.8 | Check electrical installation for proper wiring practice, polarity, earthing, and integrirty of terminations according to appropriate regulations |
| 3.9 | Identify perfomance and safety issues, and implement corrective measures |
| 3.10 | Compile and maintain records of system operation, performance, and maintenance |

## *3. REVIEW OF MAJOR TRAINING PROGRAMS*

This chapter reviews major training programs for solar PV installers and system designers, including analysis of strengths and weaknesses.

### 3.1 NORTH AMERICAN BOARD OF CERTIFIED ENERGY PRACTITIONERS (NABCEP), US& CANADA

NABCEP is a voluntary certification body officially acknowledged in the US and Canada that develops national certification programs promoting Renewable Energy, particularly Solar Energy, RE worker safety and skills, and RE consumer confidence. NABCEP has two certified professional programs on Solar PV, namely, PV Technical Sales and PV Installation Professional Certification Schemes. The schemes designate the training curriculums and provide certifications, while the trainings are conducted in NABCEP Registered Solar PV training providers. Certification provides a measure of protection to the public by giving a credential for judging the competency of practitioners.

#### Solar PV Technical Sales Certification

The NABCEP PV Technical Sales Certification is aimed at professionals that have experience in the field selling PV systems, need qualified credential and intend to provide quality assurance for customers in selling PV systems. The targeted professionals of PV Technical Sales Certification is fall under the following categories: solar PV sales person, application engineers, financial or performance analysts or site assessors. The curriculum addresses how to qualify the customer, perform site analysis, conduct conceptual design, prepare estimates of financial costs, incentives, and savings, as well as financial benefit analysis and financing, evaluate non-financial benefits, conduct performance analysis and prepare proposal for customers.

#### PV Installation Professional Certification Information

The NABCEP PV Installation Professional certification is aimed at professionals with field experience in installing PV systems having minimum 58 hours of advanced PV training acknowledged by NABCEP. To qualify for NABCEP PV Installation Professional exam, the candidates must provide (i) documentation for three (3) or five (5) installations where they have acted in the role of contractor, lead installer, foreman, supervisor, or journeyman, and (2) system information, permits and inspections for each project that he/she has installed. Examples of target candidates for NABCEP PV Installation are PV installers; project managers; installation, foreman/supervisor, and designers. The curriculum for the Solar PV installers covers verification of system design, maintenance and troubleshooting, installation of electrical and mechanical components, complete installation systems, and project management aspects.

### 3.2 CLEAN ENERGY COUNCIL AUSTRALIA

Solar PV accreditation in Australia is administered by the Clean Energy Council Australia (CEC). The CEC Solar PV accreditation scheme covers competent qualification in design and/or installation of stand-alone and grid-connected solar PV power systems in Australia. This accreditation scheme aim to increase customer confident in receiving high quality, safe and reliable solar PV system which leads to increasing solar PV system uptake, improve the safety, performance and reliability of solar PV system, and encourage industry best practice of solar PV system. CEC require installers and designers to complete training each year to renew their accreditation under the Continuous Professional Development (CPD) program. The CEC assesses training and assigns it a number of CPD points. Installers and designers must complete 100 CPD per year to renew. Systems designed and installed by CEC accredited installers are eligible for government incentives and rebates. The training institutions providing the training under CEC solar PV accreditation are required to be registered as training organizations with Australian Skills Quality Authority (ASQA) which is a federal government organization.  .

The curriculum for Solar PV installers largely covers electrical knowledge, PV system knowledge and detailed installation of PV power systems. The Curriculum for the Solar PV designers cover mostly those of solar PV installers in addition to basic repairs and problem solving for installed solar PV system, both stand-alone or grid connected. Summary of curriculum contents is provided in Appendix B and Appendix C.

### 3.3 PVTRIN EUROPE

PVTRIN provides a training for solar PV system installers in six EU countries whose market maturity is still developing.  These countries are: Greece, Bulgaria, Croatia, Cyprus, Romania and Spain.  The training program provides accreditation requirements for the training facilities and certification assessment methods for the trainees.

The course provides essential theory behind PV systems, related regulations, applicable standards, safety requirements, installation and testing procedures.  A hands-on training section provides practice in the application of practical skills for installation and testing.  A total of 10 days are provided for the certification training.

What sets apart the PVTRIN training system is the availability of the e-learning platform that allows the participants to study online, self-evaluate their progress and to receive further training.  It covers the design, installation and maintenance principles of small scale (residential) PV installations.  Participants develop their skills and understanding of basic solar theory, system components, design, installation, commissioning, and handover of a small scale PV system.  This also includes the maintenance and troubleshooting of the system.

Qualified electricians with relevant working experience are the training course's target group of trainees.  These electricians need to have an interest in developing their skills and knowledge to include solar PV installation and maintenance. The focus of the training is in the installation, troubleshooting and maintenance of a small scale residential solar PV systems.  This fits with the targeted countries' market development where the potential for solar PV projects will be for the urban rooftop installations.

### 3.4 EXPERT CLUB INDIA

Working together with Solar Energy International, the oldest and largest renewable energy training organization in the USA, the Expert Club provides 2-day solar PV installer training sessions throughout India.  The training session is packed with information about system design basics, grid tied solar PV system installation, battery based solar PV systems, energy efficiency measures, and commissioning of solar PV systems.

The training course was designed as an introduction to the solar technology offering including system design, component selection, solar installation practices, maintenance and trouble-shooting and basic safety-related training when working with solar PV systems.  After the training and one successful solar installation in the field the expert club certificate is awarded which is valid for two years.

What is unique about this training course is that it is provided by a commercial entity and a completion of the course provides access for the members to further sales and business development training.  In addition, the participants are also given access to premium-quality, German/USA made modules, inverters & racking with short lead times, preferred pricing from EnerPlus Solutions (the company providing the training) on the entire offering of solar energy systems, and access to end-customer leads from EnerPlus, leading to increased sales opportunities.

### 3.5 SOLAR PV TRAINING INSTITUTO DE INVESTIGACIONES ELECTRICAS (ELECTRIC RESEARCH INSTITUTE)

One of Mexico's solar PV training program is offered through the IIE (Electric Research Institute) as a 3 day course focusing specifically on grid tied residential solar PV systems. The materials are covered within 2 days of lectures and 1 day of hands on practice.

The course starts with basic knowledge of solar PV and basic electrical theory (such as AC vs DC, key electrical terms, etc) are covered as well as the current status of technology and available incentives.

During the practical sessions, the participants are doing basic experiments that enforces the first day's theoretical lectures. While there is no hands on system installation, the participants get to play with the solar PV electrical characteristics under different conditions such as tilt angle, temperature, characteristic curve of a solar PV module, and effects of shading. Very basic installation methods are practiced but limited to making series and parallel connections between solar PV modules.

The third day's lectures focuses a little bit more on the utility grid and the impact of a grid connected solar PV system on the grid. Different grid conditions such as blackouts, voltage fluctuations and power factor is explained and how it would impact the solar PV system. This lecture is followed by a more comprehensive explanation of the different system components and an explanation of the mechanical and electrical installation of such system. One session of note that is not taught in the other curriculum is the system's security from theft.

The last session of this day covers the operations, maintenance and service, and troubleshooting of a grid connected solar PV system. Having only 2.5 hours to cover these topics, it is impossible to cover them in depth. Most of the training material mentions the basic commissioning in a general sense rather than having specific examples that draws from a comprehensive set of industry best practices. The same thing obviously happens for the maintenance/service and troubleshooting portions of this session.

What this training program does is to provide someone interested in a grid connected solar PV systems with the basic knowledge for them to continue learning. Depending on their interest, they can pursue further training as a system designer or as a system installer.

There have been other training sessions provided by NABCEP accredited institutions in Mexico, but these training workshops are not done on a regular basis. These training workshops only happen when it is requested by certain organizations interested in introducing the curriculum to the Mexican workforce.

