



Promotion of Renewable Energy for Water production through Desalination

www.prodes-project.org

Deliverable 3.3:

Report on the first course for students

WP3 – Task 3.4

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Intelligent Energy  **Europe**

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Introduction

Within the ProDes project training courses for students are organised and implemented. It is planned to have two courses in each one of the target countries, Italy, Spain, Greece and Portugal, during the project lifetime, from October 2009 until September 2010. In the first 15 months of the project the first round of courses for students has been completed. This document presents the reports from these four courses, while an overview is given in the table below:

Country	Spain
Location	University of Almería (CIESOL) and Plataforma Solar de Almería
Time scheduling	From the 15 th of May 2009 to the 9th of July 2009
Target group	Students from Master Course on Solar Energy organized by CIESOL, joint centre of University of Almería and Plataforma Solar de Almería (CIEMAT)
N° of participants	21
Course duration	40 hrs lectures/tutorials
Country	Italy
Location	University of Palermo, Palermo (Italy)
Time scheduling	From the 17 th of March 2009 to the 23 rd of July 2009 (with some weeks off for vacancies), usually lectures of 3 hrs once per week
Target group	Students from the Engineering Faculty of the University of Palermo
N° of participants	66
Course duration	35 hrs lectures/tutorials; 8hrs visit to the MED Trapani plant
Country	Greece
Location	Centre for Renewable Energy Sources & Saving, CRES, Greece
Time scheduling	29/10/2009 – 3/11/2009
Target group	Amongst others from the following Universities: AUA, NTUA, TEI of Athens, Aristotle University, University of Patras etc.
N° of participants	98

Course duration	32 hrs lectures/tutorials; 8hrs visit to: CRES Wind Park, CRES Energy Park in Keratea, AUA Solar Rankine cycle desalination plant in Marathonas.
Country	Portugal
Location	LNEG and FCT/UL facilities,
Time scheduling	September – December 2009
Target group	Students of the Master in Energy & Environment Engineering of the Faculty of Sciences of the University of Lisbon
N° of participants	26
Course duration	20 hrs lectures/tutorials – shorter because renewable energy topics were already covered within the Masters course

The second round of courses will be implemented within the period February to June 2010. As most of the courses have already been integrated to established University curricula, and have been embraced from the students who showed great interest in the topic it is expected that the course will continue also after the end of the ProDes project.

1 Course in Italy

1.1 University of Palermo and the Engineering Faculty

Università degli Studi di Palermo (UNIPA) is a long established academic institution whose origins date back to 1806. It is the largest University in Sicily and one of the largest in Italy, with over 60,000 enrolled students. The Faculty of Engineering is one of the largest faculties of UNIPA, with more than 7000 students and represents one of the most scientifically active. Within this context the PRODES course has been offered to the last year bachelor and master students of the engineering courses, with the majority of students attending the Chemical Engineering course.

1.2 Justification of the course

The Engineering Faculty is strongly interested in topics such as non-conventional water sources and renewable energy. For this reason, the organization of the PRODES course on the use of “Renewable Energy for water production through Desalination” has been very much appreciated and promoted by providing classrooms and facilities within the faculty. Moreover the course has been accepted as an optional course with official acknowledgment of credits to be included, after a final assessment, into the academic curricula of students.

1.3 Implementation of the course

The course has been carried out in the Chemical Engineering Dept. building. A large classroom has been provided by the head of the department to give the lectures to about 60 students (a list of attending students is reported in Annex I). The course has been advertised by leaflet and advertising put in the Chemical engineering department (Annex II) and by informing the head of several departments in the Engineering Faculty about the course implementation.

The course structure developed in Task 3.2 has been fully met and a detailed description of teaching activities is reported in Table 1.

Table 1. Lectures timetable:

Lecture Argument	Type of lecture	Date and duration	Lecturers
Introduction to seawater desalination processes	Theoretical	17 th March 2009, 3hrs	G. Micale, A. Cipollina, L. Rizzuti
Conventional desalination processes: technology description and economics	Theoretical	24 th March 2009, 3hrs	A. Cipollina
Conventional desalination processes: basic design	Tutorial	7 th April 2009, 3hrs	A. Cipollina

Renewable energies for desalination	Theoretical	28th April 2009, 3hrs	A. Cipollina
Reverse Osmosis powered by Photovoltaic Energy and by Wind/Photovoltaic hybrid Energy	Theoretical	5 th May 2009, 2hrs	A. Cipollina
Reverse Osmosis powered by Photovoltaic Energy and by Wind/Photovoltaic hybrid Energy	Tutorial	5 th May 2009, 1hr	A. Cipollina
Solar Stills and solar powered Humidification-Dehumidification processes	Theoretical	12 th May 2009, 2hrs	H. Mueller-Holst, A. Cipollina
Solar Stills and solar powered Humidification-Dehumidification processes	Tutorial	12 th May 2009, 1hr	H. Mueller-Holst, A. Cipollina
Solar ORC and Wind energy for RO Desalination	Theoretical	19 th May 2009, 2hrs	G. Micale
Solar ORC and Wind energy for RO Desalination	Tutorial	19 th May 2009, 1hr	F. Di Stefano
Solar ponds and solar thermal processes: MED, MSF	Theoretical	26 th May 2009, 3hrs	A. Cipollina, G. Micale
Solar driven desalination systems based on Membrane Distillation	Theoretical	4 th June 2009, 1hr	A. Cipollina, F. Di Stefano
Solar driven desalination systems based on Membrane Distillation	Tutorial	4 th June 2009, 1hr	A. Cipollina, F. Di Stefano
Post-treatments for desalinated water	Theoretical	4 th June 2009, 1hr	A. Cipollina,
Environmental issues; potential solutions to the brine disposal problem. A case study: Trapani MED-TVC coupled to saline ponds	Theoretical	9 th June 2009, 3hrs	G. D'Ali Staiti, A. Cipollina
Final assessment for students, through a discussion on (topics of the final report prepared by students): RE-Membrane Distillation technologies; Solar ponds and solar thermal collectors coupled to MED units; Reverse Osmosis units powered by an Organic Rankin Cycle	Theoretical/Tutorial	30 th June 2009, 2hrs	A. Cipollina, G. Micale, L. Rizzuti

