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Discussing Educational Solar Energy Training at Metropolia UAS for Asylum Seekers

Helsinki Metropolia University of Applied Sciences
Bachelor of Engineering

Degree Programme in Environmental Engineering

Thesis

Date 24.08.2016

Author(s) Title Number of Pages Date	Rupesh Sharma Discussing Educational Solar Training at Metropolia UAS for Asylum Seekers 26 pages + 3 appendices 24 August 2016
Degree	Bachelor of Engineering
Degree Programme	Environmental Engineering
Specialisation option	Renewable Energy
Instructor(s)	Antti Tohka, Senior Lecturer

The on-going conflicts in different parts of the world has resulted in growing the number of asylum seekers in many countries. Finland, being one of the most developed countries with a high living standard is one of the top destination for the asylum seekers. Metropolia UAS is particularly interested in providing solar energy training to the asylum seekers.

The purpose of this thesis was to study different university courses and design a course and course assignments for asylum seekers. The plan was to study the courses offered by partner universities, but due to lack of enough Metropolia partner universities providing solar courses, universities other than partner universities were taken into account. Due to the lack of a complete overview of laboratory assignments provided by the universities, the assignments designed in this project had to be improvised.

As solar energy is the focus of training to be offered, a course on solar energy was designed for understanding of solar terminology and principles. A total of four laboratory assignments were designed in this project. The first two is for better understanding of the solar energy system and the final two for getting familiar with solar devices and for gaining experience in building them.

Keywords	solar energy, training, lab works, asylum seekers

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Acknowledgement

My fore-most gratitude goes to Antti Tohka for providing me this thesis topic and guiding me in every step. I cannot thank Antti enough for his support and help during time of crisis. I want to thank my language instructor Minna Paananen Porkka for reviewing my thesis and providing vital comments.

I would also like to thank my parents and friends for their motivation and constant support.

1 Introduction

World is searching for replacements for fossil fuel and human dependency on renewable energy source in near future is not a far-fetched idea. Solar energy is one of the largest forms of energy available for human beings. The total amount of sunlight falling on Earth’s surface for about two hours could power entire planet for an estimated period of a year. Harnessing solar power isn’t new idea but has gradually being increasing in popularity. Solar power could be utilized in a simple way with few apparatuses in hand and have varieties apart from electricity production. Around 1.05 percent of electricity is generated in the world from solar energy. It is predicted that solar power could supply 27 percent of global population’s energy needs by 2050 (UNDP, 2016).

Growing number of conflicts in different parts of the world have increased the number of asylum seekers in many countries (UNHCR, The UN Refugee Agency, 2015). Finland, being one of the most developed countries with a high living standard, is one of the top destination for asylum seekers (Tanner, 2016). Metropolia UAS is particularly interested in providing solar training to the asylum seekers. Access to education and training is a vital part of the socio-vocational integration process of asylum seekers. The development of training setups could help them empower their learning process and prepare a step towards integration to the Finnish labour market and society (ASAP, asylum support appeals project, 2007). Solar energy emerges as easy, convenient and promising when compared to other renewable energy sources. This project aims towards designing a simple solar energy course with a few laboratory assignments which serve as training.

2 Background

According to Finnish Immigration, asylum seekers arriving in Finland is increasing every year. In 2015, Finland received 32,476 asylum seeker applications, out of which 1628 were provided asylum (Finnish immigration Service, 2016). Many of the seekers are educated and are looking for opportunities for complete assimilation in Finnish daily life. A number of companies and educational institutions in Finland have established internship and training programs to help the arriving asylum seeker integrate into Finnish work environment. Hanken university (Hanken university, 2016) and Valmet (Valmet, 2016) are examples of institutions helping asylum seekers with internship and training program.

This project is continuation of such attempt to help asylum seekers and provide them solar energy knowledge. This project aims to provide asylum seekers with basic knowledge of solar energy which might prove an important opportunity for some of the participants to integrate in Finnish society.

Although many educational institutions have solar programs which are open to asylum seekers in Finland, this is the first attempt of Metropolia (Myyrmaki unit).

3 Methodology

Metropolia is planning an approach to provide the asylum seekers with a basic knowledge on solar energy which might be a vital program in some seeker's rehabilitation process. A scanning process will be carried out and a few of the interested seekers would be provided with the training. Scanning procedure includes educational level and level of English communication. A basic introductory course was designed by studying the course contents of solar courses provided by different universities and interviewing possible employees. Some of the studied universities are partner universities of Metropolia. Below is a list of universities and their respective courses (Table 1).

Table 1 List of universities and their respective courses

No.	**Name of University**	**Course name**
1	Frederick university	Solar energy (Frederick university, 2016)
2	Lorain county community college	Photovoltaic systems (Lorain Community college, 2016)
3	Högskolan Dalarna	Applied Solar Energy Engineering (Högskolan Dalarna, 2016)
4	Oregon polytechnic	Applied Photovoltaics (Oregon Tech, 2016)
5	Pima community college	Photovoltaic Installation (Pima Community college, 2016)
6	Texas state technical college	Solar Energy Technology (Texas State Technical College, 2016)
7	Norwegian University of Science and Technology	Solar Cells and Photovoltaic Nanostructures (NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, 2016)
8	The University of New South Wales	Solar Cells (The University of New South Wales, 2016)
9	Egypt-Japan university of science	Solar Energy Engineering (Egypt-Japan University for Science and Technology, 2016)
10	Stellenbosch University	Introduction to solar energy (Stellenbosch University, 2016)
11	University of Northumbria	Photovoltaic system technology (Northumbria University, 2016)
12	Cork institute of technology	Solar Energy (Cork Institute of Technology, 2016)
13	University of Toronto	Power Management for Photovoltaic Systems (University of Toronto, 2016)
14	Heroit Watt University	Solar Photovoltaic (PV) Technology (Heriot Watt University, 2016)
15	Singapore Polytechnic	Solar Photovoltaic System Design (Singapore Polytechnic, 2016)

These courses listed in Table 1 above by above ranges from introductory level to professional level courses. The course that is intended for the asylum seekers would be an introductory level course aiming not only for the understanding of some important terms also for thorough instruction for laboratory assignments to provide practical skills and knowledge on solar energy.

Hardly any of the universities whose solar energy courses were studied in this thesis included laboratory assigments in their course curricula. Thus, the laboratory assigments that are designed in this thesis are researched outside of the university courses.

Janne Käpylehto, who is expert in energy and has worked for many small scale solar projects, was interviewed about possibility of asylum seekers getting a career in field of solar energy and about the requirements for a complete solar training program. Janne Käpylehto's comments for proper training setup was taken into account while designing courses and laboratory assignments. His opinion for solar training included basic solar energy knowledge, basics on sizing of solar system, sales and service training, and safety training. A basic introductory course and system sizing basics were included but safety, sales and service training were out of scope for this project.

4 University course overview

The university courses were compared and an outlined of the results are presented in Table 2.