### Exhibit 3.1 Comparison of Existing PV Training Programs and Certification Schemes

| No | Training Program | State/<br><br>Region | Certified Profession | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|
| 1 | NABCEP | US, Canada | PV Technical Sales | A sales person, application engineer, financial or performance analyst, or site assessor. | | | North American Board of Certified Energy Practitioners (NABCEP). | North American Board of Certified Energy Practitioners (NABCEP).<br><br>Accredited to the ISO/IEC 17024 standard by | http://www.nabcep.org/ |
| | | | PV Installation Professional | | | All advanced PV training must be offered by designated education providers.[28] | | | |

[28] In order to qualify for the Solar PV Installer Exam, a candidate must successfully complete a minimum of 58 hours of advanced PV training before the application deadline. A minimum of forty(40) of the fifty eight (58) prescribed hours must cover advanced solar PV installation and design principles and practices addressed in the NABCEP PV Installer Job Task Analysis. All advanced PV training must be offered by one of the following education providers:

1. Institutions accredited by an agency recognized by the federal Department of Education, or Canadian equivalent (Universities, Community Colleges, etc.)
2. U.S. Department of Labor Registered Apprenticeship Training Programs(http://www.doleta.gov/oa/)
3. Training Programs accredited, Independent Instructors, or Independent Master Trainers certified by the Interstate Renewable Energy Council (IREC) to IREC or IREC ISPQ Standards.
4. Training institutions approved by State Contractor Licensing Boards or Canadian Provincial equivalents
5. State or Provincial Department of Education or equivalent registered Vocational / Technical training programs

http://www.nabcep.org/certification/pv-installer-certification

| No | Training Program | State/ Region | Certified Profession | | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | A maximum of eighteen (18) of the fifty-eight (58) prescribed hours may be obtained from non-accredited, non-certified sources.[29] | | ANSI | |
| 2 | Clean | Australia | Stand- | SPS | The applicant is | | Registered | | Clean Energy | |

[29] A maximum of eighteen (18) of the fifty-eight (58) prescribed hours may be obtained from non-accredited, non-certified sources such as:

1. Courses covering building and electrical codes relevant to the installation of solar PV systems
2. Entry Level coursework through a NABCEP Registered PV Entry Level Exam Provider, provided that a passing score achievement was obtained on the NABCEP PV Entry Level Exam. NOTE: Courses leading to the NABCEP Entry Level Exam do not qualify for the minimum 40 hours of advanced PV installation and design.
3. Additional OSHA or equivalent workplace safety courses above and beyond the required OSHA 10 hour course
4. Training programs and courses that are registered with NABCEP for Continuing Education Credits for the PV Installer Certification
5. Any other coursework that addresses topics included in the NABCEP PV Installer Job Task Analysis (NOTE: the applicant will need to submit a course outline and signed letter from the training provider detailing how many hours were spent covering the NABCEP Solar PV Installer Job Task Analysis in the course.)

http://www.nabcep.org/certification/pv-installer-certification

| No | Training Program | State/ Region | Certified Profession | | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|---|
| | Energy Council | | alone Power System | Design | accredited for the design of a SPS photovoltaic power system. They are not responsible for any part of the installation of the power system. | | training organisations (RTOs) [30] | | Council | https://www.solaraccreditation.com.au |
| | | | | SPS Install | The applicant is accredited for the installation of a SPS photovoltaic power system. | | | | | |
| | | | | SPS Design & Install | The applicant is accredited for the design and installation of a SPS photovoltaic power system. Only those applicants who hold both Design and Install accreditation are accredited to design and install solar photovoltaic power systems. | | | | | |

[30] https://www.solaraccreditation.com.au/dam/solar-accred/installers/becoming-accredited/RTO-List-August-2013.pdf

| No | Training Program | State/ Region | Certified Profession | | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Grid-connect (GC) PV System Accreditation | GC Design | The applicant is accredited for the design of a GC photovoltaic power system. They are not responsible for any part of the installation of the power system. | | | | | |
| | | | | GC Install | The applicant is accredited for the installation of a GC photovoltaic power system. | | | | | |
| | | | | GC Design & Install | The applicant is accredited for the design and installation of a GC photovoltaic power system. Only those applicants who hold both Design and Install accreditation are accredited to design and install solar photovoltaic power systems. | | | | | |
| 3 | PVTRIN | Europe | PV Installer | | Qualified electricians (that have received training on DC | PVTRIN trainers should | Must have access to all | Assessing knowledge and | A certification body | http://www.pvtrin.eu/home/in |

| No | Training Program | State/<br><br>Region | Certified Profession | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|
| | | (Greece, Bulgaria, Croatia, Cyprus, Romania and Spain) | | system and are qualified/licensed to practice in in electrical installation of at least 10 kW) who wish to enter into the photovoltaic market and to activate in PV installation and maintenance.<br><br>They are expected to have gained relevant experience whilst working for a PV installation company, electrical installation company or a roofing company.<br><br>The level of field experience required is likely to depend on the qualifications of the trainee. | possess an approprate training or assessment qualification from a recognised national authority. They should also have verifiable experience and knowledge of PV system and their installation. This may include qualificationrel evant to the PV installation industry awarded by a recognised organization. | resourcess needed to deliver the PVTRIN training course.<br><br>Availability of suatably qualified and experience trainers and assessors.<br><br>In compliance with the requirements of ISO/IEC 17024 or recognised by the National Authority responsible for the certification of vocational training institutions. | skills of the trainees. Can be working on behalf of the accredited training center. | accredited to ISO/IEC 17024 or EN 45011 (ISO/IEC Guide 65) | dex.html |
| 4 | Expert | India | PV Installer | renewable energy | | Enerplus | | Enerplus | http://enerplus |

| No | Training Program | State/<br><br>Region | Certified Profession | Target Group | Trainers | Training Provider | Assessor | Certification Body | Source of Information |
|---|---|---|---|---|---|---|---|---|---|
| | Club | | | professionals in India and neighboring international markets who are seeking exposure to an international offering of products, and eager to adopt international standards of installation expertise and leverage such expertise to offer premium service to their local customers. | | Solutions India | | Solutions India | solutions.com |

## *4. TRAINING CURRICULUM*

The proposed training curriculum for solar PV designer, installer and trainer delineated in this chapter contains: (i) the pre-requisites for PV designer, installer and trainer (ii) the summary of training curriculum content for Solar PV designer, installer and trainer, (iii) the lecture topics, and (iv) the differentiation of allocation of time and lecture topics for solar PV designer and installer.

A comparison of Solar PV training curriculum among different certification schemes (Developed economies and Developing Economies) is given in Appendix A for references.

### 4.1 PRE-REQUISITES

The proposed pre-requisites for training participants are as follows:

1. *Solar PV Installer*: to be an installer, one has to possess minimum a 2-year certificate (associates degree) in an engineering or technical field, or a trade certification in electrical installation.
2. *Solar PV Designer*: To be a designer, one has to possess minimum a 4-year degree (bachelor degree) in any field and demonstrate basic knowledge of electrical and mechanical design.
3. *Solar PV trainer for designer and/or installer*: To be a trainer, one must have both designer and installer certification, and is required to have: (i) 1 year experience as designer and 1 year experience as installer, (ii) at least three years of professional teaching experience, (iii) at least three years examining experience. All these criteria must be acknowledged and approved by the accrediting body/ government.

### 4.2 TRAINING CURRICULUM FOR PV SYSTEM DESIGNER

The content/material for PV system designer is summarized as follows:

- The different ways to harness the sun's energy (including solar water heater, solar PV, and solar thermal electricity generation)
- Different types of solar PV installation
- Recognizing field conditions (shadowing, existing electrical issues, existing structural issues, etc)
- Local standards and safety codes for solar PV installation and electrical installation (MCB size, labeling, etc)
- Common electrical symbols
- Single line and 3-line diagram generation
- Installation procedures common to the industry (batteries, inverter, grid inverter, solar panels, etc) with examples from several big brands' installation procedures. Reading specifications and manuals to specify equipment
- Cost payback period calculations
- Simple investment analysis/financial modeling
- Basic electrical design to match with local codes and standards as well as manufacturers requirements (such as cable sizing, MCB, etc)
- Electrical load demand analysis
- Basic system design and sizing (watt/watt peak/ampere/voltage/watt hour)
- Commercial software system design (PVSyst and others that's appropriate for the region)

- Finding appropriate databases for solar resource (NASA, satellite data, etc)
- Manufacturer's software system design (SMA, Outback, Morningstar)
- Perform site survey
- Develop site survey questions
- Analyze site survey data to design a solar PV system

## 4.3 TRAINING CURRICULUM FOR PV INSTALLER

The content/material for PV system installer[31] is summarized as follows:

- The different ways to harness the sun's energy (including solar water heater, solar PV, and solar thermal electricity generation)
- Different types of solar PV installation
- Recognizing field conditions (shadowing, existing electrical issues, existing structural issues, etc)
- Local standards and safety codes for solar PV installation and electrical installation (MCB size, labeling, etc)
- How to read installation drawings (electrical, mechanical, civil)
- Installation procedures common to the industry (batteries, inverter, grid inverter, solar panels, etc) with examples from several big brands' installation procedures
- Safety procedures
- Basic electrical workmanship
- Performance verification methods
- Remote monitoring systems
- Perform site surveys
- Chargeman/wireman course for PV (Malaysia only).