Final assessment for students, through a discussion on (topics of the final report prepared by students):: Solar MSF; Energy Recovery systems for RO; Solar PV Electro Dialysis; Alternatives to the brine disposal problem; Pre-treatments in membrane processes; Solar MED with co-generation schemes; Wind-RO; Solar PV-RO; Costs analysis for RE desalination	Theoretical/Tutorial	23 rd July 2009, 3hrs	A. Cipollina, G. Micale, L. Rizzuti
Visit to the MED-TVC desalination plant coupled to a saline pond in Trapani	Visit to an operating plant with solar cogeneration of salt	10 th June 2009, 8hrs	G. Micale, A. Cipollina, L. Rizzuti, F. Di Stefano

Lectures were held by internal lecturers of the Engineering Faculty or by lecturers specifically invited for the event. Theoretical lectures were alternated with tutorials in order to get continuous feedbacks from students on their level of learning during the whole course.

At the end of the course a visit to the MED desalination plant in Trapani was made. Notably in this site a salt pond exists where an interesting experimentation on the re-use of brine for the production of food grade salt is currently performed. The students were divided in two groups (in order to make easier the visit tour in the plant) and each group visited separately the MED plant and the salt pond. An enthusiastic response has been recorded from students.

Eventually, a final assessment was done for each student in order to obtain the course certificate (Annex III). Students, divided into groups of 4-6 persons, gave a presentation and prepared a written report on specific topics relevant to the main thematic areas of the course. Each presentation was followed by a short discussion with the participation of both students and lecturers.

Some pictures relevant to the activities of the course are shown in the following figures.



Dr. Hendrick Mueller Holst giving a lecture on the solar MEH process



Visit to the pilot salt ponds in Trapani



Tutorial lecture on solar Membrane Distillation



Visit to the MED plant in Trapani

1.4 Lecturers' comments and feedback on the course

In general, the course has been organised in a strong logical sequence, with the topics and the structure of each lecture being developed step by step during the course itself on the basis of the student's response to the discussed topics. A good balance has been also kept between theoretical lectures and tutorials, which is advisable to keep also for the other course editions.

The presence of external experts to present specific topics of interest with insight into state of the art scientific research is very much advisable. In this edition only an external lecturer has contributed to the course, but more external experts are likely to participate to the next course edition.

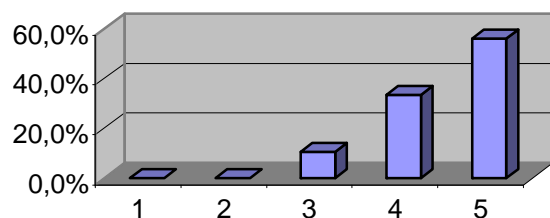
1.5 Students' feedback on the course:

In general, students' response to the course was quite enthusiastic for most of the course lectures. At the end of the course an anonymous questionnaire (Annex IV) was distributed to the students and collected. The questions reported in the questionnaire were:

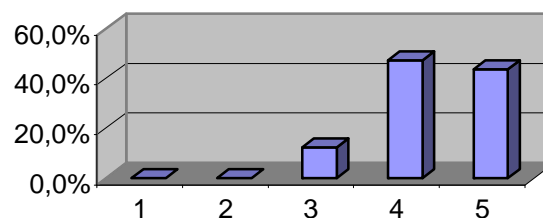
- 1) Were the course aims made clear at the start?
- 2) Were the lectures well prepared and in logical order?
- 3) Was the course starting point at the right level?
- 4) Were slides/overheads adequate and well prepared?
- 5) Was the subject matter clearly explained?
- 6) Were the tutorials useful to make the lectures clearer?
- 7) Was the material covered relevant to your studies?
- 8) Were the lecturers responsive to questions?
- 9) Did the lecturers project enthusiasm about the course?
- 10) Was the lecturers' teaching very good overall?
- 11) Total work load compared to other courses
- 12) What proportion of the lectures did you attend?

For each question students were required to assign a mark from 1 (very poor) to 5 (very good). The results of such assessment is graphically summarised in the following:

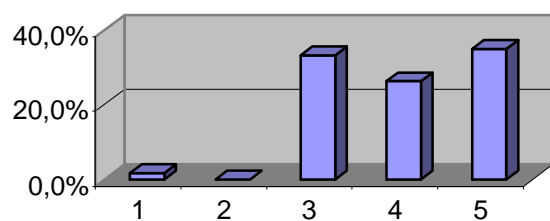
Q1: Were the course aims made clear at the start?



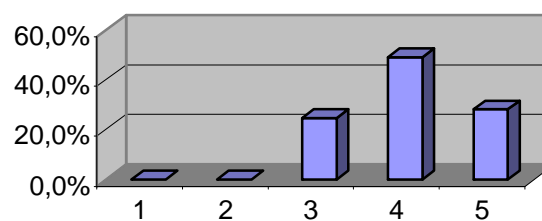
Q2: Were the lectures well prepared and in logical order?