Table 2 Course comparison

University	course name	Course outcome	Course includes lab work
Fedrick university(P)	Solar energy	Identify and associate the properties of sunlight	No (Frederick university, 2016)
		Understand working of PV cells to generate electricity	
		Access and examine solar radiation data and measurements	
		Understand and classify solar thermal technologies and systems	
Lorain county community college	Photovoltaic Systems	Install and use solar-voltaic power system	N/A (Lorain Community college, 2016)

		Access, install, maintain and trouble-shoot solar-photovoltaic electrical generating systems	
Högskolan Dalarna(P)	Applied solar energy engineering	Plan, design, build and test a solar energy system within a project	Yes (Högskolan Dalarna, 2016)
		Apply fundamental engineering and specific solar engineering knowledge in a project	
		Critically evaluate the results of the project.	
Oregon tech	Applied photovoltaic	Design stand-alone and grid connected photovoltaic systems	Yes (Oregon Tech, 2016)
		understand working of Concentrator and hybrid solar thermal and photovoltaic	
Pima Community college	Photovoltaic Installation	Describe and identify PV system components and describe their function and performance characteristics	yes (Pima Community college, 2016)
		Calculate PV system sizing and determining number of modules for a roof taking account of its size, obstructions and financial constraints	
		Demonstrate PV system electrical design and perform wire sizing	
		Demonstrate performance analysis and troubleshooting	
Texas state technical college	Solar Energy Technology	Calculate power generation and demand requirements	N/A (Texas State Technical College, 2016)

		Understand installation process for solar system components and strategies for optimizing system performance	
Norwegian University of Science and Technology	Solar Cells and Photovoltaic Nanostructures	Understand charge separation upon photon absorption in PV devices	Yes (NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, 2016)
		Perform quantitative calculations associated with PV processes.	
The University of New South Wales	Solar Cells	Understand and design and characterization of solar cells	N/A (The University of New South Wales, 2016)
		Understand laboratory-based and commercial solar cell technologies	
		Study solar cells with regard to their spectral response, temperature sensitivity, resistive losses, current generation and open-circuit voltages	
Egypt-Japan university of science	Introduction to solar energy	Principle of operation of PV cells, Design of Stand-alone and roof mounted PV systems	N/A (Egypt-Japan University for Science and Technology, 2016)
		Design of large PV systems and understanding of combined heat and power generation	

Stellenbosch University	PV system	Understand tools needed to design grid-tied PV systems within South African solar resource, technical and legislative contexts	N/A (Stellenbosch University, 2016)
		Optimizing the financial viability of the system	
University of Northumbria	Photovoltaic system technology	Be able to complete basic design of both stand alone and grid connected systems	Yes (Northumbria University, 2016)
		Understand the requirements for construction, electrical connection and operation of systems	
		Gain experience of analyzing system performance	
Cork institute of technology	Solar Energy	Appraise the components and function of solar energy systems	N/A (Cork Institute of Technology, 2016)
		Calculate the operational performance of solar energy equipment	
		Evaluate the criteria required to complete a design study for a solar energy system	
		Determine the efficiency of solar energy systems using appropriate equations	
University of Toronto	Power Management for Photovoltaic Systems	Understand grid-connected and off-grid PV technology	N/A (University of Toronto, 2016)
		Understand of power electronics	

Heroit Watt University	Solar Photovoltaic (PV) Technology	Understand PV systems	N/A (Heriot Watt University, 2016)
		understand barriers that have impact on efficiency of Scottish installations of PV's	
Singapore Polytechnic	Solar Photovoltaic System Design	Understand basic design, installation and maintenance of standalone or a grid-tied PV system	N/A (Singapore Polytechnic, 2016)
		Understand types of PV modules	
		Perform quantitative calculations associated with PV processes.	

The universities that are partner universities of Metropolia UAS are marked with '(P)'. An overview of the courses and their course learning outcomes along with course content provided key similarities between the courses. Although the course outcome varied from introduction to solar energy to detailed understanding, designing and construction of PV systems, all the courses have basic similarities in providing working details and parameters required to design and construct a PV system. Most of the courses mention laboratory assignments associated with the study but details of these assignments were not available in any of the course overviews.

A further detailed study of the course contents of solar energy courses taught in universities provided a clear insight of the minimum knowledge required to work with solar devices. The courses were then divided into three categories: 1) Basics, PV system sizing and performance analysis 2) Solar basics and understanding of PV cells and 3) Basics, installation, building and designing. Table 3 shows a further classification of the universities according to these three categories.

Table 3 Classification of courses

Universities	**Common outlines**
Basics, PV system sizing and performance analysis	
Pima community college	
Texas state technical college	
Norwegian University of Science and Technology	
Cork institute of technology	
Singapore Polytechnic	
Solar basics and understanding of PV cells	
The University of New South Wales	
Egypt-Japan university of science	
Stellenbosch University	
Frederick university	
University of Toronto	
Heroit Watt University	
Basics, Installation, build and design	
Lorain county community college	
Högskolan Dalarna	
Oregon polytechnic	
University of Northumbria	

5 Results and practical training

The further categorization of the courses provides the core differences between the courses. Table 3 shows if the courses are introductory level or advanced level courses. The classification shows which university courses focus on providing complete understanding and installation knowledge and which provides basic knowledge of solar energy and PV cells.

As a result of investigating the learning outcomes from above courses, an introductory level course was designed. Janne Käpylehto's suggestions were also considered in providing solar energy and photovoltaic basics. He suggested to focus on providing participants with basics of solar and photovoltaics along with their application. Based on his suggestion and universities course comparison, introductory courses were created. As Janne suggested, applications of solar energy are included in photovoltaics and solar heating.

An introduction of solar energy provides understanding of basics of solar energy and solar panels. An introduction to photovoltaic provides understanding of photovoltaic systems and its sizing. Moreover, an introduction to solar energy and photovoltaic would provide adequate qualifications for completing laboratory assignments. After a brief solar energy introduction, applications of solar energy are discussed and detailed instructions for construction of two applications are provided (see Appendix 1 and Appendix 2).

5.1 Introduction to electricity

Before learning about solar energy, a short introduction to electricity basics enables better understanding of photovoltaics. Photovoltaic is a process of converting sunlight directly into electricity using solar cells. Solar cells are devices which uses sunlight and converts it into electricity due to photovoltaic effect.

5.1.1 Photovoltaic cell

A number of solar cells are connected electrically onto a structure to make up a PV module and a number of module makes an array (Figure 1).

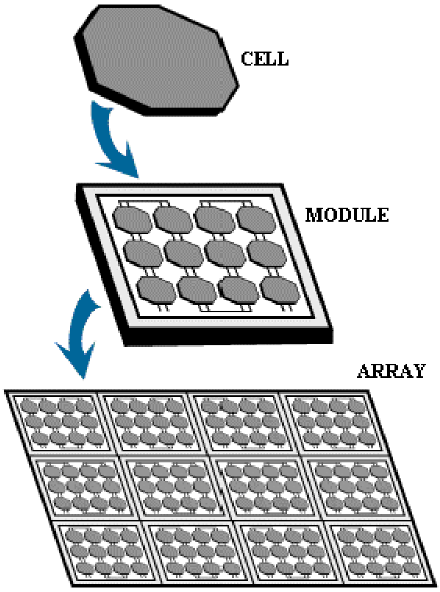

Figure 1 Cell, module and array. (23)

5.1.2 Photovoltaic effect

The photovoltaic effect is the creation of voltage or electric current in a material by the striking of sunlight. The sunlight is absorbed by an electron or charge carrier in the material and is excited to higher energy state. The excited charge carrier is contained within the material in photovoltaic effect.

5.1.3 Current (I)

The flow of electric charge is known as electric current. There are two types of current; Alternating current (AC) and Direct current (DC). An electric current which periodically reverses its direction is called AC current whereas DC current has single direction of flow. Solar cells produce direct current which is then converted into alternating current using an inverter. Currents unit is Ampere.

5.1.4 Voltage (V)

The potential difference across two points measured in Volt is voltage. The output terminals from the PV panel produces low voltage. The typical nominal output from the panel is 12 volts which is just reference volts as operating voltage can be higher than that.

5.1.5 Electric Power(P) and electrical energy

The rate of doing work is defined as power. The rate of electricity produced per unit time is called electric power. The SI unit of electric power is watt. Mathematically, power can be expressed as follows:

Power = Voltage in volts X Current in Amperes

The total work done by power [energy (*Wh*)] = power in watts X time in hours.