## 4.4 TRAINING CURRICULUM FOR TRAINERS

Training curriculum for Solar PV trainers will cover the list/content for Solar PV system designer as given in 4.2, and the following material in addition:

- Knowledge in several solar resource databases (such as NASA)
- Basic public speaking
- Basic classroom management
- Create Excel based tools for design and surveys
- Basic teaching skills

## 4.5 DETAILED LECTURE TOPICS AND TIME ALLOCATIONS

### 4.5.1 Lectures and practical hands on sessions

In terms of content types, the proposed training curriculum is divided into lectures and practical hands on sessions. Exhibit 4.1 provides list of training material, both lecture topics and practical hands-on sessions and the description of each material of each lecture/practical hands-on topics, and contents of each material.

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[31] In Malaysia, this course is known as Chargeman/Wireman course for PV.

## Exhibit 4.1 Lectures and Practical Hands-on material

**Lectures**

| ***Session Topic*** | ***Summary*** | ***Summary of Content*** |
|---|---|---|
| Basics of Solar PV | This session will explain the two components of solar energy and then focus on the different types of solar PV systems such as off-grid and grid tied as and the different subtypes within each.<br><br>Basic terminology will also be explained such as peak load, power consumption, peak sun hour, watt peak, and others | ✓ Types of energy from the sun (Solar Thermal and Solar PV and Solar Thermo-Electric)<br>✓ Types of solar PV systems<br>✓ Basic terminology<br>✓ Energy generation and storage<br>✓ Busting solar PV myths<br>✓ Effects of shading and tilt angle |
| Basics of Electricity | Gives some background about electricity and how it is related to solar PV systems. The goal here is to ensure everyone has the same basic knowledge about electricity before moving forward | ✓ How energy and power are related<br>✓ AC and DC electricity<br>✓ Current, voltage, resistance, power, energy<br>✓ Example of 12VDC vs 24VDC systems<br>✓ Ohm's law and Kirchoff's law |
| Electrical Workmanship | Basic knowledge and industry practices about electrical workmanship such as cable size calculations, physical cable routing, surge protection, lightning protection, grounding, etc | ✓ Drip loop<br>✓ Surge protection<br>✓ Lightning protection<br>✓ Cable routing<br>✓ Torque value |
| PV Modules | Explains how a PV module converts light to electricity and its basic components. Show the effects of shading and light intensity. Performance measurements of a solar PV module. | ✓ Types of PV modules and how they're made<br>✓ I-V and P-V curve and how they're measured<br>✓ Differences between Voc/Vmp and Isc/Imp<br>✓ Variables affecting output such as temperature, light intensity, etc<br>✓ PV module components such as cells, busbars, bypass diodes, blocking diodes<br><br>* Videos of solar PV module production from ore to ingots to cells to module<br><br>* Small solar PV, bright flashlight, voltmeter, incandescent light bulb and current clamp meter |

| ***Session Topic*** | ***Summary*** | ***Summary of Content*** |
|---|---|---|
| Batteries and Battery Charging | Shows the different kinds of batteries and their pros/cons as well as the applications in a solar PV systems. Safety issues with batteries | ✓ Different commercial battery types<br>✓ Viability in a solar PV system<br>✓ Lifetime cost analysis<br>✓ Variables affecting lifetime<br>✓ Busting battery myths and marketing speak |
| Solar Charge Controller | Explains the function of a solar charge controller and the different types that are currently available. Why and how to choose one type over another. How to choose the system voltage and their implications | ✓ Function of a charge controller<br>✓ Types of a charge controller<br>✓ Load control via charge control and how to integrate a battery inverter<br>✓ How to connect a solar PV and batteries to a solar charge controller<br><br>* Different types of solar charge controller<br><br>* Small solar PV, small UPS battery, small inverter and the different types of solar charge controller |
| Inverter – Battery | Shows the different types of battery inverters and their functions. Explain pure sine wave vs modified sine wave. What's an inverter/charger unit or bi-directional inverter | ✓ Types of battery inverters<br>✓ Different functions from different brands<br>✓ PWM vs MPPT<br>✓ Pure sine wave vs modified sine wave<br>✓ Inverter/charger vs solar charge controllers |
| Inverter – Grid | How a grid inverter is different from a battery inverter and what is anti-islanding. Why a grid inverter? SMA system example | ✓ Grid inverter vs battery inverter<br>✓ Why a grid inverter<br>✓ How an SMA grid inverter work |
| Bringing it Together | What is an AC or a DC coupled solar system? Different types of systems using the components introduced above | ✓ Small Home Systems/solar street lights<br>✓ Off grid systems<br>✓ Grid tied system<br>✓ Grid tied with battery backup<br>✓ AC coupled vs DC couple system<br>✓ Microgrids<br><br>* Sample small home system kit<br><br>* Sample grid tied system and the battery backup |
| Commissioning and Performance Verification | What to look for before turning on the system for the first time. Industry standard procedures for basic commissioning steps. Basic performance verification procedures to ensure the system is installed properly | ✓ Basic commissioning procedures<br>✓ Basic performance verification<br>✓ Commissioning checklist |

| *Session Topic* | *Summary* | *Summary of Content* |
|---|---|---|
| Maintenance | Regular maintenance procedures, what to look for during maintenance visits. | ✓ Preventive maintenance procedures<br>✓ Regular maintenance checklists<br>✓ Regular data logging |
| Monitoring and Inspection | Introduce the different major brand's monitoring system as well as third party monitoring systems. Knowledge about how to set up each type and the similarities and differences. The goal is not only to be able to install these monitoring system types but also to learn new ones and implement them | ✓ Different brand's monitoring system (SMA, Outback, Morningstar, Samil)<br>✓ Third party monitoring system<br>✓ Why monitor solar PV systems<br>✓ Monitoring data as marketing tools |
| Troubleshooting | Troubleshoot common mistakes and failures. | ✓ Overvoltage of the inverter/charge controller input<br>✓ Overcurrent of the inverter/charge controller input<br>✓ Effect of shadowing of the array<br>✓ System programming mistakes |
| PV System Field Survey | This session will introduce the field survey procedures and how to perform them to select the right location for solar PV installations. Some of the reasons of why specific information needs to be obtained will be explained. Some common survey tools and its use will be taught | ✓ Structural strength of roof structures<br>✓ Shading issues<br>✓ Utility interconnection issues<br>✓ Grounding issues and lightning strike assessment<br>✓ Future obstructions<br><br>* Solmetric Suneye 210, GPS, Compass |
| Field Survey Development and Analysis | Different projects may require slightly different field survey data requirements. Being able to understand how to develop field survey procedures and analyze the data is important for a solar PV system designer in order to assess the conditions for design considerations | ✓ Important components of solar PV system field survey<br>✓ Common information for generic system development<br>✓ Other data to be gathered for specific types of projects such as solar street lights, commercial size systems, microgrid development for centralized solar PV systems, etc<br>✓ How to analyze the data and what they mean for the design of the solar PV systems |
| Technical Drawings | Introduce the different types of technical drawings (Mechanical, Electrical, Civil) and how to read them. Understanding of the drawings and implementing the information conveyed in the drawings | ✓ Review the different types of solar PV mounting drawings (tiled rooftop, flat roof, ground mount, etc)<br>✓ Identify the different components in the drawings<br>✓ Understand how to install the components<br><br>* Technical installation drawings |

| Session Topic | Summary | Summary of Content |
|---|---|---|
| | | * Mounting system samples |
| Common Electrical Symbols | Understand the commonly used electrical symbols in drawings especially pertaining to installation drawings and electrical drawings | ✓ Review a list of commonly used electrical symbols and what information they convey |
| 1 and 3 line diagrams | Explain the difference between 1-line and 3-line electrical diagrams and how to read them. Understand the information conveyed and use them as part of the installation document | ✓ What is 1-line diagram<br>✓ What is 3-line diagram<br>✓ How to use either one in combination of component installation manual to understand how the system works and how they should be installed |
| Common Installation Procedures | Generic installation procedures to ensure that participants understand the basics. Combined with specific information from the component's installation manual, there should be enough information to ensure a proper installation | ✓ What are the common steps in installation procedures<br>✓ Focus is on small home system, off grid, grid tied and grid tied with battery backup |
| Brand Specific Procedures | Specific installation procedures of 4 brands: Phocos, Morningstar, SMA and Outback | ✓ Show how to install a small home system from Phocos<br>✓ Show how to install an off grid system from Morningstar<br>✓ Show how to install a grid tied system from SMA<br>✓ Show how to install a grid tied system with battery backup from SMA and Outback |
| Procurement and pricing | Understand how to search for different suppliers and get the best price. How to set up a pricing structure to ensure profitable projects | ✓ How to connect with suppliers directly<br>✓ Different online distributors<br>✓ Basic import procedures<br>✓ Basic project budgeting and profit margin calculation |
| Financial Incentives | The specifics will be different with each country, but this session will look at some examples of financial incentives and how they can help the customer reduce their cost. How to implement some of these possible incentives for the customer's benefit | ✓ Tax credit or taxable income reduction<br>✓ Import duty exemptions<br>✓ Net metering<br>✓ Feed in tariff<br>✓ Subsidies |
| Financial Analysis | Being able to convince potential clients that a solar PV project make sense | ✓ System costing<br>✓ Payback period calculation<br>✓ Return on Investment<br>✓ Lifetime cost calculations |

