



**Modernizing Undergraduate Renewable Energy
Education: EU Experience for Jordan
MUREE**

**DEV5.5 Training Workshops in Renewable Energy
in Jordan**

Princess Sumaya University for Technology



Ayman Ghamoh



Faculty of Engineering - Sapienza University - Rome
Presentation and discussion about Italy energy policy and renewable energy plans. (Prof. Vincenzo Naso)

- New power plant using coal as the fuel.
(Civitavecchia thermoelectric plant)
- Coal was used to the national policy to diversify the sources of energy, Italy had four nuclear reactors.
- Closed in the period 1987-1990 due to public rejection after accidents all over the world.

Renewable Energy Strategy & Goals:

- Diversify Resources
- Optimize power converters.
- Optimize energy efficiency.
- Optimize use of energy
- Clean energy.



Thermoelectric power plant in Civitavecchia operated by ENEL Company.

- One of the most advanced power plants of the world.
- Installed Capacity of 1980 MW (>60% of Jordan load demand)
- 45 % thermal efficiency .
- CO₂ emissions is decreased by 18 %.
- SO_x emissions is decreased by 88 %.
- Treated to produce gypsum & chalk.
- NO_x emissions are decreased by 61%.
- Treated with ammonia.
- Ashes are sold to cement industry.
- Abatement of Particulates in flue gases is 99.92%.
- Using bag-house filters.
- 3 Generators of (660 MVA , 20kV) and step-up transformers of (720 MVA, 20kV/380kV)



Laboratories visits & demonstrations of several projects (PhD& MSc)

- Turbines lab
- Fuel Cells lab
- Biomass lab
- Measurements lab
- Casting machines
- Prototyping and stereolithography
- Wind tunnel
- Machines testing

Italian inter-universities research center that offers research activities, technical support and consultation services.



Visit to ENEA - Italian National Agency for New Technologies, Energy and Sustainable Development.

- The main research topics are :
- Energy Efficiency
- Nuclear Energy
- Environment & Climate
- Safety & Health
- Innovation & vocational training.
- A national committee that work with universities and industry.
- More than 250 patents and 9 spin-offs.



Jarir Al-Nssour



Introduction

- * Visited two universities :
- * Sapienza University of Rome, Italy.
- The National Distance Education University(UNED),Spain.
- * In addition to this visit, two important places in Rome were visited:
- * The Olympic Training Center (OTC).
- * ENEA, The Italian National Agency for new Technologies.



The Olympic Training Center (OTC): 100% owned by the Ministry of Economy, ([Italian](#): Comitato Olimpico Nazionale Italiano, CONI). OTC Committee manages the centre, the School of Sport, the Institute of Medicine and Science in Sports, provides high level advisory services to the sports facilities and its redeveloping the Foro Italico park, the largest sports complex in Italy.



The Olympic Training Center (OTC)

- * Production of chilled water with heat pumps.
- * Superheating and condensing heat recovery for free preheating of pools.
- * Possible integration with thermal boiler (for pools, maintenance).
- * Free de-superheating heat recovery for DHW production and possible integration with thermal boiler.



* ENEA is the name for Italian National Agency for New Technologies, Energy and Sustainable Economic Development, and hosts over 2700 staff employees, distributed in its 9 research centers all over the national territory.

* It conducts research and innovation activities, and provides public administration, enterprises and citizens with its advanced services. Specifically, ENEA is concerned with energy efficiency, renewable energy sources, nuclear energy. It hosts experimental laboratories and facilities, and also dedicates its technological innovation skills to cultural heritage conservation, agro-food, health, and the environment.



* ENEA research activities are focused on the following sectors:

1. ENERGY EFFICIENCY : Support to Public Administration, Information and Training; Advanced Technologies for Energy and Industry.
2. RENEWABLE ENERGY SOURCES: Concentrated Solar Thermal Energy; Photovoltaics; Biomass and Biofuels; Solar Thermal Energy at low and medium temperatures; Hydrogen, Fuel Cells and Energy Storage Systems.
3. NUCLEAR ENERGY: Nuclear Fusion; Nuclear Fission.



4. CLIMATE AND THE ENVIRONMENT : Environmental Characterization, Prevention and Recovery; Environmental Technologies; Energy and Environmental Modeling; Marine environment and Sustainable Development; Antarctic Expeditions and Research in Polar Areas
5. SAFETY AND HEALTH: Seismic Protection; Radiation Biology and Human Health; Radiation Protection; Metrology of Ionizing Radiation
6. NEW TECHNOLOGIES: Materials Technologies; Radiation Applications; Sustainable Development and Innovation of the Agro-Industrial System; ICT
7. ELECTRIC SYSTEM RESEARCH: Studies and research, under a Programme Agreement with the Italian Ministry of Economic Development, aimed at innovating the National Electric System to make it cheaper, safer and more environmentally-friendly.



