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## 1. Introduction

In 2014, four training visits of Jordanian researchers and students to four different EU Universities took place. These visits focused on technical training in RES research topics including seminars on different RES technologies (PV, Wind, Bio gas, etc.), scientific measurement methodologies, introduction to state-of-the-art equipment and infrastructure, and operational and maintenance issues of testing/research equipment. An important aspect was the hands-on experience provided through practical laboratories. The participants also had the opportunity in some cases to visit the facilities of local RES industry. A description of the four visits, which successfully completed the deliverable DEV5.4 of the MUREE project, follows.

## 2. Activities Description

### (a) University of Cyprus

The training took place at the PV Technology Laboratory of the University of Cyprus (UCY) situated at the main campus. The following trainees from different Jordanian Universities participated:

- Rami Eleiwa, PSUT
- Sara Qutishat, Univ. of Jordan
- Mamoun Ahmed Khدير, JUST
- Bashar Al-Tarawneh, MUTAH University
- Mahmoud Suliman, PSUT
- Abdallah Almasry, Hashemite University

- Fathallah Al Hallaj, Naim Energy Technologies, NetEnergy
- Hamzeh Bardaweel, University of Jordan

The 1st day of the visit included onsite tours in the PV technology Laboratory both the indoor standardised testing facility and the outdoor continuous monitoring infrastructure. An outline of the agenda was presented and then a selection of some of the activities undertaken at the PV Technology group were described various members of the PV Technology laboratory presented the ongoing research work undertaken. Dr George Makrides and Alexander Phinikarides provided a guided tour of the outdoor and indoor PV Technology UCY testing facility. Additionally, Minas Patsalides presented the issues behind Power Quality and grid-integration, Vaso Paraskeva presented the research undergone at the indoor laboratory regarding novel cell characterization in particular multi-junction devices using external quantum efficiency measurements, photoluminescence and electroluminescence techniques under voltage-biasing and different sample temperatures, and Marios Toumazou presented his experimental solar desalination unit. In the afternoon, there was a dedicated discussion session on the needs of the Jordanian partners in terms of research in solar energy, PV, and advanced testing infrastructure.

The 2nd day of the visit involved a detailed presentation sessions on the following research topics investigated at the PV Technology Laboratory:

- Performance assessment evaluation of different photovoltaic technologies (by Dr George Makrides)
- Reliable assessment of degradation for different photovoltaic technologies (by Alexander Phinikarides)
- Power quality assessment (by Minas Patsalides)
- Characterisation of cell technologies (by Dr Maria Hadjipanayi)
- PV net-metering schemes (by Ioannis Koumparou)

The next presentation sessions focused on more technical aspects of PV, namely Principles of designing PV systems (by Alexander Phinikarides) and Principles of designing PV monitoring systems (by Dr George Makrides).

The 3<sup>rd</sup> and 4<sup>th</sup> day focused on hands-on practical laboratory sessions in particular on installation, testing, and maintenance of a grid-connected PV system, design and installation of a PV monitoring solution, indoor PV failure diagnosis and identification using visual techniques, as well as outdoor standard testing condition testing procedures and standardized indoor characterisation on PV cells and modules. The last day involved a detailed presentation on PV related equipment for research and professional purposes and closed with a general discussion between the participants on the topics covered in the training and questions arising.

#### **(b) Graz University of Technology**

The training took place in the period 8-11 September 2014 at the Electric Drives and Machines Institute of Graz University of Technology in Graz, Austria, including excursions to local industry. Eleven trainees from Jordanian partners had been pre-selected and participated at the training:

- Ahmad Tawayha, Saddam Ratrou, Mohammed Ashshi, and Rand Al Mdanat, PSUT
- Walaa Al Sarayrah, Hala Aljeradat, and Ammar Bani Ata MUTAH
- Hisham Al Aloul and Yousef Sarhan, UoJ
- Danah Aziz, JUST
- Fathallah Al Hallaj, Net Energy

Each participant was trained during the course of the stay at Graz University of Technology. Materials were exchanged, instruction in the field of Renewable Energy at the Electric Drives and Machines Institute of Graz University and at other institutes of Graz University of Technology discussed, as well as realization of Renewable Energy industry in Austria explored. The discussion considered the teaching methodology, its content, and the context of the Jordanian needs.

The training started with a presentation of the host and its institution, i.e. Graz University of Technology, the Faculty of Electric Engineering and Information Technology, the research and teaching facilities of the Electric Drives and Machines Institute, the courses the institute is responsible for, the methodologies used, and the context these courses are taught in. The remainder of the first day was filled with a laboratory exercise on the determination of the energy conversion efficiency of an induction machine (Dr. Klaus Krischan, EAM). The introduction comprised both the laboratory exercise itself and served as a specific example of the training methodology used. The laboratory exercise comprised the setting up of the measuring equipment, data recording for different operating points of the investigated, data analysis using MATLAB, and discussion of the results.

On the second day, a laboratory exercise on a synchronous machine was presented to the participants, serving as a second specific example of the education in the field of renewable energy (here: electro-mechanical energy conversion) at the Electric Drives and Machines Institute (Dr. Johann Bacher, EAM). At noon, until early in the afternoon, the group participated at an “Energy Lunch” on Photovoltaics by Styrian Eco-Energy Network (“NOEST”, see attached fact sheet). The event focussed on the system development of energy storage units and photovoltaic generators for domestic use. Several companies provided insight into their products and services in a series of short presentations. Then, two public funding bodies presented their views on the potential of renewable energy in general and on photovoltaic generators in particular, focussed on the Styrian region, Austria.