| ***Session Topic*** | ***Summary*** | ***Summary of Content*** |
|---|---|---|
| | financially is an important step in getting the project. This session will teach the participant the basics of calculating simple return on investment, payback period, lifetime costs, internal rate of return, etc | ✓ Internal rate of return |
| Electrical System Design | Common industry standard for electrical system design. Calculate cable sizes, circuit breaker sizing, surge protection and lightning protection, grounding, and other electrical system design best practices around the world | ✓ Cable size calculation<br>✓ Grounding system<br>✓ Surge protection<br>✓ Circuit breaker sizing<br>✓ Labeling and other safety signs<br>✓ Lightning protection |
| Commercial Solar PV System Design Tools | Familiarize participants with the different commercial packages of solar PV system design tools. | ✓ Introduction to PVSyst<br>✓ Introduction to Solmetric PV Designer<br>✓ Introduction to PV*SOL<br>✓ Introduction to SolarEdge<br><br>* Need access to the above software (additional cost) |
| Solar PV Resource Databases | Solar PV system design highly relies on meteorological data of the site. The more localized the better. This session is to introduce the different types of solar meteorological resources available out there | ✓ Introduction to NASA EOSWeb data<br>✓ Introduction to Meteonorm<br>✓ Introduction to SolarGIS<br>✓ Introduction to 3Tier<br><br>* Need access to the above software/services (additional cost) |
| PV System Design | Utilizing the information given so far and the introduction to the tools, the participants will design one of each type of solar PV system:<br>- Small home system<br>- Off grid system<br>- Grid tied system<br>- Grid tied with battery backup | ✓ Load survey and calculation<br>✓ Survey data analysis<br>✓ Component selection<br>✓ Reading datasheets<br>✓ System integration<br>✓ Calculating losses<br>✓ Calculating battery capacity<br>✓ Calculating solar PV capacity |
| Industry Standards and Safety Practices | Introduce participants to international standards | ✓ IEC 62257 (all parts)<br>✓ IEC 62124<br>✓ IEC 61727<br>✓ IEC 61173<br>✓ IEC 61194<br>✓ IEC 61277<br>✓ IEC 61724<br>✓ IEC 62446<br>✓ IEC 62458<br>✓ IEC 62738<br>✓ IEC 62947 |

| ***Session Topic*** | ***Summary*** | ***Summary of Content*** |
|---|---|---|
| | | ✓ IEC 61836<br>✓ IEEE 1013<br>✓ IEEE 1361<br>✓ IEEE 1561<br>✓ IEEE 1562<br><br>* Need access to the above standards (additional costs) |
| Local Installation Standards and Safety Codes | This session will differ by country | ✓ Additional code or standard above the international best practices<br>✓ Alignment of international best practices with local standards and codes |
| Safety Procedures | Working on rooftops and with potential high voltages on solar PV systems is very dangerous. Common safety procedures and protocols need to be taught, understood and followed diligently | ✓ Working with heights<br>✓ Working with high voltages (>600 Volts)<br>✓ Working with power tools<br>✓ Potential fire hazards<br>✓ Potential hazardous chemical hazards |
| Project Planning | Learn how to plan projects from logistics, manpower and scheduling. Important for installers to be able to estimate the amount of time it would take to finish a project. Important for designers to be able to appropriately charge customers for any overhead and labor costs | ✓ Gantt chart<br>✓ Basic process breakdown<br>✓ Task management |
| Project Management | For designers only, this session is to introduce project management concepts and tools. This knowledge will help designers to properly manage their projects and finish them on time and under budget | ✓ Lean project management<br>✓ Agile project management<br>✓ Develop project definitions, plan, monitoring method and closure<br>✓ Milestone list, gantt chart, score card, metric/KPI development |

**Practical Hands On Sessions**

| **Session Topic** | **Summary** | **Summary of Content** |
|---|---|---|
| Basic Electrical Instrumentation | To ensure everyone is able to use the basic tools for electrical instrumentation, this session will introduce the participants to a multimeter, a clamp meter, and a data logger with several electrical instrumentation sensors | ✓ Multimeter training<br>✓ Clamp meter training<br>✓ Data logger training<br><br>* Require a multimeter, a clamp meter for DC current and a data logger with a current transducer sensor |

| Session Topic | Summary | Summary of Content |
|---|---|---|
| Electrical circuit measurements | Actual measurements of an existing residential system with several items plugged in and running | ✓ Ensure that everyone can take instantaneous measurements<br><br>* Need access to several types of live loads |
| Electrical load measurements | Actual measurements of several types of electrical loads.  Need to know the peak loads and voltage or current surges during the cycle of the item | ✓ Ensure that everyone can take logged measurements with a data logger and retrieve the data later<br>✓ Notice the surge in current and/or voltage on air conditioning units, high thermal loads and refrigerators<br><br>* Need access to several types of live loads |
| Solar PV system performance verification | Actual measurements on a small home system and a small grid tied system | ✓ Ensure that everyone knows the important measurements to take in order to judge the performance of a solar PV system |
| Inspection of PV systems | Perform inspection checklist for solar PV system | |
| Monitoring of PV systems | Install and commission at least 2 different kinds of monitoring systems, one of which must be accessible remotely | ✓ Install an SMA system<br>✓ Install an Outback system or Morningstar or Schneider or Leonics or Phocos |
| Field survey | Perform field surveys based on the checklist | * Require the same tools as the classroom session on field survey |
| Solar PV system installation - off grid | Install and commission a small home system and an off grid system | * Need 3 sets of small home systems<br><br>* Need 2 sets of small off grid system |
| Solar PV system installation - grid tied | Install and commission a small grid tied system and then add the battery storage system | * Need 3 sets of small grid tied systems<br><br>* Need 3 sets of battery backup systems |
| Safety procedures | Understand safety procedures and able to use safety tools and perform all installation according to safety requirements | * Need several sets of safety equipment such as helmets, gloves, goggles and body harnesses and safety clips |

### 4.5.2 Time allocations/Training duration

Exhibit 4.2 provides an estimation of time required per each lecture topic and practical hands-on session should the training be given in a comprehensive and detailed manner. Considering that curriculum for PV installer contains only parts of that for PV system designer, the expected total duration period for PV installer training is shorter. The total duration for lecture session for PV system designer is 4.6 weeks, while that for PV installer is 3.6 weeks. Practical hands-on sessions for both PV system designer and installer are approximately 1 week. This duration estimation is based on 5-day working days.

This should be used only as guidance. Different countries have different calculations, formats and requirements. Thus the duration should vary accordingly.

For practical reasons, these training curriculum could be divided into the following categories: (i) A. Core subjects - critical to know; (ii) Minor subject - must know; and (iii) C. Electives - good to know.

The approach and exams are both in theory and practical.