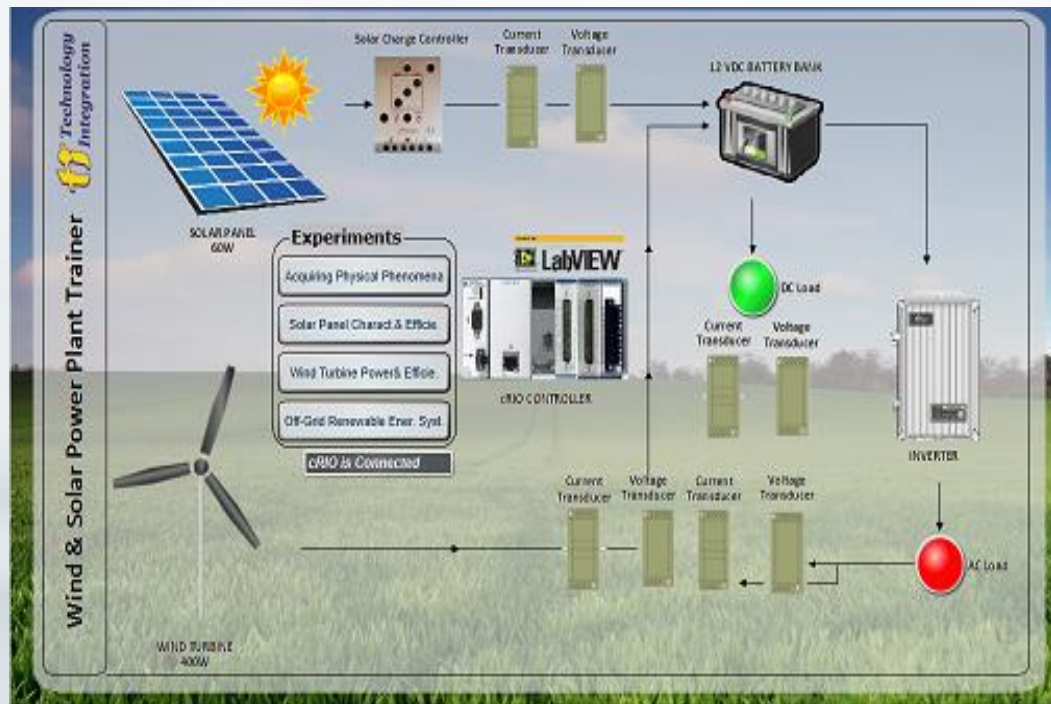
UNED-Madrid

We purchased four experiments in order to establish four remote laboratories in four universities; PSUT, JUST, Mutah and Hashemite university.

* A delegation from these universities and university of Jordan made a training visit to UNED to discuss issues related to adaptation and integration of remote laboratories and E-learning courses into VLE. In addition, the visit had a group training sessions and one-to-one consultations among UNED and the Jordanian experts.



PSUT- Remote Lab





PSUT- Remote Lab

WSPT001 Exp1 - Acquiring Physical Phenomena 2/18/2015 9:40:09 AM

Technology Integration

Solar Radiation Sensor

The Solar Radiation Sensor is a 4-wire RTD sensor (Resistance Temperature Detector) which is a resistance that varies depending on the changes of temperature, the Solar Radiation Sensor is connected to a transmitter, which excites the RTD and converts the radiation from W/m^2 to mA using the following equation:

Current (mA)	4.00662875
Radiation sensor(W/m^2)	0.66287517

Hold Values
Save Clear

Graph: Radiation (W/m^2) vs Current (mA)

Current (mA)	Radiation (W/m^2)
4	0
6	265
8	530
10	795
12	1060
14	1325
16	1590
18	1855
20	2120