5.1.6 Resistance (R)

The measure of amount of resisting factor applied by a conductor for flow of electric current through it is called resistance. Resistance affects the voltage difference across two points and measured in Ohms. The change in solar radiance striking a solar module changes both series and shunt resistance. A series resistance in a solar cell is produced due to the movement of current through emitter and base of the solar cells, contact between the metal and the silicon, and contact between top and rear metal. Wiring of the cell increases the resistance in the system. Increase in temperature also increases resistance. (Bowden)

5.1.7 Parallel and series circuit

When all the positives and negatives are connected together separately, meaning positive to positive and negative to negative, the circuit is called parallel whereas connecting together one positive and one negative of an individual power source comprises series circuit (Howell). Parallel wiring (Figure 1 a) increases current keeping voltage constant whereas voltage increases and current remains constant in series connection (Figure 1b).

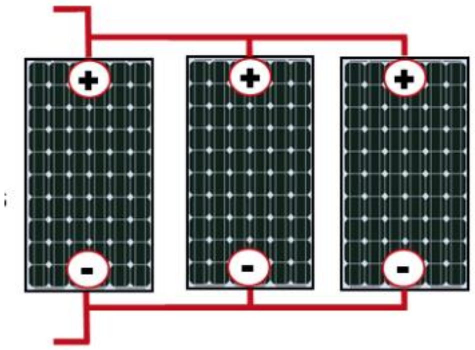

Figure 2 parallel connection (Howell)

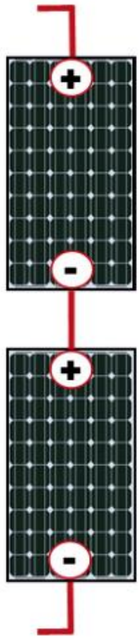

Figure 1b series connection (Howell)

5.2 Introduction to solar energy

Sun emits the energy in the form of heat and light. Both form of energies can be utilized to obtain useful output. Solar energy is the radiant heat and light harnessed using various available technologies such as photovoltaics, solar thermal energy, artificial photosynthesis.

5.2.1 Irradiance and irradiation

Irradiance is a measure of solar radiation falling over a particular area at any given time. Its unit is watts per square meter. Irradiation is the measure of irradiance over a particular area over time and is measured in watts per square meter per day.

5.2.2 Tilt of solar panels

Solar panels should face true north in the southern hemisphere and true south in the northern hemisphere. The panel tilts are either adjustable or fixed. Usually the tilt angle of the panels is equal to latitude of particular location. Most of the adjustable panels are adjusted twice or four times a year depending upon the feasibility. With the development of a tracker in recent years, solar panels adjust themselves towards the maximum irradiance increasing the optimum. Moreover, a tilt angle of +/- fifteen degrees from latitude will increase energy production in winter and summer months, respectively. (Landau, 2016)

5.2.3 Structure and Foundation

The support system for the PV are usually guided through with specific instructions from the manufacturing company of the PV cells. The PV system can be mounted on roof, ground or as shade structure in the buildings depending upon the requirement and best option for the particular system. When the roof top is a slope, panels can be adjusted as in picture 2a and if roof is flat panels can be installed using heavy metal at an angle as in figure 2b.

Figure 3 slope roof and solar panel (Home Renewable Energy LTD) Figure 2 b flat roof and solar panels (Green Power System)

5.2.4 Nominal power/ peak power of solar panel:

A PV panel or solar cell manufacturers include a data sheet specifying KWP or rated amount of power the solar panel will produce. Nominal power or peak power of a solar panel is defined as rated capacity of the panel. It is calculated by measuring current and voltage at varying resistance at predefined condition. The predefined testing conditions are specified in standards such as IEC 61215, IEC 61646 and UL 1703.

Efficiency rating is different than Peak power and is calculated by dividing peak power provided by the manufacturing company in its data sheet by surface area of the panel. (wikipedia)

5.3 Introduction to photovoltaic (PV) system

Photovoltaic is a process of converting sunlight directly into electricity using solar cells. Solar cells which make up an entire solar module are made of semiconductor materials. The most common type of semiconductor currently used are made up of silicon crystals. The striking of sunlight on the crystal produces a photovoltaic effect, which generates electricity (Figure 4).

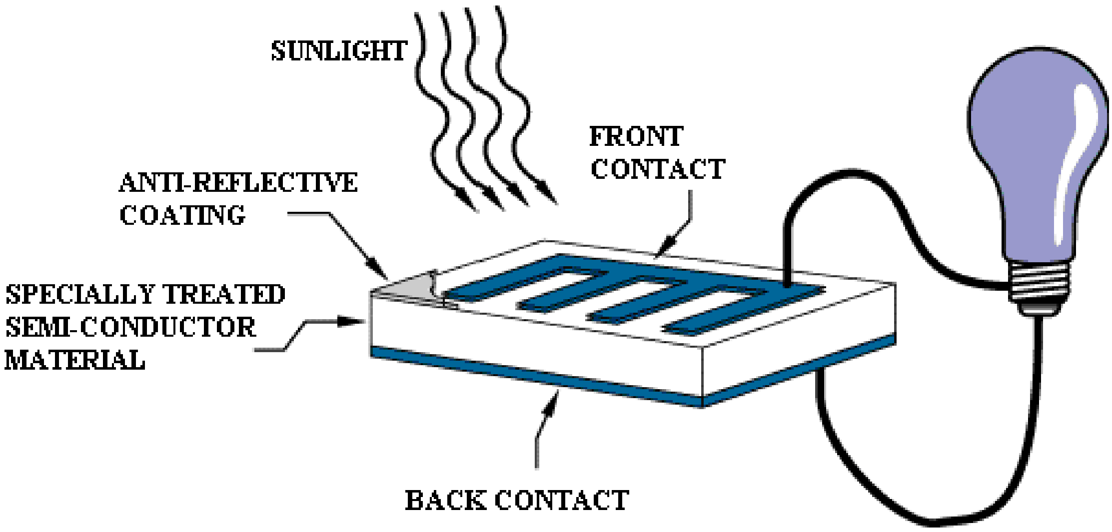

Figure 4 basic photovoltaic cell (23)

A network of electrical components used to supply, transfer and use electric power by the means of photovoltaics, is called a photovoltaic system. A simple PV system constitutes of PV modules, inverter, battery, utility meter and a charge controller. PV modules convert solar energy to DC current (Figure 5). An inverter converts DC current to AC current. A battery stores the electricity generated and supplies electricity as per the load. When the production PV is relatively low, a battery supplies uninterrupted supply of electricity to meet the demand. A Utility meter provides the electricity from main grid when the demand from solar power exceeds output. A charge controller prevents a system from battery overcharging, consequently extending the life of battery.

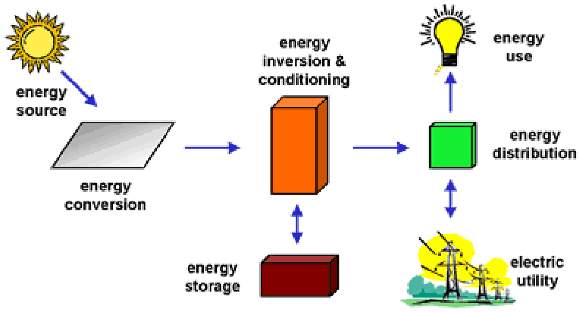

Figure 5 A simple PV system (24)

As figure 5 illustrates, solar energy is absorbed by the solar modules. The absorbed energy is then converted into useful energy. The energy is inverted or stored and distributed and used as required.

5.3.1 Installation of PV modules

Installation of PV modules requires to calculating the sizing of the PV system. For proper installation of the system following components should be sized and calculated.

Solar PV demand

To estimate the solar PV demand, calculate the total amount of watt-hours of energy to be supplied to all the appliance. Adding all the watt-hours of individual appliances and multiplying by energy loss in the system gives the final energy demand.