**Exhibit 4.2 Guidance for course duration**

| Lectures | | | |
|---|---|---|---|
| **Course Name** | **Installer** | **Designer** | **Time** |
| Basic solar PV system types | √ | √ | 0.3 days |
| Basic electricity | √ | √ | 0.3 days |
| Electrical workmanship | √ | √ | 0.7 days |
| PV modules | √ | √ | 0.7 days |
| Batteries and charging | √ | √ | 0.3 days |
| Charge controller | √ | √ | 0.3 days |
| Inverter - battery | √ | √ | 0.5 days |
| Inverter - grid | √ | √ | 0.5 days |
| Commissioning and performance verification | √ | √ | 0.5 days |
| Maintenance | √ | √ | 0.5 days |
| Monitoring and inspection | √ | √ | 0.5 days |
| Troubleshooting | √ | √ | 0.5 days |
| Technical drawings - Mechanical, Civil, Electrical | √ | √ | 0.3 days |
| Common electrical drawing symbols | √ | √ | 0.3 days |
| 1-line and 3-line diagram | √ | √ | 0.3 days |
| Common installation procedures | √ | √ | 0.3 days |
| Brand specific installation procedures | √ | √ | 0.5 days |
| Procurement and pricing | | √ | 0.3 days |
| Financial incentives and implementation | | √ | 0.3 days |
| Finance analysis | | √ | 0.5 days |
| PV system field survey | √ | √ | 0.5 days |
| Site survey development and analysis | | √ | 0.3 days |
| Electrical system design | √ | √ | 0.5 days |
| Commercial software solar PV design tools | | √ | 0.5 days |
| Solar PV resource databases | | √ | 0.5 days |
| PV system design | | √ | 1.0 days |

| | | | |
|---|---|---|---|
| Industry standards and safety practices | √ | √ | 0.5 days |
| Local installation standards and safety codes | √ | √ | 1.0 days |
| Safety procedures | √ | √ | 1.0 days |
| Project planning | √ | √ | 0.5 days |
| Project management | | √ | 0.5 days |
| | | | |
| OVERALL REVIEW | √ | √ | 3 days |
| | | | |

| **Practical Hands-on Sessions** | | | |
|---|---|---|---|
| **Course Name** | **Installer** | **Designer** | **Time** |
| Basic electrical instrumentation | √ | √ | 0.50 days |
| Electrical circuit measurements | √ | √ | 0.25 days |
| Electrical load measurements | √ | √ | 0.50 days |
| Solar PV system performance verification | √ | √ | 0.50 days |
| Inspection of PV systems | √ | √ | 0.50 days |
| Monitoring of PV systems | √ | √ | 0.25 days |
| Site survey | √ | √ | 0.50 days |
| Solar PV system installation - off grid | √ | √ | 1.00 days |
| Solar PV system installation - grid tied | √ | √ | 0.50 days |
| Safety procedures | √ | | 0.50 days |

## *APPENDIX A: COMPARISON OF TRAINING CURRICULUMS FOR SYSTEM DESIGNER*

| **Aspects** | **Australia Clean Energy Council** | | **NABCEP** | **TESDA** | **SEDA** |
|---|---|---|---|---|---|
| | **Stand Alone** | **Grid Connected** | (PV Technical Sales) | (Philippines) | (Malaysia)<br>Grid Connected |
| **Prior Knowledge** | 1. **Electrical Knowledge**<br>**a.** Apply Occupational Health and Safety regulations, codes and practices in the workplac<br>**b.** Fabricate, assemble and dismantle utilities industry components<br>**c.** Solve problems in d.c. circuits<br>**d.** Fix and secure electrotechnology equipment<br>**e.** Use drawings, diagrams, schedules, standards, codes and specifications<br>**f.** Lay wiring/cabling | 1. **Electrical Knowledge**<br>**a.** Apply Occupational Health and Safety regulations, codes and practices in the workplac<br>**b.** Fabricate, assemble and dismantle utilities industry components<br>**c.** Solve problems in d.c. circuits<br>**d.** Fix and secure electrotechnology equipment<br>**e.** Use drawings, diagrams, schedules, standards, codes and specifications<br>**f.** Lay wiring/cabling and terminate accessories for | | Have undergone training on PV Installation National Certificate Level II. | Minimum of electricity topics in the subject of physics in first year post-high school curricula. Most probably at tertiary level such as colleges/universities. |

| | | | | | |
|---|---|---|---|---|---|
| | and terminate accessories for ELV circuits<br>**g.** Solve problems in electromagnetic devices and related circuits | ELV circuits<br>**g.** Solve problems in electromagnetic devices and related circuits | | | |
| **Pre Design** | | | • Qualify the Customer<br>a. Analyze electrical bill<br>b. Perform remote site assessment<br>c. Identify customer needs<br>d. Perform ball park estimate<br>e. Identify jurisdictional issues<br>f. Manage customer expectations<br>• Site Analysis<br>a. Inspect electrical service<br>b. Identify locations for system components<br>c. Access mounting locations<br>d. Perform shade | Basic competencies:<br>• Lead workplace communication<br>• Lead small team<br>• Develop and practice negotiation<br>• Solve problem related to work activities<br>• Use mathematical concepts and techniques<br>• Use relevant technologies | • Introduction to photovoltaic systems<br>• Basic solar engineering<br>• Photovoltaic technology<br>• Grid interactive inverter<br>• Connection to the grid |

| | | | | | |
|---|---|---|---|---|---|
| | | | analysis | | |
| **Design** | **1. PV System Knowledge**<br>**a.** Design stand-alone renewable energy (RE) systems[32] | **2. PV System Knowledge**<br>Design grid connected photovoltaic power supply systems[33] | • Conceptual design<br>a. Select appropriate equipment<br>b. Determine equipment location<br>c. Plan system layout<br>d. Perform string sizing<br>e. Determine breaker size or supply side connection<br>f. Determine | Common Competencies:<br>• Prepare construction materials and tools<br>• Perform measuration and calculation<br>• Maintain tools and equipment<br>• Observe procedures, specifications and manuals of instructions<br>• Interpret technical drawings and plans | • Design and sizing |

[32] This unit covers the design of stand-alone renewable energy systems and their installation. It encompasses following design briefs, incorporating schemes for protection of persons and property from dangers of system malfunction, ensuring other safety and performance standards and functional requirements are meet and documenting design calculations and criteria. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE62011_Advanced_Diploma_of_Engineering_Technology_Renewable_Energy/Brochure_Q347.ashx#sthash.8u6jYRhw.BAGxdyXP.dpuf

[33] This unit covers the design of grid connected photovoltaic power supply systems and their installation. It encompasses following design briefs, incorporating schemes for protection of persons and property from dangers of system malfunction, ensuring other safety and performance standards and functional requirements are meet and documenting design calculations and criteria. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE50711_Diploma_of_Renewable_Energy_Engineering/Brochure_Q338.ashx#bso_822

| | | | | | |
|---|---|---|---|---|---|
| | | | mounting method and tilt angle | Core Competencies:<br>• Determine customer requirements<br>• Calculate system components requirements (system sizing)<br>• Specify components in bill of materials<br>• Prepare installation drawings. | |
| **Post Design** | **a.** Carry out basic repairs to renewable energy apparatus<br>**b.** Solve basic problems in photovoltaic energy apparatus<br>**c.** Solve problems in stand-alone renewable energy systems | | • Financial costs, incentives, and savings<br>a. Explain types of incentives and net cost<br>b. Explain types of utility rates and net electric bill savings<br>• Financial Benefit Analysis and Financing<br>a. Calculate financial analysis<br>b. Evaluate appropriate financing options<br>• Non-Financial Benefit Analysis<br>a. Calculate/quantify environmental benefits | | • System performance and evaluation<br>• Installation, operation and maintenance<br>• Lightning protection system |

| | | | | | |
|---|---|---|---|---|---|
| | | | proportional to estimated production<br>b. Describe non-financial non-environmental benefits<br>• Performance analysis<br>a. Calculate production<br>b. Identify factors that degrade system performance over time<br>• Prepare Proposal<br>a. Create minimum acceptable proposal<br>• Include additional elements as applicable and/or appropriate | | |

## *APPENDIX B: COMPARISON OF TRAINING CURRICULUMS FOR PV INSTALLER*

| Aspect | Australia Clean Energy Council | | NABCEP | PVTRIN | Power Research Institute | Expert Club |
|---|---|---|---|---|---|---|
| | Stand Alone | Grid Connected | (US, Canada) | (Europe) | (Mexico) | (India) |
| **Theory** | **A. Electrical Knowledge**<br>**a.** Apply Occupational Health and Safety regulations, codes and practices in the workplace<br>**b.** Fabricate, assemble and dismantle utilities industry components<br>**c.** Solve problems in d.c. circuits<br>**d.** Fix and secure electrotechnology | **A. Electrical Knowledge**<br>**a.** Apply Occupational Health and Safety regulations, codes and practices in the workplace<br>**b.** Fabricate, assemble and dismantle utilities industry components<br>**c.** Solve problems in d.c. circuits<br>**d.** Fix and secure electrotechnology equipment<br>**e.** Use drawings, diagrams, | 1. Verify System Design<br>a. Verify Client Needs<br>b. Review Site Survey<br>c. Confirm System Sizing<br>d. Review Design of Energy Storage System<br>e. Confirm String Size calculations<br>f. Review System Component Selection<br>g. Review Wiring and Conduit Size Calculations<br>h. Review Overcurrent Protection Selection<br>i. Review Fastener Selection<br>j. Review Plan Sets | 1. Solar Basic<br>a. Solar Photovoltaic (PV)<br>b. PV System<br>c. PV Technology<br>d. Benefits of PV Technology<br>2. Design Principle<br>a. On Site Visit<br>b. System Sizing and Design<br>c. Simulation Software<br>d. Economics and Environmental Issues<br>e. Standards and Regulations<br>3. BAPV and BIPV<br>a. Mounting and Building Integration Option<br>b. BIPV and BAPV on roofs<br>c. PV on facades<br>d. Glass roofs, shading systems and other application<br>e. Design | 1. Photovoltaic technology<br>a. Fundamentals of Photovoltaics<br>b. Basics of photovoltaic technology<br>c. What is connected to the electricity grid PV system?<br>d. Types of PV systems connected to the network<br>**e.** Scope International<br>2. Fundamentals of electricity in SFVI<br>a. Description of electrical parameters<br>b. Concept of generator and load average driver<br>c. Circuits of direct current (DC)<br>d. Circuits Alternating Current (AC)<br>e. The grid Mexican SE<br>f. Basic Classification SFVI residential<br>3. Investors<br>a. Types of investors to SFVI<br>b. Operational conditions to consider<br>c. Requirements for | 1. Module technology, module components, module warranty.<br>2. PV Design basics (Site survey, PV simulation, series, parallel, shading and sunpath)<br>3. Structure Design (Wind Loads), understanding structural differences, hands on installation<br>4. Load Sizing, Energy Effficieny measures, LED lighting benefit measurements, LEED buildings<br>5. Session-6: Battery |