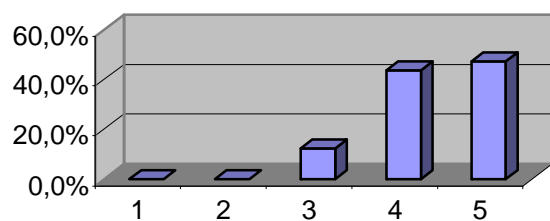
Q3: Was the course starting point at the right level?



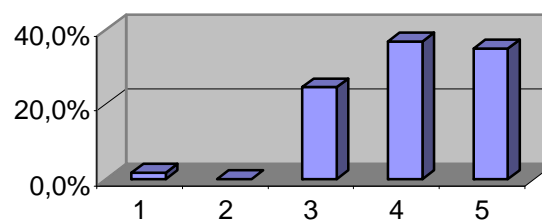
Q4: Were slides/overheads adequate and well prepared?



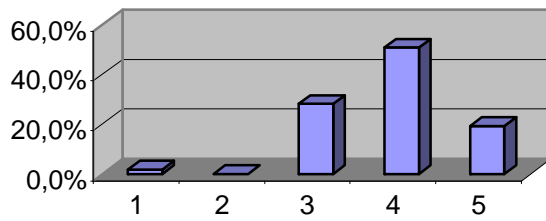
Q5: Was the subject matter clearly explained?



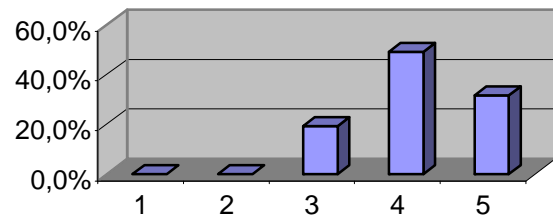
Q6: Were the tutorials useful to make the lectures clearer?



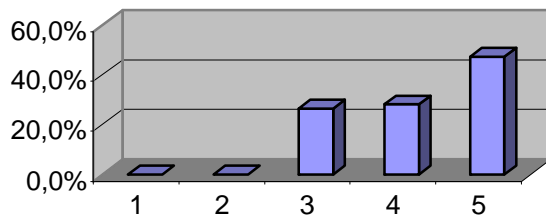
Q7: Was the material covered relevant to your studies?



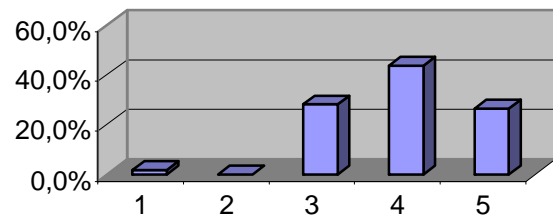
Q8: Were the lecturers responsive to questions?



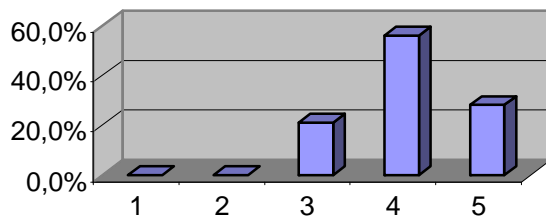
Q9: Did the lecturers project enthusiasm about the course?



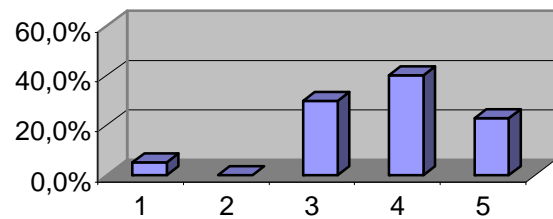
Q10: Was the lecturers' teaching very good overall?



Q11: Total work load compared to other courses



Q12: What proportion of the lectures did you attend?



These results show that the course has been positively evaluated by the vast majority of students, who have indicated only some criticism on the starting point of the course, suggesting to spend some more time on fundamentals.

1.6 Plans for the next courses

The second Prodes course for students will be held again at the University of Palermo in the period March-July 2010.

Given the enthusiastic response of students and the availability of structures and people, the course will likely be continued as optional course in the Chemical, Environmental and Management Engineering degrees in the years following the end of Prodes project.

Annex 1.1 List of students attending the course


<i>Master Degree in Chemical Engineering</i>	
Name	e-mail address
Alaimo Laura	alaimolaura@gmail.com
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Raspanti Antonino	antonino.raspanti@gmail.com
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Sabatino Simona	simonas86@libero.it
Salvo Rosangela	rosangelasalvo@hotmail.it
Sironi Guido	guido.sironi@libero.it
Tedesco Michele	m.tedesco@studenti.unipa.it
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Sanfilippo Maddalena	paddu87@hotmail.it
Silvia Palano	edera88@hotmail.it
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Annex 1.2. Course advertisement






Promotion of
Renewable Energy
for Water production
through Desalination








Università degli Studi di Palermo
Dipartimento di Ingegneria Chimica dei Processi e dei Materiali

Processi di Dissalazione con Energie Rinnovabili

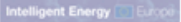
Contenuti del corso:

1. Introduzione.
2. Processi di dissalazione convenzionali: termici e a membrana.
3. Energie rinnovabili utilizzabili in accoppiamento con processi di dissalazione.
4. Energie rinnovabili e dissalazione:
 - Unità di dissalazione solare semplici: "Solar stills",
 - Processi di dissalazione termica alimentati da energia solare,
 - Processi di dissalazione a membrane alimentati da energia solare fotovoltaica,
 - Processi di dissalazione solare per piccole comunità attraverso processi di Umidificazione/De-Umidificazione e di Distillazione a Membrana,
 - Accumulo di energia termica tramite l'uso di "Solar ponds",
 - Processi di dissalazione che utilizzano energia eolica.
5. Cenni di progettazione degli impianti di dissalazione che utilizzano energie rinnovabili.
6. Analisi dei costi e sostenibilità ambientale dei processi di dissalazione che utilizzano energie rinnovabili.
7. Esercitazioni pratiche sui contenuti trattati durante il corso.


