Erasmus+ KA2 Capacity Building project

Development of the targeted Educational program for Bachelors in Solar Energy in Uzbekistan

(DEBSEUz)

May 20-24, 2024

First Technical Training and Project Meeting Torino, Italy

Venue:

Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino

Participating Institutions

- Tashkent University of Information Technology (TUIT), Uzbekistan
- Politecnico Di Torino (POLITO), Italy
- Universidade de Evora (UEVORA), Portugal
- Universidad Politecnica De Madrid (UPM), Spain
- Turin Polytechnic University in Tashkent (TTPU), Uzbekistan
- Jizzakh polytechnic institute (JizPi), Uzbekistan
- Fergana Polytechnic Institute (FerPi), Uzbekistan
- Andijan state university (ASU), Uzbekistan
- National Research University “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers institute” (TIIAME), Uzbekistan
- Karakalpak State University (KSU), Uzbekistan
- Ministry of higher education, science, and innovations of the Republic of Uzbekistan (MHSSERUZ)

Scope and organization of the training

The Debseuz project aims to develop a new bachelor degree and courses in the field of solar energy. In addition, in order to enhance the collaboration with institutional and industrial stakeholders, the project aims to develop labs and co-working spaces. The Debseuz proposal considered an initial set of courses to be developed, listed below:

1. Technological measurements and instruments of the industry
2. Electronic technical materials and elements
3. Electrical technological devices
4. Solar Power
5. Optical and physical properties of semiconductor materials
6. Design of energy devices and stations based on alternative energy
7. Hybrid solar power plants
8. Production, transmission and distribution of electrical energy
9. Solar thermal devices and systems
10. Technology for the preparation of solar elements, photoelectric batteries and their component devices
11. Energy storage methods and devices
12. Design of new technical developments based on alternative energy

While modifications can be made after a detailed assessment of needs and request of Uzbek partners and agreement with EACEA, an initial training has been organized focusing on 4 out of 12 courses listed above. The training on remainder courses will be organized in Evora and Madrid according to the plan of the project.
Therefore, the training in Torino will foresee the following courses:

- Solar power systems based on PV: *Politecnico di Torino*
- Solar power systems based on CSP**:** *Universidade de Evora*
- Energy storage methods and devices: *Politecnico di Torino*
- Technological measurements and instruments of the industry: *Universidad Politecnica De Madrid*
- Solar thermal devices and systems: *Politecnico di Torino*

The training will focus on most important theoretical topics to provide background knowledge to future students of the Debseuz bachelor. In addition, the training will provide most interesting educational approaches with practices, labs, group projects to provide capacity skills. The training will also include a visit to two labs (solar PV lab at PoliTO and battery technology lab at PoliTO), as well as a visit to a coworking space for student team working at PoliTO (car racing team).

May 19th, 2024	
	Arrival and check-in of the participants in the hotels

May 20th, 2024 – Technical Training DAY 1 Meeting ZOOM ID: 4554929707, Access code: 1	
09:00 – 09:30	**Meeting at 09:00 at Politecnico di Torino main entrance –** Address: Corso Duca degli Abruzzi, 24, 10129 Torino TO https://maps.app.goo.gl/fhyKT3bogXFJznbe6; https://yandex.com/maps/-/CDb1eDMz then registration at the ROOM sala multimediale
09:30 – 10:30	**Opening welcome and presentation to the training week** • Welcome address from Project Coordinator - DEBSEUz Halimjon Khujamatov, TUIT, Uzbekistan • Keynote speech from Filippo Spertino, Professor at POLITO, Italy – The THREE-LANKA project • Presentation of the training week Pierluigi Leone, Professor at POLITO, Italy
10:30 -11:00	**Coffee Break**
11:00 – 12:30	**Module I - fundamental skills** (ROOM sala multimediale) **Solar power systems based on PV – fundamental physics part I** • Politecnico Di Torino (POLITO), Italy
12:30-14:00	**Lunch break at Il Ferrucci Ristorante & Bistrot**
14:00 – 15:30	**Module I - fundamental skills** (ROOM sala multimediale) **Solar power systems based on PV – technology and systems part II** • Politecnico Di Torino (POLITO), Italy
15:30 – 16:00	**Q&A with coffee break**
16:00 – 17:30	**Module I - labs and practice** (ROOM sala multimediale) **Solar power systems based on PV – practice with educational softwares part III** • Politecnico Di Torino (POLITO), Italy
20:00	**Welcome Dinner @ Sfashion Cafè,** Via Cesare Battisti, 13 - 10123 Torino (TO)