PV module size

The power generated by the PV module is directly affected by the size. Total peak watt produced on the site of PV installation affects the sizing of the module. Total peak watt produced depends on climate of specific site. It is also necessary to know to know the panel generation factor. Dividing total Solar PV demand by panel generation factor gives total watt-peak rating of PV modules. To calculate number of panels required, watt peak rating is divided by output watt-peak of the PV modules available. Output watt-peak is also known as nominal power. The calculation yields the minimum number of panels required a functioning system, but adding more panels provide improved performance of the system.

Inverter size

The power generated by solar module is in the form of DC current; an inverter converts DC into AC and is rated in Watts. For example, a 3000 Watt inverter can power up to

3000 Watt continuously. The sizing of the inverter depends on the rating of the PV system meaning if the solar PV system is rated 3000 Watt, a 3000 Watt inverter is required. Inverter comes with different voltage setting. For the system to work, an inverter should have same input voltage as of the battery.

Battery sizing

A battery is required for the proper functioning of the PV system during insufficient production of electricity from the modules. The following should be considered for the proper sizing of the battery:

- Calculate daily energy used in watt-hours.
- Find the depth of discharge of the battery chosen.
- Find the battery loss of the chosen battery
- Calculate number of days a battery is needed for energy supply also known as days of autonomy.
- Find the battery voltage
- Finally, calculate battery capacity or minimum battery Ah capacity using a simple formula:
  Battery capacity (*Ah*) = (total watt-hours per day * Days of autonomy) / (depth of discharge* battery loss* battery voltage)

Charge controller size

A charge controller size depends on the voltage of PV modules and batteries chosen. The solar charge controller must have enough capacity to handle the current from the PV array. The total watt of the PV panels is divided by the battery's voltage to have an estimate of amps of the controller needed. (Leonics, 2016)

After the calculation of the required sizing of the system, wiring of the system is next step. The wiring of the system is done by professionals (one with electrician certificate).

5.3.2 Practical application 1: Panel tour at Metropolia’s roof

A tour of solar panel site at Metropolia’s roof for the attendees enables better understanding of photovoltaic systems. Attendee would be able to connect the theoretical knowledge learned with this practical application.

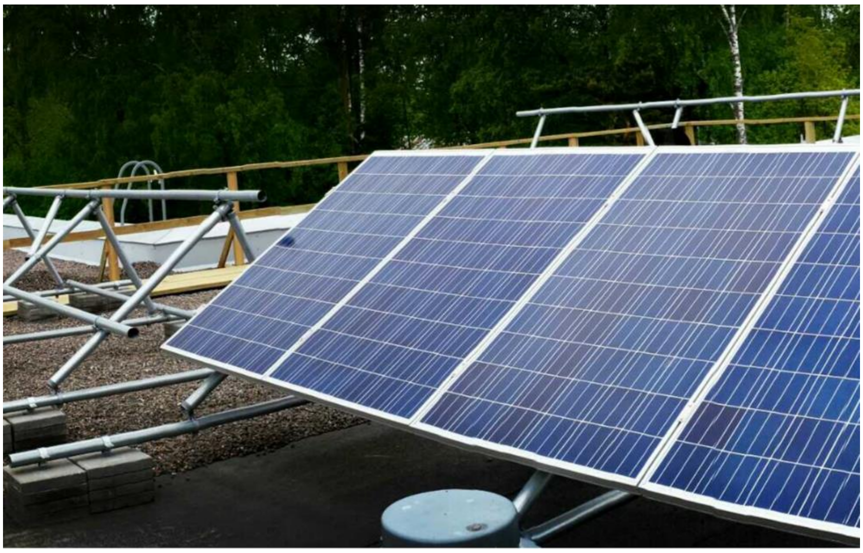

Figure 6 Metropolia UAS solar panels (Itkonen)

Metropolia building (Myyrmäki unit) has panels mounted on roof top having maximum peak power of 2,3 Kilowatts (Figure 7). Solar panels installed on roof top points towards south to maximize the collection of sunlight. It is mounted at 40-degree angle. The wiring has three wires: positive, negative and grounding wires differentiated by its green color. Foundation has been adjusted on concrete bricks. The control room has inverter, charge controller, combination box, fuse for alternating current and main switch. The two wires positive and negative carrying direct current goes through main switch for direct current and combination box with voltage controller. The next unit is current controller. The current controller for direct current is larger than for alternating controller. Then the wires from controller goes to the inverter.

Inverter converts direct current to alternating current and feeds it to the fuse box for protecting the main unit from any damage. Then the current goes to main switchboard. The grounding wire from voltage protector and panels goes to the grounding point at the electric center of the building where proper grounding has been installed.

5.3.3 Practical application 2: Solar water pumping

A typical Solar water pumping system uses a motor utilizing a DC from the PV panels. A motor using AC are also considered for the system, but it is rarely used because it has the disadvantage of losing energy during the process of changing DC to AC. The pump could be mounted on surface, submersed or floating depending upon the source of water. The amount of water pumped by the system depends on the amount of available solar energy and size of solar module. A solar water pumping system consists of following components: water pump, source of water, PV panels, water storage tank.

- Water pump

There are two main types of pumps; a displacement pump using diaphragms, vanes or pistons to seal water in a chamber and to force it through a discharge outlet and a centrifugal pump using a spinning impeller to pump water. As mentioned earlier, a pump can be surficial or submersible depending upon the source (Figure 5). A pump's power is rated in accordance of the voltage of energy required for it to run. A typical example of small pump is a 12-Volt pump.

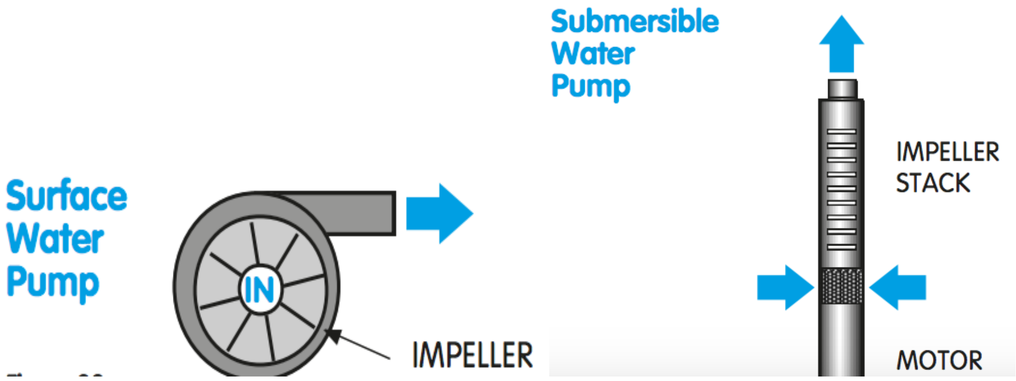

Figure 7 A surface water pump and submersible pump (27)

A displacement pumps are used when the TDH is high and required flow rate is low, whereas centrifugal pumps are used when TDH is low and high flow rate it required. TDH is the total equivalent height that a water needs to be pumped. These factors affect the pump selection and are typically found in the specifications of the pump provided by the manufacturing company. A pump's operating voltage reflects the efficiency of the pump and is vital while selecting the pump. A high operating voltage loses less energy loss from the reduced current required to deliver the same power. A general rule of thumb is that if the array has more than four panels and is more than 50 feet away, a high voltage pump is used. (SNV, 2016)

- Source of water

The solar water pump system design is basically based upon the type of water source used. It influences the type of pump to be used and the overall design of the system. The water source could be surface or subsurface. The recharge rate of the source and volume of the source reservoir are important factors for the system design. If the source takes longer to recharge than the pump carrying water out, the reservoir could be empty causing potential harm to the pump and the system.

- PV panels

The panels are selected according to the peak power requirement of the selected pump. Having a larger panel setup boosts the overall system producing power even during low sunlight.

- Water storage

A storage tank is necessary for the systematic working of the system. A typical tank stores enough water during the peak power production to balance out low power production scenarios.