| Aspect | Australia Clean Energy Council | | NABCEP | PVTRIN | Power Research Institute | Expert Club |
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| | Stand Alone | Grid Connected | (US, Canada) | (Europe) | (Mexico) | (India) |
| | equipment<br>**e.** Use drawings, diagrams, schedules, standards, codes and specifications<br>**f.** Lay wiring/cabling and terminate accessories for ELV circuits<br>**g.** Solve problems in electromagnetic devices and related circuits | schedules, standards, codes and specifications<br>**f.** Lay wiring/cabling and terminate accessories for ELV circuits<br>**g.** Solve problems in electromagnetic devices and related circuits<br>**B. PV System Knowledge**<br>**a.** Solve basic problems in photovoltaic energy | 2. Conducting Maintenance and Troubleshooting Activities<br>a. Perform visual Inspection<br>b. Verify System Operation<br>c. Perform Corrective Action<br>d. Verify Effectiveness of Corrective Actions | Parameters and Performance Factors<br>4. Maintenance and Troubleshooting<br>a. Maintenance Plan<br>b. Common Mistakes and Failures<br>c. Diagnostic Prosedures Documentation to the customer<br>d. Customer Documentatio<br>e. Maintenance Cheklist | investors SFVI<br>**d.** Current status of technology<br>4. (Theory) Implications of interconnection techniques and solution strategies harmonic<br>a. Distorsión<br>b. Power Factor<br>c. Voltage Fluctuation<br>d. Response to fault situations<br>e. Operating Condition in "island mode" (islanding)<br>f. Analysis of the technical specification CFE-G100-04<br>5. System components and installation<br>a. System Components<br>b. Electrical Installation<br>c. Mechanical Installation<br>d. Security<br>6. Operation, Maintenance | Technology (Types, Selection, Maintenance)<br>6. Charge controllers, UPS, Off-grid inverters, Hybrid inverters, AC coupling concepts, Maximizing PV output<br>7. Session-8: On-grid Design and Off-Grid Design Basics<br>8. Commissioning, Remote Monitoring & Troubleshooting |

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| | Stand Alone | Grid Connected | (US, Canada) | (Europe) | (Mexico) | (India) |
| | **B. PV System Knowledge**<br>**a.** Carry out basic repairs to renewable energy apparatus[34]<br>**b.** Solve basic problems in photovoltaic energy apparatus[35] | apparatus[36] | | | and Trouble Shooting<br>a. Operation SFVI<br>b. Maintenance and service<br>c. Fault Detection<br>**d.** Trouble Shooting | |

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[34] This unit deals with the replacement of electrical and non-electrical components of renewable energy apparatus. It encompasses safe working practices, following written and oral instructions and procedures, basic testing techniques, disconnecting and reconnecting electrical/electronic components, dismantling and assembling apparatus and reporting repair activities. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE62011_Advanced_Diploma_of_Engineering_Technology_Renewable_Energy/Brochure_Q347.ashx#sthash.8u6jYRhw.BAGxdyXP.dpuf

[35] This unit covers providing known solutions to predictable problems in stand-alone renewable energy systems operated at extra-low voltage. It encompasses working safely, problem solving procedures, including the use of basic voltage, current and resistance measuring devices, providing known solutions to predictable circuit problems. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE62011_Advanced_Diploma_of_Engineering_Technology_Renewable_Energy/Brochure_Q347.ashx#sthash.8u6jYRhw.BAGxdyXP.dpuf

| Aspect | Australia Clean Energy Council | | NABCEP | PVTRIN | Power Research Institute | Expert Club |
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| | Stand Alone | Grid Connected | (US, Canada) | (Europe) | (Mexico) | (India) |
| | **c.** Solve problems in stand-alone renewable energy systems | | | | | |
| **Practical** | **e.** Install ELV standalone photovoltaic power systems[37] | **b.** Install, configure and commission LV grid connected photovoltaic power systems[38] | 3. Installing Electrical Components<br>a. Mitigate Electrical Hazards<br>b. Installing Grounding System<br>c. Install Conduit | 5. Installation – Site work<br>a. Working safely with PV<br>b. Intallation Plan<br>c. Electrical components Installation<br>d. Mechanical Components | 9. (Practice)<br>a. Experiment 1: Getting the characteristic curve of the diode.<br>b. Experiment 2: Getting the characteristic curve of a PV module.<br>c. Experiment 3: Obtaining the characteristic curve of | 10. On-Grid installation AC Design & Hands on (Transformer-less / Transformer Inverters, Single phase/3Phase, |

[36] This unit covers providing known solutions to predictable problems in photovoltaic energy apparatus and systems operated at ELV and LV. It encompasses working safely, problem solving procedures, including the use of basic voltage, current and resistance measuring devices, providing known solutions to predictable circuit problems. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE50711_Diploma_of_Renewable_Energy_Engineering/Brochure_Q338.ashx#bso_821

[37] This competency standard unit covers the installation, adjustment and set up of ELV stand-alone photovoltaic power systems. It encompasses working safely and to installation standards, matching components with that specified for a given location, placing and securing system components accurately, making required circuit connections and completing the necessary installation documentation. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE62011_Advanced_Diploma_of_Engineering_Technology_Renewable_Energy/Brochure_Q347.ashx#sthash.8u6jYRhw.BAGxdyXP.dpuf

[38] This unit covers the installation, adjustment and set-up of photovoltaic power systems and connecting to a supply grid inverter. It encompasses working safely and to installation standards, matching components with that specified for a given location, placing and securing system components accurately, making required circuit connections and completing the necessary installation documentation. - See more at: http://coursesearch.skillstech.tafe.qld.gov.au/tafe/training/UEE50711_Diploma_of_Renewable_Energy_Engineering/Brochure_Q338.ashx#bso_821

| Aspect | Australia Clean Energy Council | | NABCEP (US, Canada) | PVTRIN (Europe) | Power Research Institute (Mexico) | Expert Club (India) |
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| | Stand Alone | Grid Connected | | | | |
| | | | and Raceways<br>d. Install Electrical Components<br>e. Install Circuit Conductors<br>f. Install Utility Interconnection<br>g. Install System Instrumentation<br>h. Install Battery Componets<br>4. Installing Mechanical Componets<br>a. Install Equipment Foundation<br>b. Install Mounting System<br>c. Install PV Modules<br>5. Complete System Installation<br>a. Test the System<br>b. Commission the System<br>c. Complete System | Installation<br>e. Grid-connected PV System<br>f. Stand-alone PV System<br>g. Mounting system and building installation<br>h. Completing the PV Installation<br>i. Installation Cheklist | a PV module at different amounts of radiation.<br>d. Experiment 4: Effect of temperature on the characteristic curve of a photovoltaic module.<br>e. Experiment 5: Effect of the tilt angle of the PV module output power.<br>f. Experiment 6: Simulation monitoring in summer / winter.<br>g. Experiment 7: Series connection of photovoltaic modules.<br>h. Experiment 8: Parallel connection of photovoltaic modules.<br>i. Experiment 9: Shading photovoltaic modules without bypass diode.<br>j. Experiment 10: Shading photovoltaic module with bypass diode.<br>**k.** Experiment 11: Operation of a PV system interconnected to the network. | Negative Grounding, Earthing/ Lightning, Surge Protection, Disconnects, Grid Synchronization) |

| Aspect | Australia Clean Energy Council | | NABCEP | PVTRIN | Power Research Institute | Expert Club |
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| | Stand Alone | Grid Connected | (US, Canada) | (Europe) | (Mexico) | (India) |
| | | | Documentation<br>d. Orient Customer to system | | | |
| **Soft Skill** | | | 6. Managing the Project<br>a. Conduct Pre-Construction Meetings<br>b. Secure Permits and Approvals<br>c. Manage Project Labor<br>d. Adapt System Design<br>e. Manage Project Equipment<br>**f.** Implement a Site-Specific Safety Plan | 6. Quality Management & Customer Care<br>a. Quality Principle<br>b. EU Standards for PV<br>c. Customer Care | | |