May 21, 2024 – Technical Training DAY 2 & Project Meeting

Meeting ZOOM ID: 4554929707, Access code: 1

09:00 – 10:30	**Module I - fundamental skills (ROOM sala multimediale)** **Solar power systems based on CSP - fundamental physics part I** • Universidade de Evora (UEVORA), Portugal
10:30 -11:00	**Coffee Break**
11:00 – 12:30	**Module I - labs and practice** (ROOM sala multimediale) **Solar power systems based on CSP - technology and design with LAB practice** • Universidade de Evora (UEVORA), Portugal
12:30-14:00	**Lunch break at Il Ferrucci Ristorante & Bistrot**
14:00 – 15:30	**Project meeting – part I** (ROOM sala multimediale) • Analysis of skill gas • Analysis of existing curricula • Analysis of disseminating results (FerPi) • Preparation for the National Conference 1 (FerPi)
15:30 – 16:00	**Coffee break**
16:00 – 17:30	**Project meeting – part II** (ROOM sala multimediale) • Approval of equipment • Quality and meeting with external quality expert
20:00	**Social Dinner - La Capannina Ristorante Pizzeria (offered by PoliTO)** via Vitaliano Donati, 1 - 10121 Torino (TO)

May 22, 2024 – Technical Training DAY 3

Meeting ZOOM ID: 4554929707, Access code: 1

	Module II - fundamental skills (ROOM aula DE)
09:00 – 10:30	**Solar thermal devices and systems** • Politecnico Di Torino (POLITO), Italy
10:30 -11:00	**Coffee Break**
11:00 – 12:30	**Module II - labs and practice** (ROOM aula DE) **Solar thermal devices and systems** • Politecnico Di Torino (POLITO), Italy
12:30-14:00	**Lunch break at Il Ferrucci Ristorante & Bistrot**
14:00 – 15:30	**Module III: (fundamental skills)** (ROOM sala multimediale) **Technological measurements and instruments of the industry** • Universidad Politecnica De Madrid (UPM), Spain
15:30 – 16:00	**Coffee break**
16:00 – 17:30	**Module III - labs and practices** (ROOM sala multimediale) **Technological measurements and instruments of the industry** • Universidad Politecnica De Madrid (UPM), Spain
20:00	**Free Dinner**

May 23, 2024 – Technical Training DAY 4

Meeting ZOOM ID: 4554929707, Access code: 1

09:00 – 10:30	**Module IV - fundamental skills** (ROOM sala multimediale) **Energy storage methods and devices** • Politecnico Di Torino (POLITO), Italy
10:30 -11:00	**Coffee Break**
11:00 – 12:30	**Module IV - labs and practices** (ROOM sala multimediale) **Energy storage methods and devices** • Politecnico Di Torino (POLITO), Italy
12:30-14:00	**Lunch break at Il Ferrucci Ristorante & Bistrot**
14:00 – 17:30	**VISIT of a co-working lab: student racing teams (public bus ticket needed!!)** • Politecnico Di Torino (POLITO), Italy
20:00	**Free Dinner**