Per informazioni contattare il Prof. Giorgio Micale. E-mail: micale@dicpm.unipa.it




Promotion of Renewable Energy for Water
production through Desalination



Annex 1.3 Course's certificate of attendance

Promotion of Renewable
Energies for Water Production
through Desalination





Università degli Studi di Palermo
Dipartimento di Ingegneria, Chimica dei Processi e dei Materiali

Attestato


Si attesta che l'allievo ingegnere Laura Malino ha frequentato il
Corso di Renewable Energies for Water Production through
Desalination ; svolto presso la Facoltà di Ingegneria dell'Università
degli Studi di Palermo nel periodo Marzo - Giugno 2009 per 40 ore
totali.


Il Responsabile del Corso
Prof. Ing. Giorgio Misale

Palermo addì 23 Luglio 2009


PRODES project is supported by
Intelligent Energy  Europe


Annex 1.4. Students' assessment form






Promotion of
Renewable Energy
for Water production
through Desalination







FACULTY OF ENGINEERING - COURSE QUESTIONNAIRE

Department: *Dipartimento di Ingegneria dei Processi e dei Materiali, Università di Palermo (DICPM-UNIPA)*

Course: *Desalination Powered by Renewable Energy (March-June 2009)*

To help us adapt our teaching methods to student needs, you are asked to give an assessment of the following aspects of the above course by putting a tick in the appropriate right-hand column.	Yes					No				
	5	4	3	2	1					
1. Were the course aims made clear at the start?										
2. Were the lectures well prepared and in logical order?										
3. Was the course starting point at the right level?										
4. Were slides/overheads adequate and well prepared?										
5. Was the subject matter clearly explained?										
6. Were the tutorials useful to make the lectures clearer?										
7. Was the material covered relevant to your studies?										
8. Were the lecturers responsive to questions?										
9. Did the lecturers project enthusiasm about the course?										
10. Was the lecturers' teaching very good overall?										
	high					low				
11. Total work load compared to other courses.										
	all					none				
12. What proportion of the lectures did you attend?										
Comments (do not leave blank this space: you have to leave at least two comments or suggestions):										

2 Course in Spain

2.1 CIESOL Master Course on Solar Energy

Plataforma Solar de Almería (PSA) belongs to the governmental institution CIEMAT (Centre for Energy, Environment and Technology Research). Together with the University of Almería, CIEMAT established CIESOL, a joint centre for research, development, teaching and dissemination of different applications of solar energy. Amongst the activities of CIESOL is the organization of a Master Course on Solar Energy which is given by lecturers from both PSA-CIEMAT and UAL. The Course has 535 hours and one of its ten modules is devoted to Applications of Solar Energy to Water Treatment, with full teaching responsibility of PSA-CIEMAT. The third edition of the Master Course started the 17th of October 2008, and lectures were given in the CIESOL building at the University of Almería site, with practical works carried out at the Plataforma Solar de Almería. In the Master Course, desalination with solar energy is thoroughly covered, but not desalination with other renewable energies and some other topics included in the official PRODES course program. Therefore, additional lectures were offered to the students so that they could complete the official PRODES program with those lectures already included in the Master Course. The 21 students of the CIESOL Master Course signed up for the extension and attended the extra lectures to obtain a PRODES course certification.

2.2 PRODES course

The summary of the lectures that conform with the PRODES program is shown in Table 1 (asterisks indicate lectures additional to those of the CIESOL Master Course on Solar Energy). Lectures include theory and tutorials as corresponds to the PRODES official course material. Practical works refer to field work using real installations.

Table 1. Lectures timetable:

<i>Title</i>	<i>Type</i>	<i>Date and duration</i>	<i>Lecturers</i>
Introduction to seawater desalination processes. Definition, fundamentals and historic review	Lecture	15 th May 2009, 2.5hrs	J. Blanco
Conventional technologies for desalination	Lecture	15 th May 2009, 2.5hrs	D. Alarcón
Renewable energies for desalination *	Lecture	25 th June 2009, 2.5 hrs	J. Blanco
Reverse Osmosis powered by Photovoltaic Energy and by Wind/Photovoltaic hybrid Energy *	Lecture	25 th June 2009, 2.5 hrs	G. Zaragoza
Solar Stills	Lecture	23 th May 2009, 1.5hrs	G. Zaragoza