Mahmoud Fares

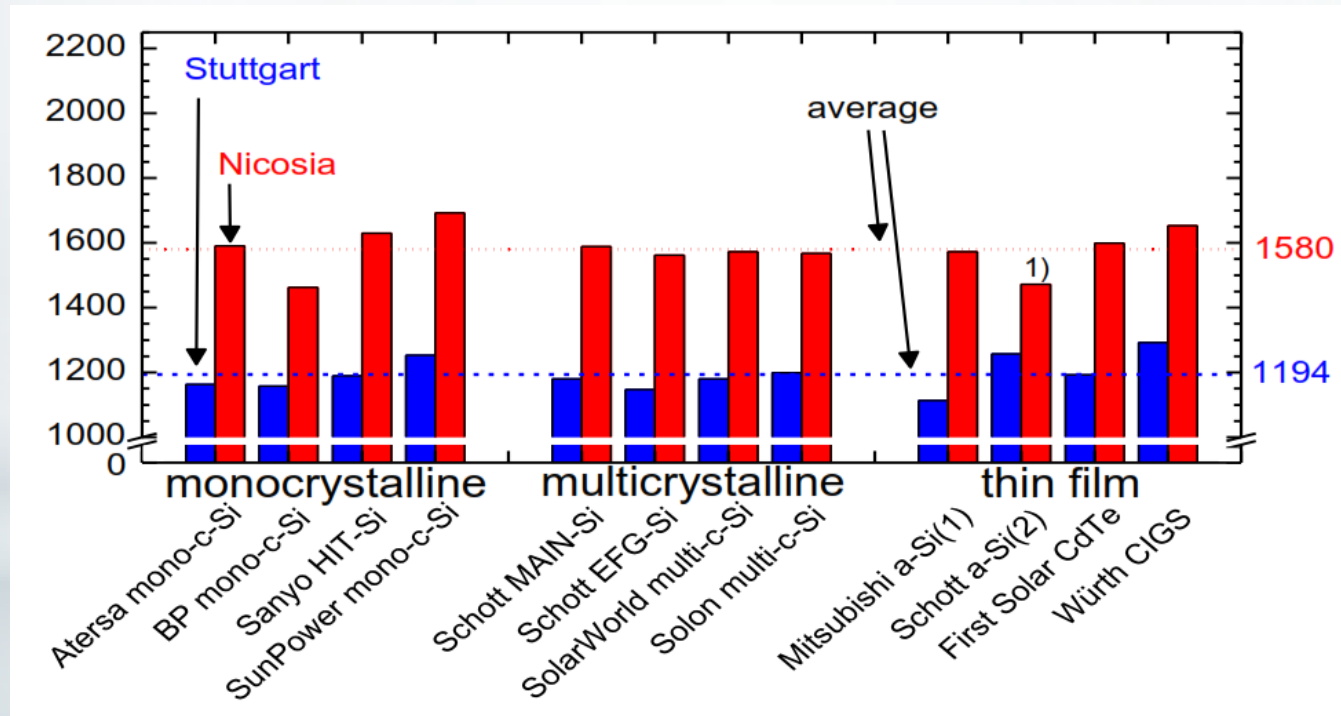


Theory - Key characteristics of commercially available PV modules

Parameter	Mono-c-Si	Poly-c-Si	a-Si	Flexible a-Si	CdTe	CIGS
Efficiency (%)	14 – 20	11 - 15	4 - 8	6.5	10 - 11	7 - 12
Area (m ²)	1.4 - 1.7	1.4 - 1.7	~1.5	~2.15	~0.6 - 1	~0.6 - 1
Area of 1 kW _p system	~7	~8	~15	~16	~10	~9
NOCT	46 – 49	47 - 48	49	46	45	51
Power temperature coefficients (%/C)	-0.43 - 0.45	-0.43 - 0.45	-0.20	-0.21	-0.25	-0.38
Power tolerance (%)	±3/5	±3/5	±5	±5	±5	±5
Degradation	10 years 90 % 25 years 80 %	10 years 90 % 25 years 80 %	year 2-30 <0.5 %	10 years 92 % 25 years 80 %	10 years 90 % 25 years 80 %	10 years 90 % 25 years 80 %
Module structure	Glass-EVA-Cell-Tedlar	Glass-EVA-Cell-Tedlar	Glass-EVA-Cell-Glass	Laminate	Glass-EVA-Cell-Glass	Glass-EVA-Cell-Glass
Length / Width / Height (mm)	1660x990x42	1660x990x42	1308x1108x35	5412x373x3	1200x600x42	1210x605x40
Weight (kg)	21	21	20.8	7.4	12	12.6
Module front-view						