May 24, 2024 – Technical Training DAY 4 Meeting ZOOM ID: 4554929707, Access code: 1	
09:00 – 10:30	**Wrap up & discussion of the training** (ROOM sala multimediale) • Lesson learned • Next trainings in Evora & Madrid
10:30 -11:00	**Coffee Break**
11:00 – 12:30	**VISIT of a solar energy education lab** • Politecnico Di Torino (POLITO), Italy
12:30-14:00	**Lunch break at Il Ferrucci Ristorante & Bistrot**
14:00 – 17:30	**VISIT of a battery technology education lab** • Politecnico Di Torino (POLITO), Italy
20:00	**Free Dinner**

List of participants

Tashkent University of Information Technology (TUIT), Uzbekistan		
1	Khujamatov Halimjon	Associate Professor
2	Reypnazarov Ernazar	senior lecturer
3	Imamov Erkin	Professor
4	Akhmedov Nurshod	PhD student
5	Lazarev Amir	PhD student
Universidade de Evora (UEVORA), Portugal		
1	Diogo Canvarro	Auxiliary Researcher
2	André Santos	PhD student
Universidad Politecnica De Madrid (UPM), Spain		
1	Slobodan Bojanic	Professor
2	Liliana Medic (Online)	Professor
Turin Polytechnic University in Tashkent (TTPU), Uzbekistan		
1	Yarbekov Abdurasul	Associate Professor
2	Khamidulla Khabibullaev	PhD researcher
3	Javlonbek Abdujalilov	Project administrator
Jizzakh polytechnic institute (JizPi), Uzbekistan		
1	Temur Berdiyorov	associate professor
2	Anarboev Mukhiddin	associate professor
3	Abdullaev Elnur	senior lecturer
Fergana Polytechnic Institute (FerPi), Uzbekistan		
1	Avezova Nilufar	Professor
2	Oshchepkova Elvira	PhD Student
3	Jakhongirov Ilmdorjon Kahongirjon	Vice Rector
Andijan state university (ASU), Uzbekistan		
1	Aliev Rayimjon	Professor
2	Abbosova Nozimakhon	PhD Student
3	Eraliyev Abduhalil	PhD Student
National Research University "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers institute" (TIIAME), Uzbekistan		
1	Siddikov Ilkhomjon Khakimovich	Professor
2	Kodirov Dilshod Botirovich	Head of Department
3	Izzatillaev Jurabek Olimjonovich	Associate professor
Karakalpak State University (KSU), Uzbekistan		
1	Ismaylov Kanatbay Abdreymovich	Professor, Head of Department
2	Reymov Kamal Mambetkarimovich	Associate Professor, Head of Department
3	Kamalov Khayratdin Usnatdinovich	Associate Professor
Ministry of higher education, science, and innovations of the Republic of Uzbekistan (MHSSERUZ)		
1	Muydinov Dilshod Najmiddinovich	Head of Department
Politecnico di Torino (PoliTo), Italy		
1	Pierluigi Leone	Full Professor
2	Marco Cavana	Assistant Professor
3	Pacifique Koshikwinja Matabishi	PhD Candidate

4	Luisa di Francesco	PhD Candidate
5	Jamshid Yakhshilikov	PhD Candidate
6	Angela Spiteri	Project administration

Logistics information

Most of international flight connections refer to Milano Malpensa Airport. Torino has its own airport (Torino Caselle) where most of EU flight carriers operate.

In order to reach Torino from Milano Malpelsa, these bus fleets can be considered:

- Bus Turin to Milan Malpensa Airport - Buy affordable tickets (flixbus.com)
- https://autostradale.it/it-IT/orari-aeroportuali/torino-malpensaaeroporti

cost is 44 euro round trip.