- Design of the solar powered water pumping

The following steps are taken into account for designing a solar powered water pumping. (USDA, 2016)

Step 1- Water demand

The total amount of water required by the pump to be delivered must be calculated as it forms the foundation of the system design. It can be calculated by adding up all the average use of the water for all the required activities.

Step 2- Water source

As mentioned earlier, it is very important step for the system design and requires thorough considerations such as type of source, location, altitude and elevation, water level, water quality. If the source is subsurface such as a well, following factors should be taken into account.

- Quality of water   A brief test of fecal coliform contamination, nitrates concentrations, organic solvents, heavy metal should be done
- Level of water   Complete information of the level of water should be obtained before the system design.
- Pumping rate and drawdown   A test is carried out to evaluate the amount of water that could be pumped from the source along with the rate at with it can be pumped. When the level in the source (for example well) falls, the fall is known as drawdown. Drawdown acts as and limiting factor for the amount of water pumped. A typical source's drawdown increases with the length of time the pumping continues. (Kasenow, 2016)

And if the source is surface water then following points should be considered:

- Quality of water   Similar to that of subsurface source.
- Pumping levels   A proper screening level of pump intake should be considered to ensure the uptake of the debris and sediments are barred.

Step 3- System design

This step comprises the design of the complete layout of the system along with the setup, location and elevation of the system components. An example of a system is given (Figure 8 and Figure 9) below.

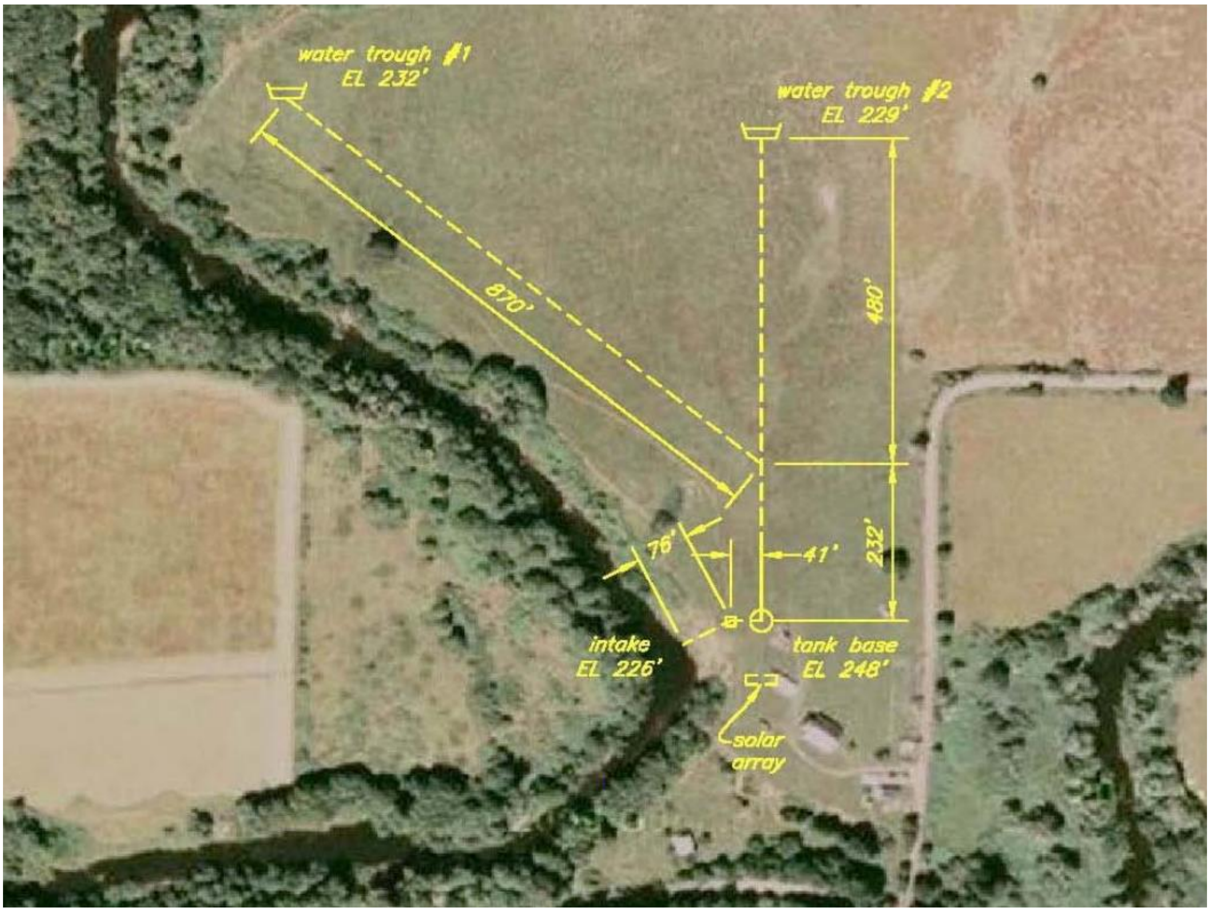

Figure 8 example of watering system with a PV array and a storage tank (29)

Step 4 Water storage

A typical system design consists of a storage tank able to store enough water for few days so that the minimum power production would not affect the supply required for the daily activities. The size of the storage tank depends on the demand. As in the example (Figure 9), the tank must be placed in an area avoiding the organic materials, debris, roots, sharp objects and the ground level must be leveled. The base has six inches of well compacted ¾ *inch* levelling rock laid under a geotextile fabric in the example. An experts help is required if the platform stand is to be installed.

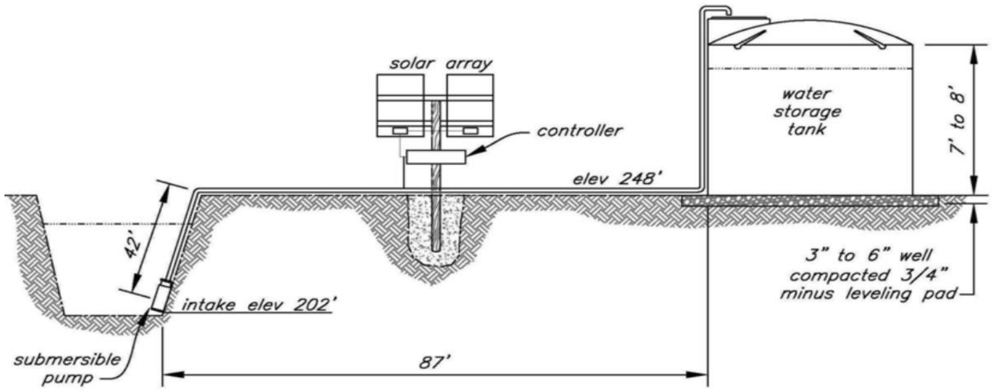

Figure 9 example of a typical surface water pump system powered by solar array. (29)

Step 5 Solar data and PV array setup

Solar insolation data must be retrieved for the system location. If the data is unavailable for the location chosen, a brief study is conducted to obtain the insolation data. All the possible shading on the panel should be avoided at any cost because it significantly affects the power generated. The panel setup however is depended upon the site location and elevation and the insolation data. A close placement of solar module to the pump decreases the power loss.

Step 6 Flow rate of the pump

The flow rate of the pump is derived by daily water need divided by number of peak sun hours per day. For example, if the system requires a daily water supply of 2000 liters/day with average solar insolation value of 7.5 hours/day, the flow rate is calculated as follows:

flow rate = (2000 *liters/day*) / (7.5 *hours/day*) = 11.11 *liters/hour*.

Step 7 Total dynamic head (TDH) for the pump and pump selection

TDH is the total equivalent height that the water needs to be pumped with consideration of friction losses in the pipe. Total dynamic head is the addition of static height, static lift and friction loss. Static height is the maximum height reached by the pipe after pump also known as discharge head. Static lift is the height of the water will rise before arriving at the pump also known as suction head. Friction loss or head loss is the loss of energy in the flow due to friction (Wikipedia, 2016).