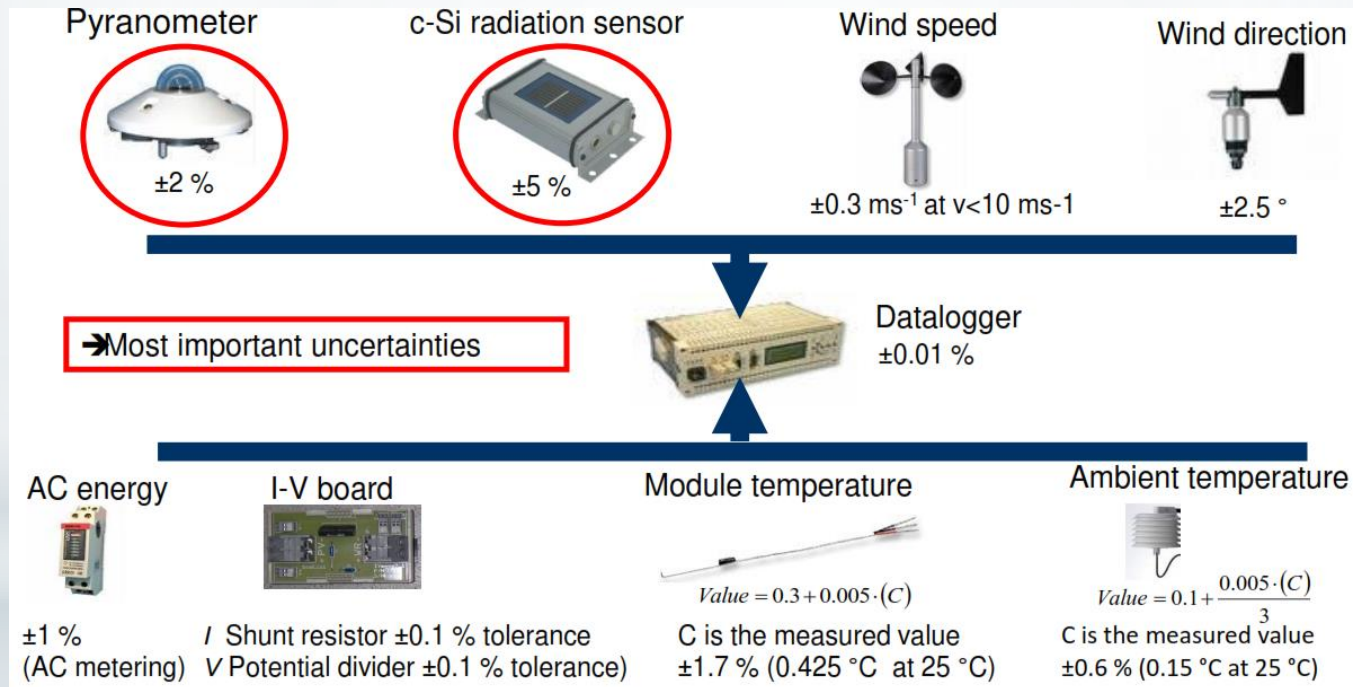


Performance vs climatic conditions (Cyprus and Germany)





Measurement uncertainties





- Mono-crystalline Silicon (Atersa)
- Multi-crystalline Silicon (SolarWorld, Solon)
- Amorphous Silicon (Schott Solar, MHI)
- EFG and Main (Schott Solar)
- Mono-crystalline Silicon Saturn Cell (BP Solar)
- Mono-crystalline Silicon Back Contact Cell (Sunpower)
- Mono-crystalline Silicon HIT (Sanyo)
- Cadmium Telluride (First Solar)
- Copper Indium Gallium Diselenide, CIGS (Wurth Solar)
- Tracked System - Concentrator System (Concentrix Solar)



Review of the status of the remote laboratories, and Adaptation of the Remote Laboratories on the VLE Moodle .





Moodle plug-in for Remote Laboratories

The screenshot displays a Moodle course interface for 'MUREE Meeting Course'. The browser address bar shows the URL `mercurio.scc.uned.es/moodle/course/view.php?id=3`. The user is logged in as 'Mahmoud Fares'. The course page includes a navigation menu on the left with sections for 'Home', 'Current course' (MUREE), and 'Administration'. The main content area features a 'News forum', a list of participants (Mamour, Haneen, Mahmoud), and 'Lesson 3: Solar Energy' with sub-sections for 'Laboratories Description' and 'Laboratoy video'. A 'Turn editing on' button is visible in the top right. The Windows taskbar at the bottom shows the time as 2:15 and the date as 18-Feb-15.



Mahmoud Hassan



IGFOFON Visit

A PV Company established by a Professor from Cadez University.

Visited PV facilities of the company which is used for generating electricity and for PV training.

Cadez University Old Campus Visit.

Visiting a 100 KWP PV system installed on the University building roofs.

Cadez University New Campus Visit.

Visiting research laboratories for characterizing PV samples received from industry in Spain.



Meeting with MUREE Quality Assurance Committee.

I have answered questions regarding the MUREE grant for Power and Machines Lab. These discussions helped the speed up of the grant approvals.

UCY PV Research Facilities

We visited UCY PV research facility, we have been briefed on different existing PV systems and PV testing facilities.