Solar powered Humidification-Dehumidification processes	Lecture	23 th May 2009, 1.5hrs	G. Zaragoza
Solar ORC and Wind energy for RO Desalination *	Lecture	2 th July 2009, 2.5hrs	G. Zaragoza
Solar ponds	Lecture	23 th May 2009, 2hr	G. Zaragoza
Solar thermal processes: MED, MSF	Lecture	16 th May 2009, 2.5hrs	D. Alarcón
Solar thermal processes: MED, MSF	Tutorial	16 th May 2009, 2.5hrs	D. Alarcón
Solar driven desalination systems based on Membrane Distillation	Lecture	22 nd May 2009, 2.5hrs	E. Guillén
Solar driven desalination systems based on Membrane Distillation	Tutorial	22 th May 2009, 2.5hr	E. Guillén
Desalination with other renewable energies *	Lecture	2 nd July 2009, 2.5hrs	J. Blanco
Post-treatments for desalinated water *	Lecture	9 th July 2009, 2.5hr	D. Alarcón
Environmental, economic and sustainability issues. *	Lecture	9 th July 2009, 2.5hrs	J. Blanco
Visit to the solar energy installations of the Desalination group at Plataforma Solar de Almería	Practical	30 th May 2009, 1hr	J. Blanco
Visit to the operating MED desalination plant at Plataforma Solar de Almería	Practical	30 th May 2009, 2hrs	D. Alarcón
Visit to the operating membrane distillation plant at Plataforma Solar de Almería	Practical	30 th May 2009, 2 hrs	E. Guillén

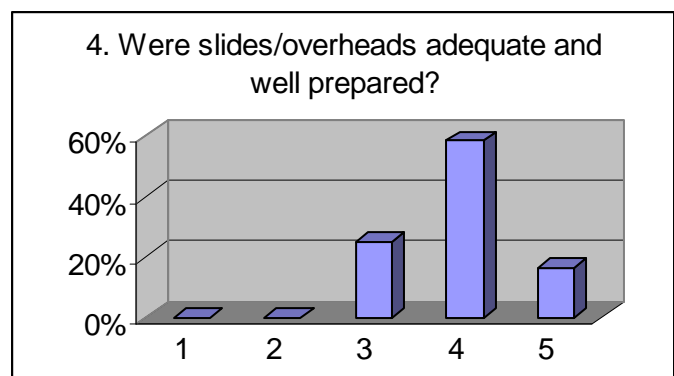
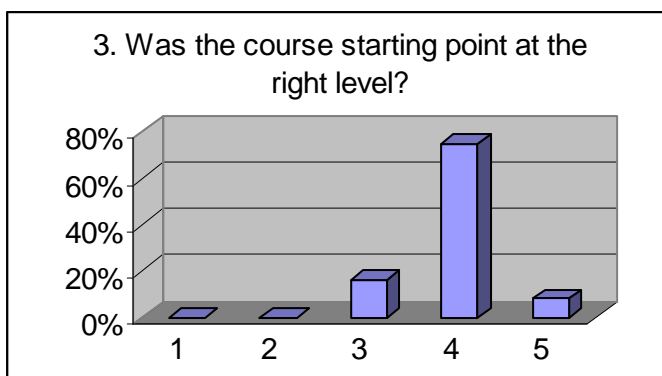
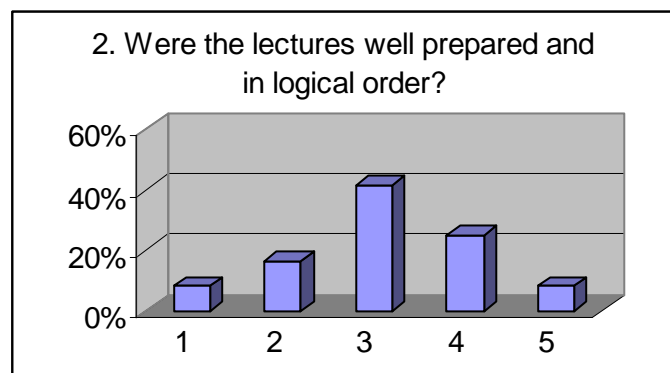
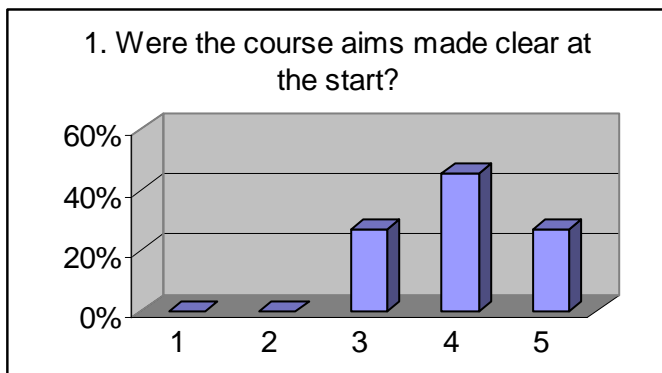
Lectures were given by scientists from PSA-CIEMAT. The field work was organized by dividing students in two groups, so while one group was going through the operation of the MED plant, the other was with that of the MD plant and vice versa. Previously, specific tutorials on the design, parameters and operation of each plant were given.

At the end of the course an anonymous questionnaire (Annex IV) was distributed to the students and collected. The questions reported in the questionnaire were:

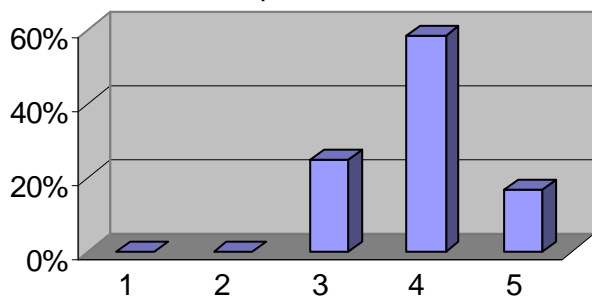
- 1) Were the course aims made clear at the start?
- 2) Were the lectures well prepared and in logical order?
- 3) Was the course starting point at the right level?
- 4) Were slides/overheads adequate and well prepared?
- 5) Was the subject matter clearly explained?