The pump is selected so that the pump can produce the required flow versus the known TDH. A performance curve for the pump should be studied before the pump selection. Most of the pump suppliers have the computer programs for the sizing of the pump based on the solar insolation, pumping head and pump flow rate.

Step 8 PV selection and setup

The number of panels required are selected based on the peak power requirement of the selected pump. The combination of the panels might be series, parallel or both depending upon the final voltage and amperage of the pump.

Step 9 Water flow rates and delivery point pressure

The required pressure at the delivery point must be calculated and use of valves is required to check the operation flow rates. In the Figure 9 there is no pressure at delivery point so the pressure head is zero feet.

5.4 Solar heating

Solar heating is process of harnessing thermal energy to provide hot water, space heating, cooling and pool heating and other industrial, residential applications. The application of solar heating varies from low end heating and cooling to high end electricity generation depending upon collectors. The solar collectors absorb sunlight and transfer heat collected through transfer fluids which could be air, water, oil, glycol and water mixture.

5.4.1 Practical application 1: Solar box cooker

A solar cooker is a device utilizing solar energy to cook or heat up food and drinks. There are a variety of solar cooker designs available. A simple solar cooker could be made with a cost less than 10 euros and within few hours depending upon the design.

A solar box cooker is based on the concept of oven where food is placed inside an insulated box trapping solar energy and transforming it to heat energy. Different materials are used to design box solar cooker ranging from wood, plastic, cardboard etc. The design instructions are provided in Appendix 1.

5.4.2 Practical application 2: Solar air heater

Solar air heating is technology which harnesses solar insolation by absorbing into a medium to heat up the air. A solar heater circulates air into an enclosed design which absorbs solar heat and forces hot air out into the room. A simple instruction for constructing air heater for heating a room is provided in Appendix 2.

5.5 Interview

A summary of Janne's interview is provided below and complete transcript of the interview can be found in Appendix 3.

A solar training setup requires introduction to solar energy basics and complete knowledge of sizing a solar system. Applications of solar system helps participants to connect theoretical knowledge and physical system. A person with minimum skills could work as a helper for installation of solar panels but, basic mechanical skills and handling of works tool is handy. Electrical connection work requires professionals with an electrician's certificate accepted by Finnish authorities. The education could also focus on sales, system design, services, transportation and sourcing. English as a working language is also accepted depending upon the situation. The prospect of solar energy in Finland is bright at the moment, and it is an exciting time for the solar sector.

6 Discussion and conclusion

The aim of this thesis project was to discuss solar energy related training for asylum seekers after studying solar courses offered by different universities, mainly Metropolia’s partner universities and interviewing solar energy experts. Studying and comparing courses offered by universities provided basic requirements for a solar energy course. Interviewing solar expert Janne Käpylehto, provided an insight to the requirements for a basic training which could be enough for getting traineeship in solar companies. The introductory course content in this project is enough for working with laboratory assignments designed. The participating individuals in the training setup would be able to understand the basics of solar energy, calculate size of a basic solar system and learn practical applications of solar system.

Although, the project attendees would learn solar basics, sizing a system and solar energy applications; it doesn’t cover all the solar applications and laboratory assignment is limited. An attendee of this project might find an internship or job in solar companies after the training. Interviewing asylum seeker would have provided different outcome for this project but unfortunately, interviewing of asylum seekers was not possible after various attempts.

In future, Metropolia should aim at designing higher level courses and advance level laboratory assignments which enable better and wide understanding of solar energy. This would be helpful for the attendees of training program to gain enough experience of work related environment. Moreover, interviewing more solar experts and also solar companies would combine both requirements of companies for hiring and complete training requirements. Also, interviewing asylum seekers in future for similar project like this to understand their expectations, interest and desire would benefit Metropolia and the participants of training program.

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Appendix 1. Instructions for constructing solar box cooker

Design instructions

Simplified instructions are laid out for construction of solar box cooker below.

Materials and equipment required (Bradbury, 2016)

- 2 Cardboard for reflectors of size 4m by 1m; for an example, a two computer monitor cardboard box could be used.
- Cardboard for inner box of size 28 cm by 45 cm
- Cardboard for inner box lid of size 13 cm in width and 157.4 *cm* (1.5 m) in length
- Cardboard for outer box of size 40.5 cm by 56 cm and about 16 cm deep
- Aluminum foil of thick size and about $7m^2$ roll
- Aluminum foil tape
- Foam insulation board of about 1.3 cm thick and 1.2 m by 2.5 m
- Glass plate of size 30 cm by 22 cm
- 2m roll of 1.3 cm wide adhesive foam weather-stripping
- One strong bond white glue
- Measuring tape
- Knife and blades
- Markers
- Brush

Procedure (Bradbury, 2016)

Follow the following instructions and take extra care while using sharp cutting devices.

- Cut 12.7cm wide cardboard until you have 157.5 cm (1.5 *m*) length and use aluminum tape to join them together. This would serve as inner box.
- Cut two 12.7 cm wide and 45.7 cm in length and two 12.7 cm wide and 31.7 cm in length piece from the insulation board.

- Make sure the cut pieces fit around the inner box lid.
- Now for the reflector, cut a rectangle of size 101.6 cm by 90 cm. Take 101.6 as the top part of the reflector and draw a line parallel to top which is 50.8 cm from the top. Draw 25.4 cm on each side from this line making a rectangle having one side 50.8 cm and other 38.1 cm. Draw an angle of 22.5 degrees from the top of drawn rectangle to the end to the top. Cut the marked lines and end up with the following shape.

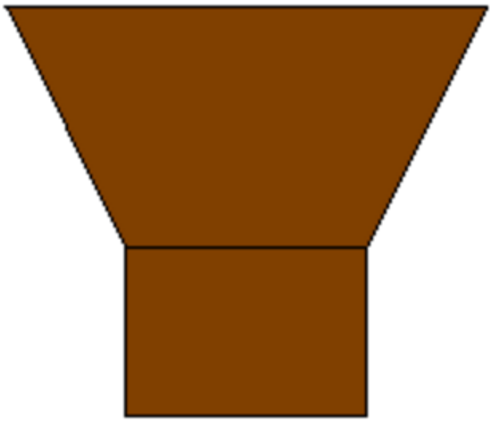

Figure A1.1 cardboard for the Reflector (31)

- Make another one with same dimension.
- Now make another two similar shaped cardboards but a smaller one, Cut rectangle of 86.3 cm by 90 cm. Take 86.3 cm as top side, measure 50.8 *cm* from top and draw a line parallel to top. Draw 25.4 cm on each side from this line making a rectangle having one side 35.6 cm and other 38.1 cm. Make an angle of 22.5 degrees from the top of the drawn rectangle and cut the pieces to get the final piece as (Figure A1.1) above.

- Lay down the four pieces that are carved out of the cardboard and glue aluminum foil to the trapezoid shaped parts as (Figure A1.2) below.

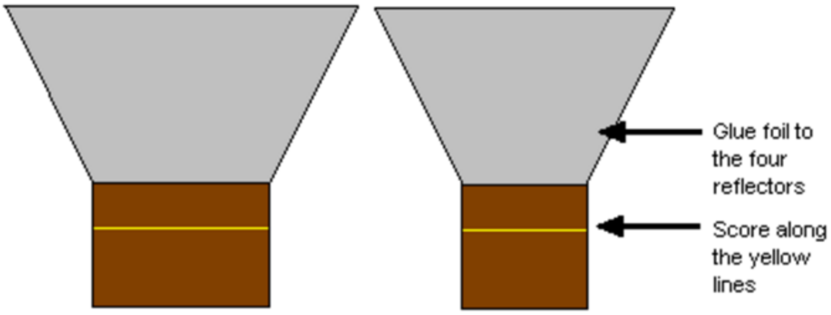

Figure A1.2 Instruction for applying aluminum foil and scoring of the cardboard. (31)

- Now for the scoring of the cardboard, cut through the one layer of card-board. Use a blade to make a channel along the cardboard surface and gently fold the channel as (Figure A1.3) below.