Participation in Lectures and Discussions.

UCY group briefed us about their suggested PV course.

I have presented PSUT plans for establishing a teaching/ research PV Lab.



Rami Eleiwa



University of Cyprus(UCY)

- * UCY established in 1989 in Nicosia and admitted first student in 1992.
- * There are eight Faculties within the University: Faculty of Humanities , Faculty of Pure and Applied Sciences , Faculty of Social Sciences and Education, Faculty of Economics and Management



* Faculty of Engineering, Faculty of Letters, Faculty of Graduate Studies, The Medicine School with approximately 6500 student.

* Beside the above faculties UCY established a photovoltaic technology research center in 2005 in collaboration with the institute Fur Physikalische Electronic in Stuttgart.



* The PV Technology Laboratory has developed outdoor and indoor facilities for the characterization, evaluation, and monitoring of different PV technologies.

* All the tests done on two levels, on the cell level and on the module level (which consist of many cells)



Indoor Facility

- * Environmental Chamber
- * Solar and UV Simulator
- * Electroluminescence imaging apparatus
- * PV characterization



Outdoor Facility

- * PV characterization
- * Outdoor system level performance infrastructure
- * Meteorological stations
- * NOCT (Nominal Operating Cell Temperature)infrastructure
- * Outdoor cell/module level performance infrastructure
- * Potential Induced Degradation (PID) infrastructure



It was a very nice experience to meet new people and to see new technologies.

* GROUP OF WORK.



Rund Madanat



KOMPTECH

Komptech is a leading international supplier of technology for machines and plants for the mechanical and biological treatment of solid waste and biomass.

The **Komptech** product portfolio comprises more than 30 different types of machine whose areas of expertise are the treatment of solid waste and treatment of woody biomass.

The product range includes over 30 different types of machines, that cover all process steps in modern waste handling-shredding, separation, and biological treatment.



They provide Energy For life





1- 50% Save Heating costs!

By switching to renewable wood fuels you can heat safely and independently while saving up to 50% of the running heating costs!

In contrast, heating with oil, gas or coal is crisis-prone.

These resources are because becoming ever more scarce and the prices for heating oil and natural gas continue to rise due to increasing supply storages.



2- CO2 balance:

When wood is burned, only CO₂ is released into the atmosphere as a tree has absorbed during its lifetime.

Heating with log wood, wood chips or pellets is thus CO₂ neutral and an important contribution to climate protection.

3- Sufficient Biomass!

Renewable wood fuels are available in sufficient quantity, Every year, more wood grows in domestic forests than can be used. And the proportion of the forests is continually growing throughout Europe. In addition to wood from forests, energy wood(fast-growing willows and poplars) on agricultural areas is also available as an additional source of raw material.