For hotel, some suggestions are:

- BQ hotel (https://politecnico.bqhotel.it/en/)
- Universo hotel (http://www.universohotel.it/eng/hotel-torino-porta-susa)
- NH hotel (https://www.nh-hotels.com/en/hotel/nh-torino-centro)

Outline of training courses

1. Solar power systems based on PV: Politecnico di Torino - Pacifique Koshikwinja Matabishi

i. Introduction and status of PV systems
   - History and status of PV systems
   - Market, cost, and prices
   - Applications
   - Environmental benefits and concerns

ii. Solar power systems based on PV – fundamental physics.
   - Solar radiation
   - Photovoltaic effect and PV cell working principle.
   - Types of solar cells
   - Electrical properties of solar cells

iii. Solar power systems based on PV – technology and systems.
   - PV systems components
   - PV modules and accessories
   - Inverters
   - Batteries
   - Charge controller.
   - Other system components: cabling, switches and connections systems, etc.

iv. Planning and design of PV systems
   - Introduction to microgrid and backup systems
   - Grid connected PV systems.
   - Off-grid PV systems
   - Assessment of Energy production from PV system and economic analysis
   - Site assessment and shading analysis.

v. Solar power systems based on PV – Practice with educational softwares.
   - PV cell simulation in Matlab
   - Sizing and component selection of a stand-alone PV system (using an Excell template)
   - PV system simulation and shading analysis (demonstration with PVSOL)

vi. References

2. Solar power systems based on CSP: Universidade de Evora, Dr. Diogo Canavarro & André Santos

i. Introduction
   - Why to concentrate solar radiation?
   - Definition of geometric concentration
   - Etendue and maximum concentration

ii. Fundamentals of concentrating optics
   - Laws of reflection, refraction and absorption
   - Materials and properties
   - Sunshape profile and optical errors
   - Collector efficiency, IAM, acceptance angle and CAP

iii. Concentrated Solar Power technologies
   - 2D or linear focus technologies
     - Parabolic Trough concentrators
     - Linear Fresnel concentrators
   - 3D or point focus technologies
     - Parabolic Dish concentrators
     - Central Tower Receiver concentrators
   - 3D or point focus technologies
   - Non imaging optics: approaching the limits

iv. Design and performance of CSP concentrators
   - Combination between imaging and non-imaging optics
   - Non-imaging optics for CSP technologies

v. Raytracing software and performance calculation
   - Software tools
   - Exercise

3. Energy storage methods and devices: Politecnico di Torino – Prof. Domenico Ferrero

Electric Energy Storage (EES) play a crucial role for the integration variable renewable electricity generation, both for grid-connected and off-grid systems. Different EES methods and technologies are available, each with peculiar characteristics. This module provides a summary of EES methods and technologies. A practical application example of EES system sizing implementing an optimization methodology is presented. Practical laboratory experiences for the characterization of hydrogen-based electrochemical devices are also presented.

i. Introduction
   - Electric Energy Storage (EES): roles and emerging needs of EES
   - Classification of EES methods
   - Technical comparison of EES technologies

ii. Fundamentals of Electrochemical Energy Storage
   - Introduction to batteries: battery types and basics of battery chemistry
   - Fundamentals parameters of batteries

iii. Batteries for Grid Energy Storage
   - Secondary batteries: Metal ion batteries, Lead–Acid Batteries, Molten Salt Batteries, Alkaline Batteries, Metal–Air Batteries.
   - Redox Flow Batteries

iv. Chemical Energy Storage
   - Introduction to Power-to-X concept
   - Power-to-Hydrogen: basics of electrolysis and summary of the state-of-the-art of the technology
   - Summary of hydrogen storage methods
   - Hydrogen-to-chemicals: summary of H2 to chemicals routes
   - Hydrogen-to-X: hydrogen conversion to SNG, basics of methanation
   - Hydrogen-to-X: fuel cells basics and summary of the state-of-the-art of the technology

v. Optimal sizing of EES systems: application to off-grid systems
   - Case study: hybrid Hydrogen-Battery storage for micro-grid application
   - Basics of techno-economic analysis applied to the case study
   - Optimization methodology applied to system sizing

vi. Laboratory experience: characterization of hydrogen-based electrochemical devices
   - Hydrogen laboratory: remote laboratory experience in TeacHy project
   - Hydrogen laboratories: lab experience from Hyset Master

4. Technological measurements and instruments of the industry: Universidad Politecnica De Madrid – Prof. Liliana Medic

i. Introduction

- Overview of Solar Energy
- Importance of Technological Measurements and Instruments
- Signal processing for analyzing and interpreting collected data and monitoring solar energy systems
- International Standards

ii. Solar Radiation Measurement Instruments

Solar radiation measurement instruments play a crucial role in the assessment, monitoring and use of solar energy resources. The purpose of these instruments is the quantification of various parameters of solar radiation, such as intensity, spectral distribution and duration, which are essential for understanding the availability and potential of solar energy at a particular location.