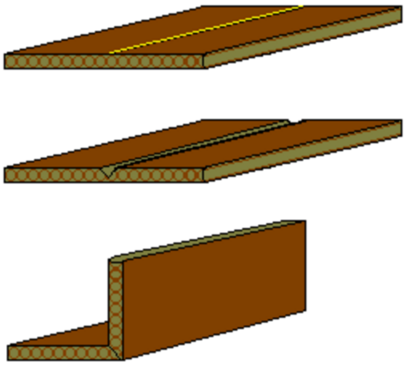

Figure 10 Score instruction. (31)

- Tape together the reflectors as (Figure A1.4) below.

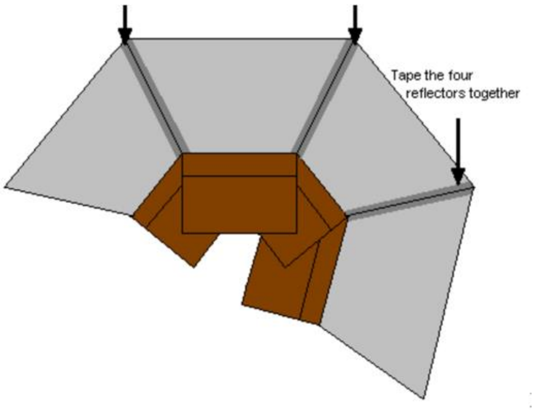

Figure A1.4 Gluing reflectors (31)

- Assemble the reflector along the taped edges to form a rectangular funnel as in the picture (Figure A1.5) below.

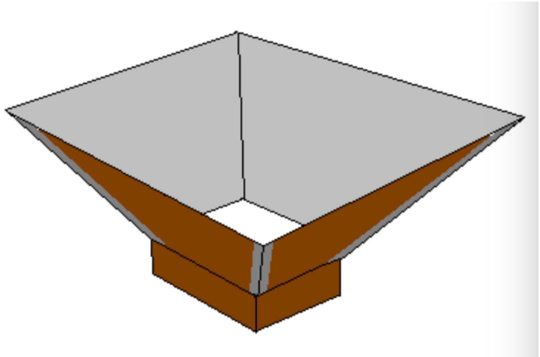

Figure A1.5 Final shape of reflector (31)

- For the inner box which should be well insulated as the box is the part where cooking utensil is placed, glue aluminum foil inside the box carefully. Now place the insulation materials on outside of box. Use aluminum foil
- tape to attach the layers permanently and have final box as the picture (Figure A1.6) below.

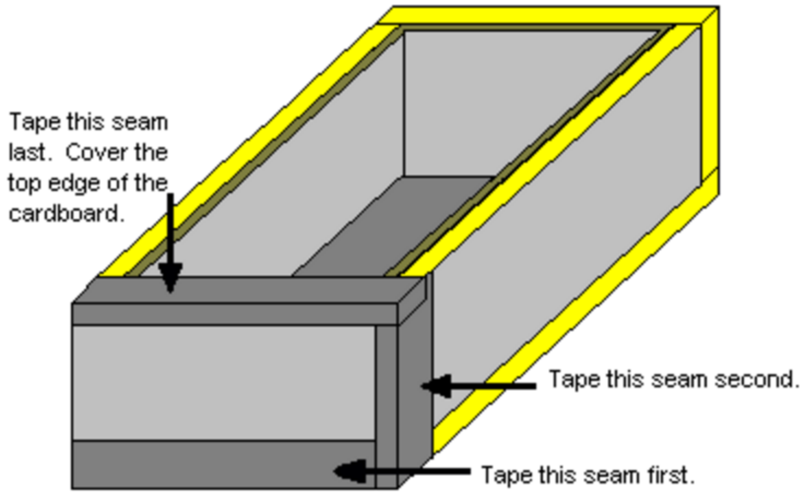

Figure A1.6 Inner box of the cooker (31)

- For the glass, measure if the glass fits the box. If it doesn't get a piece that fits and put the weather-stripping to the edges of the glass.

- For the inner box lid, take the cardboard and mark a straight line parallel to 157.4cm long end 2.5 cm from the top. Mark a line from 29,8 cm from one edge and second 48,9cm from first mark. Mark third line 29,8 cm from second and the final line is 48,9 cm from the edge. Below (Figure A1.7) is the instruction for the drawing.

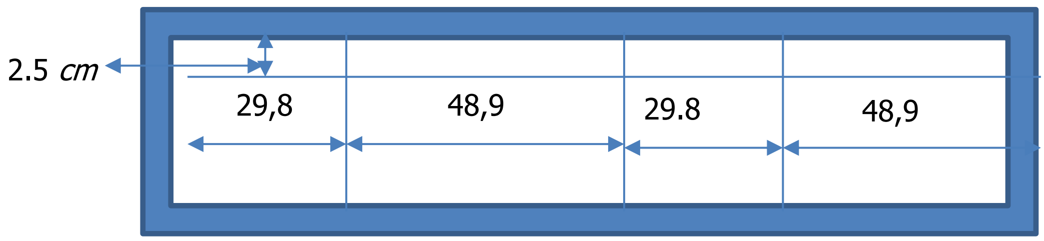

Figure A1.7 lengths of the required marking

- Once the drawing is completed cut the marked cardboard as (Figure A1.8) below.

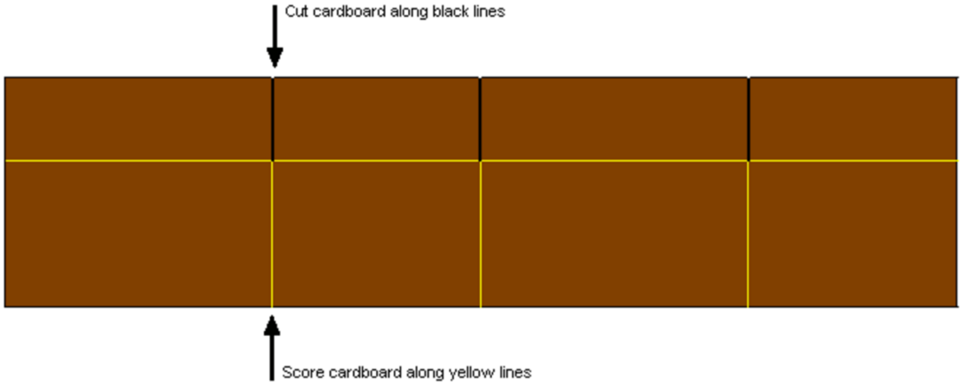

Figure A1.8 cutting instruction for inner box lid (31)

- Tape the cardboard into a rectangular shape and glue aluminum foil to both sides. Insulate the lid as before and place the glass top of inside box and check if the final lid fits the inside box of the cooker as (Figure A1.9) below.