In addition to the training curriculum listed below, SEDA Malaysia provides similar training which is called Chargeman/wireman PV course. The content of this training is listed as follows:

Introduction:

- Background
- Course structure
- Competency Course
- Methodology and approach
- Training scope and objective

1. Grid-connected PV
    - Introduction
    - Basic concept of on-grid solar PV
    - PV modules characteristics
    - Grid Connected Inverter
    - Other components
    - Practical hands-on (practice)
2. Installation
    - Introduction
    - Safety aspects
    - Tools and components
    - Installation procedures
    - Installation activities
    - Practice
3. Grid connected Solar PV operation and maintenance
    - background
    - methodology and objectives
    - Switch on and switch-off the system
    - Test and commissioning
    - System maintenance

4. Experiments

***APPENDIX C: VIDEO SCRIPT- PRACTICAL HANDS-ON TRAINING ON INSTALLATION OF ROOFTOP SOLAR PV SYSTEM***

| VISUAL | AUDIO |
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| Collage of pictures from the video content, 2D animation of the video title:<br><br>“Hands-on Training on Installation of Rooftop Solar PV System” | Music<br><br>VO: “Hands – on Training on Installation of Rooftop Solar PV System” |
| - Explaining the purpose and content of the video<br><br>The video is consisted of four (4) parts:<br>A. First Interaction with Customer and Site Visit Preparation<br>B. Site visit<br>C. System design<br>D. Installation<br>- Visual Graphic 2D animation of the parts<br>- Solar PV engineer talking to the camera | Solar PV Engineer:<br><br>“This video is a tutorial video Hands – on Training of Rooftop Solar PV System. Through this video you can learn how to handle the customer and the correct process to install Rooftop Solar PV System”<br><br>“This video consist of four parts:<br>A. First Interaction with Customer and site visit preparation.<br>B. Site Visit<br>C. System Design<br>D. Installation” |
| 2D Animation Graphic:<br>A. “First Interaction with Customer and Site Visit Preparation”<br>- Talking head The Senior Engineer explain the purpose of this part.<br>- Medium shot track right: an employee talking to the customer on the phone.<br><br>- Close up an employee asking the customer<br>- Close shot the employee writing the | The Solar PV engineer:<br><br>“In this video, we would like to explain about the first interaction with customer and upon agreement for a site visit between customer and company, the engineer conduct preparation for a site visit.” |

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| customer question<br><br>- Full shot the employee start to answer the Q's track out to –<br><br>- The Solar PV engineer in frame and explaining a quick survey for go or no go.<br><br>2D Animation on what kind of question customer usually asked.<br><br>Full shot an employee on the phone | Employee: May I help you sir?<br><br>Voice Over Customer (on the phone):<br><br>"I am interested in installing Solar PV but I need more information about it. How will I know if solar energy can work for me?"<br><br>Employee: "Solar PV works on just about any location, as long as the site doesn't receive shade. If your roof is shaded, solar PV can be installed on a ground mount system, on a pole mount system, or on a garage, shed or adjacent building." (the voice slowly fading out)<br><br>The senior engineer: "The quick survey on the phone is very important. The customer usually asking about the thing that's not familiar to them about Solar PV. We have to deliver the very detail explanation on how the Solar PV works.<br><br>The customer usually asked about the price, technical installation requirement, process duration, what is the benefit on having the Solar PV etc."<br><br>"We also need to get more information from the customer includes their needs, basic structure of house and roof."<br><br>Employee: "Base on your information I think we can help you to install the Solar PV sir, but we need to visit the site. Our team will |

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| Preparation for a site visit.<br><br>Montage: A new engineer being trained by a senior engineer to do site survey. The senior engineer showing to the new one the checklist and the tools/materials to be prepare.<br>- Suppers and graphics of the materials:<br>▪ Tools<br>▪ Survey form<br>▪ Methodology<br>▪ Safety equipment<br>▪ Safety procedures<br><br>Video was ended with a closing scene: The two engineers leave in a car with a slow pan through the back of the truck showing all of the tools. | assist you get the detail information about the site include the strength of the roof, the shade, the electrical system and type of the roof. Can we do it on Monday, April 21, 2015?<br><br>VO. Customer: “ Sure… see you on Monday then…”<br><br>Music |
| 2D Animation Graphic<br><br>B. Site Visit<br><br>- Traveling shot the van on the road to the customer house.<br><br>- The van stop in front of the customer’s house. The engineers come out of the car and meet the customer. They have a little chat.<br><br>- Full shot the engineer talking to the customer. | Music |

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| - The engineers walking around the property and checking the orientation.<br>- After that they decide the roof that suitable for solar PV installation.<br>- Begin to do the visual inspection if any loose, crack or broken tile. Make the note on the site drawing<br>- Looking for the obstruction like dormer window, vent pipes and make a note in site drawing.<br>- Measure the roof<br>- Measuring the length<br>- Measuring the slope<br>- The engineer climbing to the roof and measure the slope physically.<br>- Full shot and detail of engineers measure the slope using inclinometer or application from their Smartphone.<br>- 2D graphic animation on how to measure the slope. | Senior Engineer: “Ok sir, to start the survey first we have to take a walk around your property to get the orientation of the property.”<br><br>Customer: “Sure, please do what you have to do.”<br><br>VO: We need to measure the available roof area. First, we have to measure the length.<br><br>Then, we have to measure the slope. There are two ways to measure the slope:<br>1. Physically measure the slope<br>2. Measure the width of the roof from the ground and measure the angle in degrees using inclinometer. Once you have the roof depth and angle you can measure the length.<br><br>Now you have the number and you can workout the needs of the panel that should be installed on the roof.<br><br>The number of the panel is varied depend on the size of the panels. You can count the kilowatt peak of the system by multiplying the output of one panel to the numbers |

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| | of panel that will fit on the roof and this will give you the total array size. |
| - Identify the roof covering | The roof covering type will tell the installer what type of bracket they need to use to install the panel. |
| - Measure the height of the building | Measure the height of the building from ground to gutter and put some note on how many scaffolding will set and note also any access restriction. |
| - Full shot of the engineers surveying on shading | Shading is very important when we have to install the Solar PV. Even a small amount of over shading can impact the performance of the Solar PV. |
| 2D Graphics on the type of shading.<br><br>2D Graphics Overshading Factors Table | There are numbers of type of shading:<br>1. None or very little < 20% of sky will be blocked by obstacles<br>2. Moderate 20% - 60% of the sky will be blocked by obstacles<br>3. Significant 60%-80% of the sky will be blocked by obstacles<br>4. Heavy > 80% of the sky will be blocked by obstacles. |
| - inspecting the loft | Shading is always subjective but this table will guide you to decide the shading. Please remember that the sun is not always static. |
| | - We now look at surveying the loft. First, we have to survey the loft hatch and measure it. Now entering the loft and find any problems and recording it.<br>- Measure the spaces between the rafters, and measure the depth and width of the rafters and record this.<br>- Record if there is any ladder in to the loft and any lighting and |

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| - Electrical section<br><br>- Earthing<br>2D animation or graphics on the earthing systems.<br><br>Full Shot the engineer talking to the customer and say goodbye… | flooring present.<br>- Recommend where to install inverter and the isolator. Loft is often an ideal place to site this to minimize the DC cable round.<br>- If the loft is not suitable you should make a notification and locate another place that you thing suitable to site the inverter and isolator, for example in the garage or the cellar or any other appropriate place that the customer will be happy with. The cable will be run from the inverter to the panel and another connection from the inverter to the property's electrical supply.<br><br>- Locate the electrical supply, the meter and the fuse box. Measure the needs of the cable to connect the electrical supply to the inverter.<br><br>- You need also to capture the earthing.<br><br>- There are 3 main earthing systems<br><br>1. TN-C-S System<br>2. TT System<br>3. TN-S system<br><br>What we need to identify is how the earthing cable is terminated. This is purely visual inspection, if there is any doubt please capture the images of the supply so this will be very obvious for the installer. |
| C. Design<br>The senior engineer explains on how to do below analysis<br>o Size of the system<br>o Location/direction/tilt | A meeting and design making on how they will install the solar PV |