- Pyranometers
- Actinometers
- Thermal Radiometers
- UV and IR Radiation Meters
- Spectrophotometers

iii. Instruments for Solar Panel Parameter Measurement

Essential Measurements and Instruments for evaluating the performance, efficiency and overall quality of photovoltaic (PV) modules are solar panel parameter measurement instruments. These tools make it possible to characterize the various parameters of solar panels, helping to optimize how the panels operate and maximize the energy produced:

- Voltage-Current (IV) Curve Tracers
- Impedance Analyzers
- Solar Simulators
- Thermal Imaging Cameras

iv. Instrumentation for Photovoltaic Material Characterization

Photovoltaic (PV) materials characterization instrumentation comprises a wide range of tools and techniques for analyzing the structural, optical, electrical and chemical properties of solar cell materials. These tools are essential for the understanding of the performance, efficiency and durability of PV materials, and for the optimization of their design for improved energy conversion:

- UV-Vis-NIR Spectrophotometers
- Scanning Electron Microscopes (SEM)
- Mass Spectrometers
- Atomic Force Microscopes (AFM)

v. Instruments for Solar System Monitoring and Control

Solar monitoring and control Instruments are essential for operating, optimizing performance and maintaining solar energy systems. These Instruments provide real-time data, facilitate remote monitoring, and enable proactive management of solar installations to maximize energy production, improve reliability, and extend the life of the system:

- Charge Controllers
- Power Inverters

- Energy Meters
- Remote Monitoring Systems

vi. Performance Assessment Tools

To assess the efficiency, reliability and overall performance of solar energy systems, performance assessment tools are essential. These tools can help identify opportunities for improvement and optimisation by providing valuable insight into various aspects of system operation:

- Conversion Efficiency Measurement
- Loss and Gain Analysis
- Energy Production Evaluation
- Performance Tracking and Optimization

vii. References

5. Solar thermal devices and systems: Politecnico di Torino – Prof. Pierluigi Leone

i. Fundamental physics
   - Solar Radiation (solar constant, spectral distribution of extraterrestrial radiation, solar angles, available solar radiation, etc..)
   - Heat transfer topics for solar energy (radiation mechanism – blackbody and greybody models and Stefan-Boltzmann equation; convection mechanism – forced and natural convection, dimentionless numbers and empirical correlations; heat exchangers design and efficiency)
   - Radiation characteristics of opaque materials (solar absorptance and the long-wave or infrared emittance, Kirchhoff's law, reflectance of surfaces, relationships among absorptance, emittance and reflectance, broadband emittance and absorptance, selective surfaces)
   - Radiation transmission through glazing: refractive index n and the extinction coefficient K

ii. Energy analysis and performance
   - Thermal balance of a solar collector and analysis of temperature profile of the plate.
   - Overall heat loss coefficient.
   - Hottel and Whillier equation.
   - Energy demand of different users.

iii. Technology
   - Solar collector typologies and definition of efficiency.
   - Collector components: cover, absorber, fluid
   - Glazed, unglazed and evacuated tubes collectors
   - Storage technology

iv. Applications
   - Installation typologies, components and applications.
   - Solar water heaters
   - Solar heating
   - Solar cooling
   - Solar industrial process heat

v. Sizing criteria and softwares
   - Sizing criteria. Methods for the evaluation of seasonal performance of solar thermal installations. The f-chart method.
   - Software for the dynamic simulation of solar thermal installations (Polysun).

vi. References