- 6) Were the tutorials useful to make the lectures clearer?
- 7) Was the material covered relevant to your studies?
- 8) Were the lecturers responsive to questions?
- 9) Did the lecturers project enthusiasm about the course?
- 10) Was the lecturers' teaching very good overall?
- 11) Total work load compared to other courses
- 12) What proportion of the lectures did you attend?

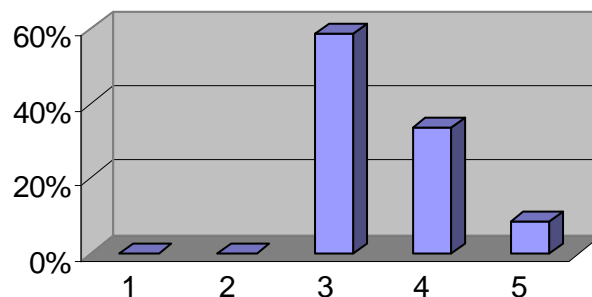
For each question students were required to assign a mark from 1 (very poor) to 5 (very good). The results of such assessment are graphically summarised in the following:



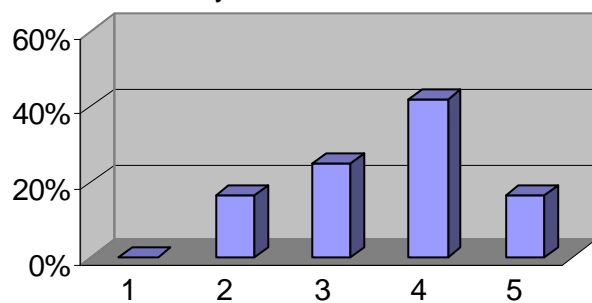
5. Was the subject matter clearly explained?



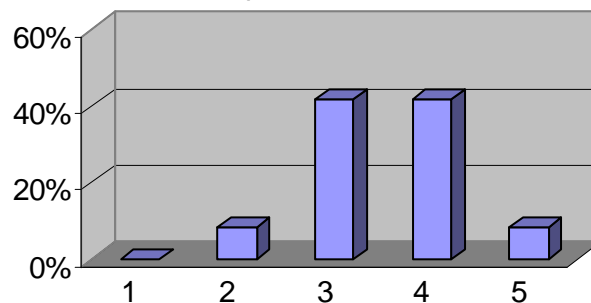
6. Were the tutorials useful to make the lectures clearer?



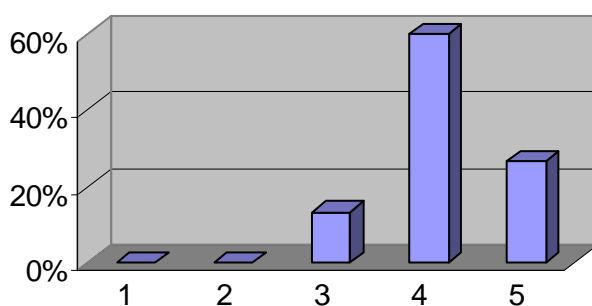
7. Was the material covered relevant to your studies?



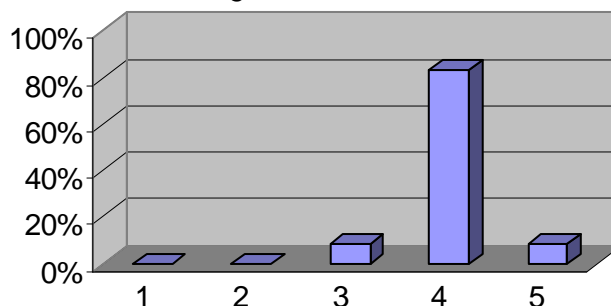
8. Were the lecturers responsive to questions?

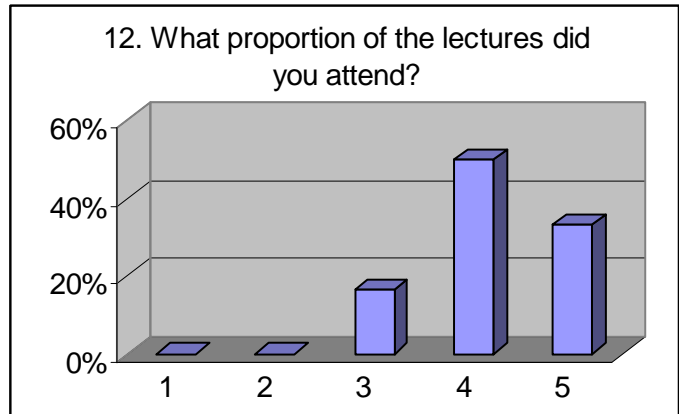
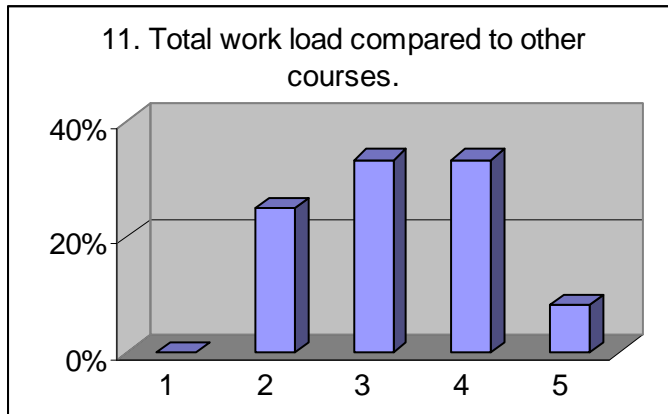


9. Did the lecturers project enthusiasm about the course?



10. Was the lecturers' teaching very good overall?





These results show that the course has been positively evaluated by the majority of students, who have indicated only some criticism on the organization and order of the lectures. This is understandable due to the nature of the course, a mash up of a self-consistent module focused more on solar desalination with some additional lectures added later on.