The third day comprised a visit to a company developing and producing bio mass conditioning utilities, “Komptech” ([www.komptech.com](http://www.komptech.com)). A presentation was given on the product range (including all steps needed for biomass as well as for waste processing), followed by a tour of the production facilities. The afternoon was again spent in the laboratory, with an introduction to the laboratory “Introduction to Electrical Engineering, Laboratory” (DI Heinrich Eickhoff, EAM). This exercise introduces students into the measurement of electric quantities using various types of instruments. Thereby, they also enhance their understanding of electric engineering fundamentals.

On day four, the company “KWB” ([www.kwb.at](http://www.kwb.at)) was visited. This company develops and produces heating furnaces for biomass (pellets, chips and log wood) with rated power ranging from single house heating up to district heating networks. During the visit current products and technology, as well as very recent development activities were presented. The visit was concluded by a guided tour of the production facilities.

Overall, the laboratory exercises on the first, second and third day triggered exhaustive discussions on teaching methodologies for laboratory courses as well as on the selection of topics to be taught, measurements carried out and the depth of explanations given when carrying out the exercise in the laboratory.

Joining the “NOEST Energy Lunch” on the second day provided ideas and opportunities for establishing networking platforms to intensify the exchange of knowledge with different partners of the area.

The third and fourth day’s company visits showed how ideas may make their way to products, manufacturing and to the market. The young companies’ history from their foundation – based on inventive ideas and individual determination – to serious players in local markets with important export shares showed possibilities and chances for entrepreneurship even in small countries and local markets. Selected material was made available to the Jordanian Partners by the host as well as by the visited companies.

### (c) **Sapienza University of Rome**

(d) The training at Sapienza University of Rome was held in the period 26-30 May 2014 and was attended by 7 participants from Jordan including a PhD and a MSc student. The participants were:

- Eng. Nabeel Abu Shaban (PhD Student),
- Ammar Bani-Ata ( MSc. Student),
- Dr. Montasir Hader,
- Eyad Mostafa Sulaiman Rowashdeh,
- Eng. Eyad Kouz,
- Ms. Hanin Hijaz,
- Mr. Jarir Nsour.

The technical training started with a seminar on the courses on RES at Sapienza (by Dr. Cipri), followed by a seminar on second level Master course (by Dr. Sangiorgio). There was a guided visit at the Faculty of Engineering with a particular focus on the laboratories). The second day involved a technical visit to energy plants of CONI which focus on Co-generation. In particular, during the visit the participants were guided through the work done on reversible heat pumps and District Heating applied to sporting structures.

The 3<sup>rd</sup> day involved a technical visit to ENEA, Italian National Agency for New Technologies, Energy and Sustainable Development, in particular to the Solar concentration Plant, the house of Energy, the Photovoltaic plant, and the biomass labs. The last day involved general discussions and meetings with Sistemi Energetici 2's students as well as the Director of CIRPS (Prof Vincenzo Naso), who provided further insight into RES studies and research at Sapienza.

(e) **Technische Universität Berlin** A trainer's course in the areas of bio-energy and wind energy was organized in Berlin from 16-20 June 2014 by the Technische Universität Berlin in collaboration with its partner organization the Renewables Academy (RENAC). The course provided the participants with:

- An overview of biogas and wind energy technologies and their different applications
- An understanding of the key implementation steps and the key success factors of wind and biogas projects
- A visit to a renewable energy site that included both wind and biogas systems
- Activities in a training center for hands-on practical DEVs

4 participants took part in a four-day practical and theoretical workshop. The four participants are listed as follows:

- Ms. Doha Qutishat, Hashemite University
- Ms. Suad AlHaj Mustafa, University of Jordan
- Mr. Hisham Al-Aloul, University of Jordan
- Ms. Omaymah Bany Salman, Jordanian University of Science and Technology

The 5-day workshop included the following contents:

Module	Contents
Biogas	<ul style="list-style-type: none"> <li>• Introduction to biogas</li> <li>• Sustainability aspects – pros and cons of biogas</li> <li>• Biogas technology</li> <li>• Fields of application</li> <li>• Biogas potential of different substrates</li> <li>• Technology levels</li> <li>• Biogas and digestate utilisation</li> <li>• Market development</li> <li>• Biogas plant design exercise</li> <li>• Financial parameters &amp; biogas calculation tool exercise</li> </ul>

Wind energy	<ul style="list-style-type: none"> <li>• The wind resource</li> <li>• Wind energy principles</li> <li>• Basics of wind power systems</li> <li>• Wind resource assessment</li> <li>• Power curves</li> <li>• Energy yield calculation</li> <li>• Environmental impacts</li> <li>• Economic aspects</li> <li>• Market development</li> <li>• Wind energy laboratory:             <ul style="list-style-type: none"> <li>- Wind blower calibration</li> <li>- Power curve measurement</li> <li>- Lift effect at different tilt angles</li> <li>- Drag wind turbine</li> <li>- Power coefficient (<math>c_p</math>) measurement</li> <li>- Tip speed ratio (<math>\lambda</math>) measurement</li> <li>- <math>c_p - \lambda</math> curve</li> </ul> </li> </ul>
Site visit	<ul style="list-style-type: none"> <li>• Visit to the wind farm and Bioenergy plant in Feldheim</li> </ul>

Some photos from the visit to TUB and local industry are shown below.







### **3. Conclusions**

Overall, the 4 technical visits were successful in terms of important knowledge transfer and hands-on experience in scientific measurements and RES laboratories. A particularly useful aspect of the visits were the targeted training sessions and workshops (theoretical and practical) in different topics in RES work and the visits to dedicated RES facilities and local RES industry in the host countries. Through the technical visits, a solid foundation for further exchange of experience between the Jordanian partners and the EU Universities was laid. The host Universities are very happy to keep supporting the further development of the education in renewable energy in Jordan.