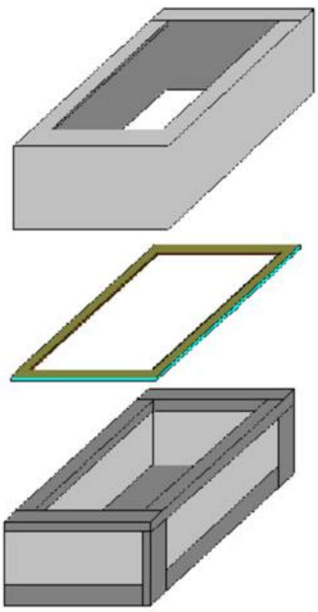

Figure A1.9 The lid inside of the box and the glass (31)

- The finished solar cooker box is shown (Figure A1.10) below

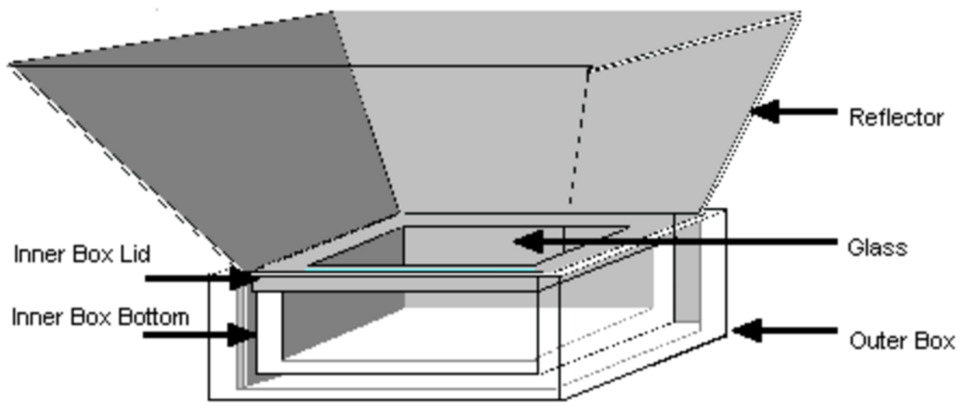

Figure A1.10 A solar box cooker. (31)

Instruction for construction of solar air heater

Materials required (Science Buddies, 2016)

- Measuring tape
- A large piece of cardboard
- A wide painter's tape and duct tape
- Acrylic gesso paste
- Cotton string (thin)
- Paint brush
- Black acrylic paint
- Plastic plates
- Scissor, ruler and knife
- Thermometer
- Thumbtacks

Procedure (Science Buddies, 2016)

- Select a window that is facing due south and possibly without any obstruction in front of it. Have the dimensions of the window measured and note it down on a paper. Cut out a piece of cardboard that is 25 cm wide and 25 cm long.
- Cut 13 cm square out from all four corners (Figure A2.1). Fold the flaps inward. Make sure the area inside the fold is of same size that of window. Apply white gesso paste or paint inside surface. Let the paste to dry.

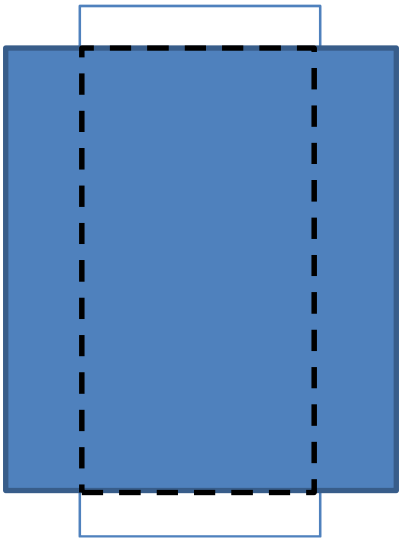

Figure A2.1 Cardboard shape after square cut outs

- Fold on the dotted lines. Area of the window must be equal to area inside the doted lines.
- Now use a brush to apply the black paint on top of gesso. Paint all the inside part of the cardboard. Let the paint dry.
- Cut vent hole of size 8 cm wide and 8 cm long at about 2.5 cm from top and bottom folds of the cardboard. 3 on the top and 3 on the bottom.
- Now use the thumbtack and adjust them as below into unpainted side of the cardboard. Take the cotton string and tie it around the thumbtacks making a shape of a triangle (Figure A2.2 a). Use the same string and wrap it around other two vent holes. Repeat same steps for the bottom vent holes (Figure A2.2b).

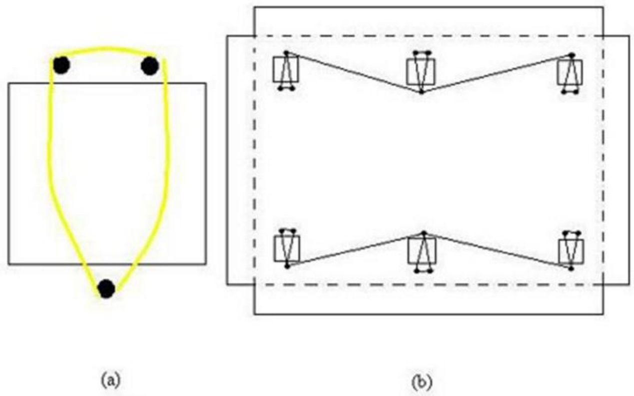

Figure A2.2(a) Placement of thumbtack and string around the vent hole, A2.2 (b) string around the top and bottom vent holes (32)

- Apply duct tapes around the thumbtack to make thumbtack intact around the cardboard.
- Wrap plastic covers around the vent holes and use a tap to seal on the top of the hole. Make sure the plastic hangs as a flap and do not completely seal the vent holes.
- Now take the cardboard and place it on the window. Make sure the plastic part of the cardboard is facing the room. Use a painter's tape to stick the heater into the window. Make sure there is no gap between the heater and window frame.

Experiment

After the installation of the heater, make the reading of the room temperatures during each hour. Chose two days to make the reading, one relatively sunny and other a cloudy one.

Table 4 Measurement table (Science Buddies, 2016)

Air heater measurements			
S. N	Time	Intake temperature(bottom)	Output temperature (top)

Appendix 3. Interview with Janne Käpylehto

Q: What kind of theory background they would need (electricity, voltage, current, resistance, etc.)?

If helping with an installation, from electronics point of view - none. Basic skill of mechanics and using basic tools is needed.

Q: How good trainees should understand how the equipment work and what properties of the equipment are most important to understand (or is it possible to work without any knowledge of equipment)

It is possible to work without knowledge but it surely helps and motivates. With grid-systems: panels, cabling, grid-inverter and installation systems: basic features.

Q: What are the main structural and mechanical issues that are important to follow during assembling of the panels on the roof?

In case of attaching to the frame,

- different installation systems for different roof types
- safety issues, both electrical, mechanical and work-related
- All electrical connections are within professional electrician work (voltage over 120VDC)
- Details from my book

Q: What are the Work safety issues? Any requirements of specific work safety certificates?

If just helping, none needed. Most grid PV installations are in the roof, which is always a bit dangerous. Safety against dropping is needed and proper work setup. For doing electrical connections, regular electrician 'certificate' is needed (accepted by Finnish authorities).

Q: What are other important issues he would highlight in education?

Other areas with grid PV are:

- sales
- system design
- Services

- transportation
- sourcing
- etc.

Q: (Since Asylum Seekers have minimum Finnish language skills) Is working language strictly Finnish?

Finnish or English is ok for most cases.

Q: Do people having degrees in only related field are hired or people with minimum solar background are also given a chance?

In general, I would advise to be active and just ask from many companies - what are their needs. For Solarvoima, I can check the needs if you can provide some information about people who are interested.

Q: Since you are expert in solar panel installation, if someone is trying to design a solar training program, what things would you like them to focus on?

For off-grid solar installation, provide knowledge about basics and sizing of all the parts of a PV system. Also include solar energy application for better understanding.

Q: What are the requirement for getting a trainee position in your company (someone with basic solar knowledge)?

Send an open application or through system application online and show your interest and strength in the field. We are always looking for both sales and installation department.

Q: Since you have been working in solar field for long time, what do you think about future possibilities for solar sector? Will there be more demand or it might drop low?

In case of Finland, it is at very interesting stage. The solar power use doubled in 2015 compared to 2014 and is expected to go higher in 2016. It looks promising for Finland.

Q: What do you recommend for people like me who are looking for future in solar energy field?

One needs to be active, meet different people and companies. Networking plays a vital part in getting a job. More importantly be active, write an email and make sure you call them.