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| - Location of components<br><br>The video ends with a view of a finished electrical and mechanical drawings. | based on the survey<br><br>(*VO or senior engineer explaining the design process)<br><br>For rooftop solar PV systems with a grid tied scheme, there are two considerations:<br>- There is regulation allowing net metering or feed in tariff<br>- There is NOT a regulation allowing net metering or feed in tariff. This scenario is called self-consumption<br><br>When net metering/Feed in Tariff is allowed, then the size of the solar PV system can be as large as the customer is willing to install within the limits of their facility. This is because any excess energy produced will be sent to the grid and the client will be credited for it.<br><br>When net metering/feed in tariff is not allowed, then the size of the solar PV system cannot exceed their day time energy and power usage. Based on the earlier survey, this should already be known. Let's say that the client is using 3500 watts maximum between 10am and 2pm and the total daytime energy use between 9am and 4pm is 5kWh, then we would install a system that will produce no more than 5 kWh. In this area that means around 1.25-1.5kWp of solar panels. Because the power produced is less than the peak power used by the client, then this is okay.<br><br>If the client is using 2000 watts maximum between 10am and 2pm |

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| | and the total daytime energy use between 9am and 4pm is 12kWh then to be able to cover that demand we would need about 3kWp of solar panels.  But because this value is much higher than the 2000 watts maximum power that the client needs, this system size would produce excess energy and power.  Since there is no feed in tariff or net metering available, then this system will be wasting this excess energy.<br><br>For this client, the recommendation is that we install something like 1.5kWp so that the system will not produce any excess energy.  But as a consequence, this system will only produce about 6kWh of energy during the day and it would only cover 50% of the client's daytime energy use.<br><br>Now that we know the size of the system, let's figure out where to install it.  Fortunately the roof is facing North already.  We are south of the equator, and the panels need to be tilted toward the equator so in this case, North.  Also fortunately, the roof is already at a 20 degree tilt.  The tilt for the solar panels are usually matched with the latitude of the location.  For areas near the equator (<15 degrees) we do recommend that the tilt is at 15 degrees minimum.  This will allow any rain water that fall on the panels to run off on its own and somewhat clean the normal dust and debris on the surface.<br><br>Once the solar panels are located, now we have to figure out where to install the rest of the components.  As can be seen on this single line diagram, we have the solar array |

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| | DC disconnect, inverter and AC disconnect at a minimum. The solar array DC disconnect need to be located near the array and near the inverter. If the inverter is already close to the inverter then only one is required. Often inverters have a DC disconnect built in already. The inverters also need to be installed as close to the solar panels as possible in order to minimize the DC cable run. DC cables are usually expensive and we need to minimize this to save cost. Also, the DC circuit is a high voltage one (up to 600VDC on residential solar PV systems). This can pose a significant hazard so this need to be shortened as much as possible. |
| D. Installation<br>This video consists of two parts. Part one is about the preparation and part two is about the installation itself.<br><br>The senior engineer explains that the checklist for preparation are:<br>o Tools<br>o Safety<br>o Logistics<br>o Shipping to site<br>o Carrying equipment safely | Now let's document this and get the drawing ready for the installers.<br><br>VO on how preparation process at the office |
| At the office, the engineers are discussing the logistics to site.<br><br>At the office, the engineers are loading the tools, materials and safety equipment. | Let's get ready for the installation for this client. We need to make sure that we have all the tools and safety gears needed for our work.<br><br>Since this is a normal solar rooftop installation, there's no special equipment that we'll need other than the normal set. Make sure to have:<br>- Torque wrench and screwdwriver |

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| | - Complete set of ratchets<br>- Complete set of screwdrivers<br>- Battery powered drill<br>- Drill bit sets<br>- Hammer<br>- Step ladder<br>- Ladder<br>- Torx and hex bits<br>- Etc<br>- Safety goggles<br>- Earplugs<br>- Safety vest<br>- Personal fall protection device |
| At the warehouse, the engineers are loading the trucks with the panels. | Discussing the logistics to site. So who will be going? How many people are needed for small project (2-4 people for <3kW)? What car will we take? What's the address? Are there any challenges? Are there roads going to the site or is the site a new development so there are no roads for the last few km? Can we ride with the truck that's bringing the material? |
| | Speaking of material, let's double check the documentation and check the load that's going to our job site. Is everything packed? Anything missing? Compare with the design bill of quantity and the shipping paperwork. If possible check the items individually at the warehouse. |
| Arrival at site. Unloading the tools, etc.<br>Montage of the installation process:<br>o Preparing the safety equipment.<br>o Installing inverter.<br>o Installing panels on the roof.<br>o Installing the wiring and distribution boxes (DC).<br>o Installing DC disconnect | How will the material arrive on site? Will it be shipped by a third party? Will our trucks go and deliver it? Who will receive the materials on site? How will it be stored in the mean time? Where is the storage location?<br><br>Music |

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| - Installing AC wiring<br>- Connecting DC wiring then AC wiring<br>- Explaining the turn on and shut down procedure<br>- Showing the commissioning<br>- Walking through with the client about the operation and maintenance.<br>- The video closing scene is saying good bye to a happy customer. | VO how the process to install Solar PV<br><br>Now that everything is on site and we're ready to work, let's put on our safety gear.<br><br>First let's install the solar panel mounting brackets on the roof. This is a tiled roof and we need to install the brackets on the strongest beams. It is shown on this drawing that these are the strongest beams. Make sure to return the tiles to the original arrangements so that there are no leaks.<br><br>(*note: for each training institution, select a particular brand of mounting rack and follow the instruction for that brand for this video*)<br><br>Now it's time to install the racks onto the brackets. It's very simple just these bolts and a clip. |

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| | Last but not least, let's install the solar panels. Note that there is some room underneath the panels to allow for air to flow below the panels. This will keep the heat from building up and reduce the panel's efficiency. This is by design, any commercialized solar panel mounting system will have this covered as they go through the mounting bracket selection process with us.<br><br>Now let's install the inverter. We'll install it here close to the panels but protected from direct sunlight and exposure to the rain and weather. Since it is close to the solar array we can use the built in DC disconnect on this inverter. Once this is connected to the solar pv array, keep the disconnect open so that nothing is energized until we are ready.<br><br>Routing the DC cable to the inverter is important. This can produce up to 600VDC. So make sure everything is protected in a conduit. Watch the routing and make sure to follow the design engineering drawing for the routing. However if you see that there is a safety concern with how the engineers drew the cable routing, make sure you document how it will be routed instead and why. Make sure there are enough cable for the reroute.<br><br>Now we're ready to connect the AC circuits to the main distribution board. Watch out for the routing, make sure everything is protected inside of a conduit. Just as the DC cabling, make sure the routing is |

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| | safe and if it deviates from the design drawing, it needs to be documented properly.<br><br>-------------------<br><br>Okay now that we're ready to turn on the system, remember that we do NOT want to turn it on while there are any loads.  So To turn on the system, the solar PV array disconnect need to be turned on first.  Let the inverter come on and be fully operational before the AC disconnect is turned on.<br><br>To turn it off, the process is the opposite.  We need to turn off the AC disconnect to make sure the inverter is not providing power to the loads, then we can disconnect the DC side.<br><br>---------------------------<br><br>Commissioning – see the commissioning checklist.  Just go through this document and show it.<br><br>---------------------------<br><br>Now with the client, walk through the whole system to explain how the system works from the solar panels to the inverter to the disconnect switches.<br><br>Show the solar panels, why it's installed facing this direction and |

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| | the angle. Show the inverter, talk about what it does (changes the DC voltage from the solar panels to AC voltage ready to use), talk about the display screen and what it's showing. (*note: this will be different depending on what inverter is used in the video*)<br><br>Show the turn on/shut off procedures, where are the disconnect switches, etc<br><br>Show the remote monitoring system (on the web and on the hand phone) (*note: again this will be different depending on what inverter is used and what monitoring system is used*) Show what the system's graph is saying and what they indicate.<br><br>-------------------<br><br>For the operation and maintenance, talk to the client about how to clean the panels. Maybe even show the video of cleaning the panels so the client knows how to do it. Also to check the breakers and disconnect switches.<br><br>Offer the client an operation and maintenance contract and outline what will be done:<br>- Monthly report of the system performance<br>- Alarms when the system performance is drastically abnormal<br>- Monthly cleaning<br>- Review of the system every 6 month and a site visit<br>- Review of the system every 12 months, and a site visit and a |

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| | comprehensive performance verification with specialized equipment such as IR camera, pyranometer, etc<br><br>**MUSIC CLOSING** |

Project Number: EWG 22/2013A

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