Annex 2.1. List of students attending the course

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Nikolaus Klamerth	Nikolaus.klamerth@psa.es

Annex 2.2 Course's certificate of attendance




*Plataforma Solar de Almería
Centro de Investigaciones Energéticas
Medioambientales y Tecnológicas (Ciemat)*

Certificate

*This is to certify that has
participated at the course "Renewable Energies for Water Production
through Desalination" delivered by Plataforma Solar de Almería in
cooperation with Ciesol for a total of 40 hours during May-July 2009.*

*The Director of the Course
Dr. Ing. Julián Blanco Galvex*

Tabernas 31 July 2009

PRODES project is supported by
Intelligent Energy  **Europe**

3. Course in Greece

3.1 Introduction







The purpose of the course entitled “Renewable Energy Technologies and Desalination” was to provide graduate and postgraduate students with the latest technological developments in RES, Desalination technologies, and their matching. More specifically, the course instructs students on the basic principle of wind, solar and geothermal energy, conventional desalination and on the state-of-the art of the most promising RES Desalination couplings. CRES has a significant experience, in collaboration with Universities from Greece and abroad, for the elaboration of thesis studies and on the development of courses for graduate or postgraduate students, such as the EUREC MSc Course in co-operation with the National Technical University of Athens (NTUA), which is held every year.

3.2 Implementation of the Course

The 4 days intensive course program was included theoretical lecturers and two visits at the Energy Park, Wind Park of CRES and at a demonstration RES Desalination plant of AUA. The course was organised in Athens, Greece giving to the students a good overview of the possible renewable energy-desalination combinations, including practical training. It has been carried out at AUA premises, at the Central Building of the Agricultural University of Athens. The room has a capacity of 120 people.

The course was advertised by CRES and AUA site and by email to CRES colleagues from the University of Patras, NTUA, Aristotle University, the Technical University of Crete, etc. The duration of the course was 4 days, from 29th of October to 3rd of November 2009.

The course was very successful with around 100 students attending. By the end of the course the students obtained a certificate of attendance. The following thematic areas were analyzed during the course

-  **Solar Energy – Photovoltaic Systems**
-  **Solar Energy – Solar Thermal Systems**
-  **Geothermal Energy**
-  **Wind Energy**
-  **Hybrid systems for Desalination**
-  **Environmental Aspects of RES Systems**

● **Desalination Technologies**

- The Water & the Water Management Need
- Thermal Distillation Technologies
Multi Stage Flash, MSF; Multi Effect Distillation, MED, Vapor Compression, VC
- Membrane Technologies
Electrodialysis (ED/EDR); Reverse Osmosis (RO)
- Other Desalination technologies (Freezing, Membrane distillation, Humidification-Dehumidification, Solar stills, Hybrid systems, Cogeneration – Dual Purpose plants)
- Technology Selection Criteria
- Desalination Economics
- Desalination Market
- Analytical Design of Reverse Osmosis systems

● **RES Desalination, Stand-alone Systems**

- Desalination Technologies using Wind Energy
Mechanical Vapour Compression – Wind Energy
Reverse Osmosis – Wind Energy
- Desalination Technologies using Solar Energy
Solar Thermal Distillation Systems
Reverse Osmosis – Photovoltaics
- Other RES Desalination Applications (Solar Stills, Solar Membrane Distillation, Solar Humidification -Dehumidification,Distillation–Geothermal Energy, Reverse Osmosis-Wave Energy)
- Solar Rankine Cycle Systems for Desalination
- Environmental Aspects of Desalination Systems

● **Practical visits and activities at CRES 3MW Wind Park and CRES Energy Park, Keratea, Attiki**

Presentation of the 3MW CRES Wind park – Visit to a Wind Turbine, (ENERCON 500kW)

Presentation of CRES Energy Park

Visit to the demonstration units:

- Biomass unit
- Geothermal unit
- Hydrogen unit
- Dual Axis Photovoltaic Mover
- PV Pumping unit

- Solar Desiccant Evaporative Cooling System
- Practical Visit to the Autonomous Hybrid (PV/Wind) RO unit for seawater desalination

Tutorials / Practical Exercises

Design of the autonomous PV RO system in Aqaba, Design of the Hybrid RO of CRES

- **Visit to the Solar Rankine Cycle Desalination System of AUA, Marathonas, Attiki**



3.3 Faculty

Colleagues from five departments of CRES are participated for the implementation of the course. These are as follows:


CRES Departments	Lecture's Name
Wind Department	E. Tzen
	Dr. K. Rossis
	S. Tentzerakis
Solar Thermal Energy Department	D. Chasapis
Photovoltaic Department	I. Nikolettatos
Geothermal Energy Department	Dr. K. Karytsas
Hydrogen Department	Dr. E. Varkaraki


Lectures are also provided by the colleagues from the Agricultural University of Athens, Prof. G. Papadakis, and Dr. D. Manolakos in co-operation with Dr. G. Kosmadakis, from Hellas Energy. Upon request, all the presentations are provided to Prof. G. Papadakis for further educational use.

3.4 Course Programme

Promotion of
Renewable Energy
for Water production
through Desalination





4 days Intensive Course on

«Renewable Energy Technologies and Desalination»

Organization

The seminar is organized by the Centre for Renewable Energy Sources and Saving, in co-operation with the Agricultural University of Athens within ProDes Project.