KWB PRODUCT
PELLET, WOOD-CHIP AND LOG WOOD HEATING SYSTEMS 8-300 kW





Saddam Ratrot



High voltage insulator



Circuit breaker



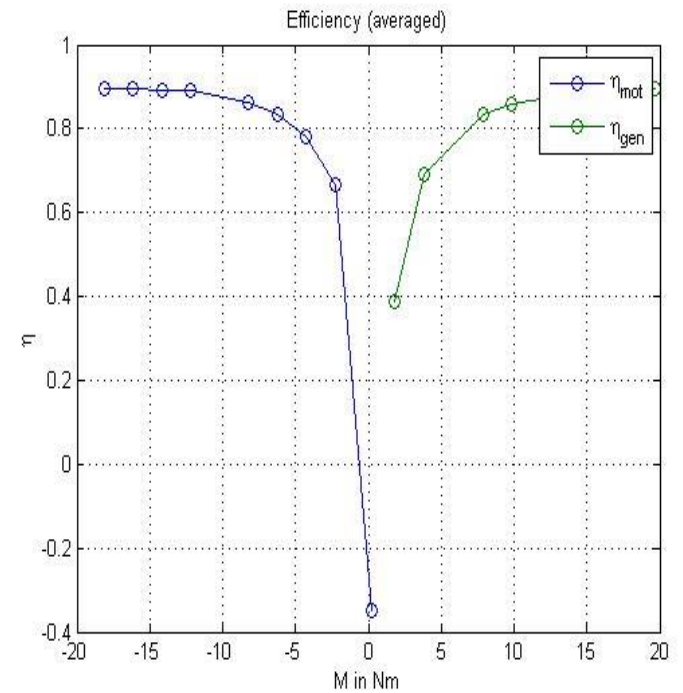
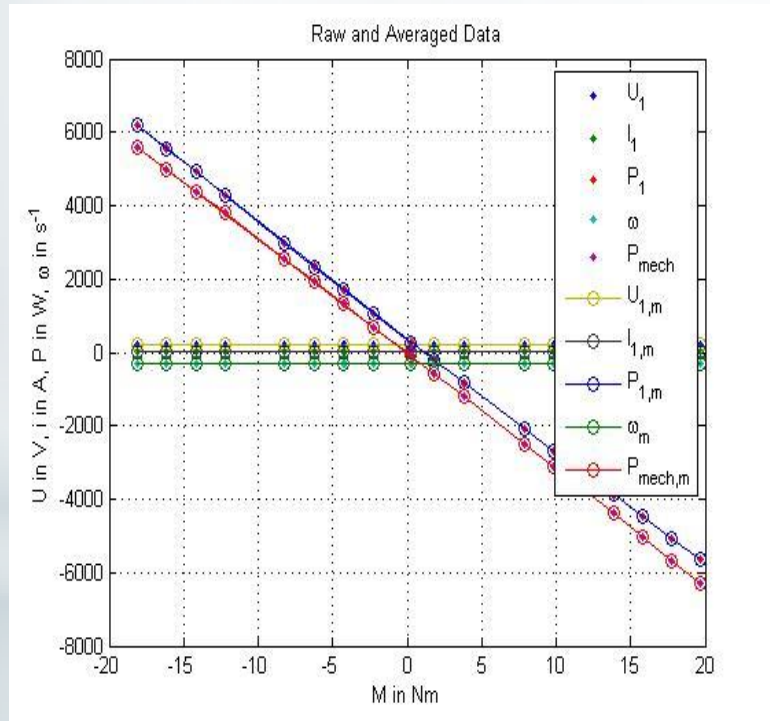


Machines Lab for Graduate Students





Some Results

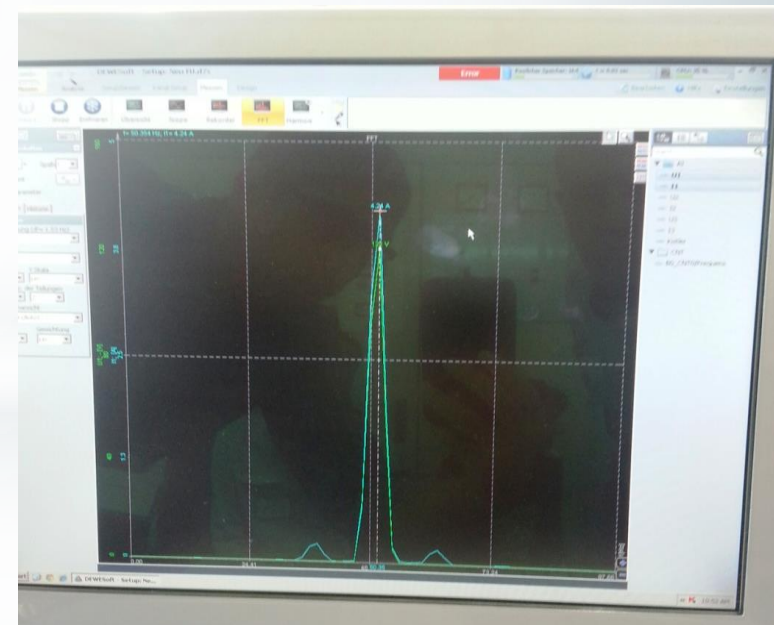
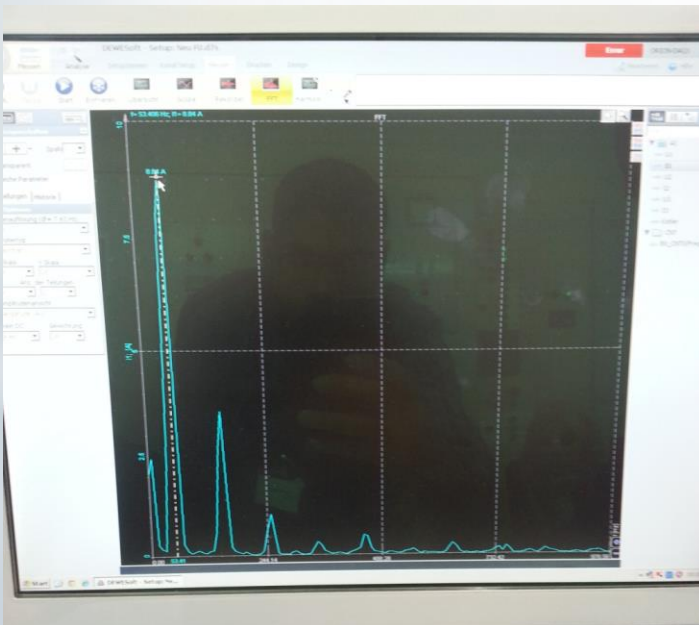




Some Results

FFT analysis for induction motor current controlled by inverter

FFT analysis for induction motor current fed directly from the main





Yazan Shwehat



Technical Visits

- * Faculty of Engineering - Sapienza University Rome
- * Thermoelectric power plant in Civitavecchia operated by ENEL Company.
- * Hydrogen Pole visit
- * Visit to ENEA - Italian National Agency for New Technologies, Energy and Sustainable Development.



Trip Agenda

* First and Second day:

- Presentation and discussion about Italy energy policy and renewable energy plans. (Prof. Vincenzo Naso).
- Presentation of Energy Conversion course outline (Prof. Ali Badran), followed by a discussion.
- Presentation of Renewable Energy course outline (Dr. Bashar Hammad), followed by a discussion.

* Third day:

- Thermoelectric power plant in Civitavecchia operated by ENEL Company.
- Hydrogen Pole visit.

* Forth day:

- Meeting with the coordinator and the students of the EFER master Program.

* Fifth day:

- Visit to ENEA - Italian National Agency for New Technologies, Energy and Sustainable Development



Ahmad Tawayha



Outline Trip To Austria

- * About TU
- * About Graz
- * Vienna Trip
- * Scientific Activities
- * Comments
- * TU University Graz



About TU

- * No. of students 12500 students
- * Strong Research Activities 1900 Graduate
- * Many Renewable Energy companies Started at TU



Scientific Activities

- * Some Undergraduate Labs
- * Some Research Oriented Labs
- * One day Meeting For Renewable Energy Companies
- * Field Trip visits to companies in the field



Comments

- * Rich Experience
- * Got exposed to latest trends in renewable Energy
- * Had an idea on undergraduate EE labs
- * I wish that there was something designed to establish joint research



Ayman Faza



* Participated in two visits:

1. Technical University Graz - April 2013

- Meeting with all partners; Jordanian and European
- Discussion of the 4-6 courses to be prepared and adopted at Jordanian Universities
- Laboratory visits at TU Graz

2. University of Cyprus - January 2014

- Academic visit
- Focused on the development of the Solar Energy Course
- Visits to the solar farm and related laboratories



University of Cyprus Academic Visit

- The main purpose of the visit was :
 - To learn from the experience of UCY in developing their solar energy course
 - However, the visit was also very useful in terms of getting an in-depth understanding of the types of equipment needed for a good research lab for solar energy
 - And to get to know the trending research topics in Solar energy and photovoltaics.



University of Cyprus Academic Visit

- * The research laboratories that we visited included:
 - A solar farm in which multiple solar panels with different technologies are used to generate electric power.
 - A solar tracker system, in which solar panels are rotated throughout the day and year to get maximum sun exposure.
- * Indoors laboratories for:
 - Accelerated testing of degradation
 - A sun simulator system to be used for studying maximum power point operation among other variables
 - A facility for monitoring power quality in terms of harmonics generated due to nonlinearities in inverters and other power electronics devices.



University of Cyprus Academic Visit

* Also visited their Educational labs:

- UCY has developed experiments for planning solar systems based on:

1. Power requirements
2. Available technologies
3. Needed capacity
4. Area of available space.

- The use advanced software systems such as PVsyst.



University of Cyprus Academic Visit

- * UCY presented the syllabus of their basic and advanced courses in Solar Energy
- * Their syllabus included topics such as:
 - Advanced crystalline devices (mono, poly)
 - Thin film devices
 - Advanced PV cells
 - Concentrated PV Systems
 - Advanced Solar Thermal Systems
 - Concentrated Solar plants
 - PV Systems Engineering - Grid connected PV Systems
 - PV Systems Engineering - Standalone PV Systems
 - Integration of Solar Systems



University of Cyprus Academic Visit

* This was personally useful for me since I developed the contents for the course: Renewable Energy systems

- This is a major course in the Power and Energy Program at PSUT
- The experience I gained during this visit made it easier to chose the appropriate topics for this course
- We are planning in the near future to build a lab for solar energy, which will contain components and ideas similar to the ones we saw at UCY



Eyad Al-Kouz



Sapienza University of Rome:

Faculty of Engineering

- * Founded in 1303.
- * In [Italian](#), [sapienza](#) means "knowledge".
- * Sapienza University of Rome has 11 faculties and 65 departments.
- * Today Sapienza, with 140,000 students and 8,000 among academic and technical and administrative staff, is the largest university in Italy.
- * Faculty of Engineering is located in the historic center of Rome, directly overlooking the Coliseum and next to the ancient Basilica of San Pietro in Vincoli, home to Michelangelo's statue of Moses.



The Heat-Cold Center (HCC) at the Olympic
Training Center (OTC)

- * 100% owned by the Ministry of Economy.
- * CONI Servizi manages the National Olympic Training Centre, the School of Sport, the Institute of Medicine and Science in Sports, provides high level advisory services to the sports facilities and is redeveloping the Foro Italico park, the largest sports complex in Italy.
- * Swimming pools, gyms, volleyball, soccer fields, hockey, baseball, rugby, guesthouses, restaurants, sport medicine, library, etc.
- * Total Surface 220 Km².
- * Surface Covered 25 Km².
- * Built 122 Km².
- * 7 active gas utilities, 7 water users active, 6 thermal power plants and 3 central cooling.



The Heat-Cold Center (HCC) at the Olympic Training Center (OTC)

* Winter Operation:

- Hot ventilation with boilers group.
- Pre-heating of pools and pre-heating for hot ventilation with heat pumps.
- Domestic hot water production with boilers group.

* Summer Operation:

- Production of chilled water with heat pumps.
- Superheating and condensing heat recovery for free preheating of pools.
- Possible integration with thermal boiler (for pools, maintenance).
- Free de-superheating heat recovery for DHW production and possible integration with thermal boiler.



The Heat-Cold Center (HCC) at the Olympic Training Center

On the basis of the prices charged to CONI Services for electricity and natural gas, the cost per kWh thermal is:

0.0614 €/kWh (Heat pump)

0.0764 €/kWh (Boiler)

Overall, considering the recovery from the de-super heater:

+0.0635 € /kWh.

The recovery of the heat of the de-super heater was a total of 617.815 kWh corresponding to a value of 47,000 Euro ... Equal to the production of about 1317 of solar panels.



ENEA (Research and Innovation for Italy's Sustainable Development)

- * The Italian national Agency for new technologies, energy and sustainable economic development.
- * ENEA is concerned with energy efficiency, renewable energy sources, nuclear energy. It hosts experimental laboratories and facilities, and also dedicates its technological innovation skills to cultural heritage conservation, agro-food, health, and the environment.
- * ENEA research activities are focused on the following sectors:
 1. ENERGY EFFICIENCY :
 - Support to Public Administration, Information and Training; Advanced Technologies for Energy and Industry.
 2. RENEWABLE ENERGY SOURCES:
 - Concentrated Solar Thermal Energy; Photovoltaics; Biomass and Biofuels; Solar Thermal Energy at low and medium temperatures; Hydrogen, Fuel Cells and Energy Storage Systems.



3. NUCLEAR ENERGY:

- Nuclear Fusion; Nuclear Fission.

4. CLIMATE AND THE ENVIRONMENT:

- Environmental Characterization, Prevention and Recovery; Environmental Technologies; Energy and Environmental Modeling; Marine environment and Sustainable Development.

5. SAFETY AND HEALTH:

- Radiation Biology and Human Health; Radiation Protection; Metrology of Ionizing Radiation.

6. NEW TECHNOLOGIES:

- Materials Technologies; Radiation Applications; Sustainable Development and Innovation of the Agro-Industrial System; ICT.

7. ELECTRIC SYSTEM RESEARCH:

- Studies and research, under a Programme Agreement with the Italian Ministry of Economic Development, aimed at innovating the National Electric System to make it cheaper, safer and more environmentally-friendly.



ENE A

* Renewable Energy Sources:

1. Concentrated Solar Thermal Energy

- By using parabolic trough collectors, ENEA has developed an innovative technology chain based on a molten salt mixture functioning as heat transfer fluid and thermal storage.

2. Photovoltaics

- Design and implementation of photovoltaic devices (crystalline silicon, thin-film silicon, polymers).

3. Biomass and Biofuels

- producing biogas to be used for electric power generation or in the grid as gas biofuel (biomethane) from organic wastes, farm wastes and/or sugar energy crops.



4. Hydrogen, Fuel Cells and Energy Storage Systems

- Hydrogen:

Development of processes producing hydrogen both from renewable energy sources (solar-powered thermochemical cycles, biomass gasification, biological processes), and from fossil fuels.

- Fuel Cells:

- A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product. As long as fuel is supplied, the fuel cell will continue to generate power.

- Development of materials and components for different cell types.

- Electric Storage:

Development of new materials and components for electrochemical storage, such as lithium batteries and super condensers.