Objectives

The purpose of this course is to provide graduate and postgraduate students with the latest technological developments in both technologies, RES and Desalination, and their matching. More specifically, the course will instruct students on the basic principle of desalination, wind, solar and geothermal energy and the state-of-the art of the most promising RES Desalination couplings.

The program includes a visit at the Energy Park, Wind Park of CRES (PENA, www.penaproject.gr) and to a demonstration RES Desalination plant of AUA. By the end of the course the students will obtain a relevant certificate of participation.

Venue

The seminar will be held at the premises of the Agricultural University of Athens, Central Building, Iera Odos 75, Athens www.aua.gr.

Time of the Seminar

The duration of the seminar is 4 days, from 29th of October to 3rd of November 2009.

Organizers

Eftihia Tzen, Wind Energy Dept., CRES, etzen@cres.gr

Prof. George Papadakis, Agricultural University of Athens, gpap@aua.gr


Dr. Dimitris Manolakos Agricultural University of Athens, dman@aua.gr

Promotion of Renewable Energy for Water Production
through Desalination
ProDes Contract No: IEE/07/781/S12.499059
ProDes Project
www.prodes-project.org


Registration Form

SURNAME:	
FIRST NAME:	
LEVEL OF EDUCATION	BSc <input type="checkbox"/> MSc <input type="checkbox"/>
SPECIALITY	
CONTACT DATA	
ADDRESS	
CITY	
Postcode	
TELEPHONE	
EMAIL	

The participation is free of charge.
 Registration is requested.
 Please send the registration form to etzen@cres.gr or by
 fax : 210 6603301



KANE CRES | CENTRE FOR RENEWABLE ENERGY SOURCES AND SAVING



Agricultural University of Athens




Promotion of
Renewable Energy
for Water production
through Desalination








Intelligent Energy Europe

1st Session - Renewable Energy Sources

Thursday 29-10-2009, 9:00 – 19:00

9:00 - 11:00 Solar Energy – Photovoltaic Systems
I. Nikolettatos, Photovoltaic Energy Dept. CRES
 PV Technology
 Design of PV systems (grid connected, stand-alone systems)
 Economics, Market

11:00 - 12:00 Solar Energy – Solar Thermal Systems
D. Chasapis, Solar Thermal Dept., CRES
 Solar thermal systems
 Economics, Market

Coffee Break

12:30 – 13:30 Geothermal Energy
Dr. K. Karytsas, Geothermal Energy Dept, CRES
 Geothermal Systems- Low, Medium & High Enthalpy systems
 Economics, Market

13:30: - 15:30 Wind Energy
S. Tentzerakis, Wind Energy Dept. CRES
 Wind Turbine Technology
 Design & Performance of VWT
 Economics, Market

Break – Light Lunch

16:30 – 17:30 Hybrid systems for Desalination
Prof. G. Papadakis, Agricultural University of Athens

17:30 – 19:00 Environmental Aspects of RES Systems
I. Nikolettatos, E. Tzen, S.Tentzerakis, KATIE

Discussion

2nd Session - Desalination Technologies, RES Desalination

Friday 30-10-2009, 9:00 – 19:00

9:00 –12:00 Desalination Technologies
E. Tzen, Wind Energy Dept, CRES
 The Water & the Water Management Need
Thermal Distillation Technologies
 Multi Stage Flash, MSF; Multi Effect Distillation, MED
 Vapor Compression, VC
Membrane Technologies
 Electrodialysis(ED/EDR); Reverse Osmosis (RO)
Other Desalination technologies (Freezing, Membrane distillation, Humidification- Dehumidification, Solar stills, Hybrid systems, Cogeneration – Dual Purpose plants)
Technology Selection Criteria
Desalination Economics
Desalination Market
Analytical Design of Reverse Osmosis systems

Coffee Break

12:30–16:00 RES Desalination, Stand-alone Systems
E. Tzen, Wind Energy Dept, CRES
Desalination Technologies using Wind Energy
 Mechanical Vapour Compression – Wind Energy
 Reverse Osmosis – Wind Energy
Desalination Technologies using Solar Energy
 Solar Thermal Distillation Systems
 Reverse Osmosis - Photovoltaics
Other RES Desalination Applications (Solar Stills, Solar Membrane Distillation, Solar Humidification - Dehumidification, Distillation - Geothermal Energy, Reverse Osmosis - Wave Energy)


Analytical Program



KATIE | CENTRE FOR RENEWABLE
ENERGY SOURCES AND SAVING



Agricultural University of Athens





Promotion of
Renewable Energy
for Water production
through Desalination




☐ salt
☐ brack
☐ water

2nd Session - Desalination Technologies, RES Desalination (cont.)

Friday 30-10-2009, 9:00 – 19:00

Break – Light Lunch

17:00 – 18:00 Solar Rankine Cycle Systems for Desalination
Dr. D. Manolakos, Agricultural University of Athens

18:00 – 19:00 Environmental Aspects of Desalination Systems
E. Tzen, Wind Energy Dept, CRES
 Pre-treatment procedures
 Post-treatment procedures
 Brine Disposal Issues

Discussion

3rd Session - Practical Training & Tutorial

Monday 2-11-2009, 9:00 – 19:00

Practical visits and activities at CRES 3MW Wind Park and CRES Energy Park, Keratea, Attiki

Presentation of the 3MW CRES Wind park – Visit to a Wind Turbine
Dr K. Rossis, Wind Energy Dept, CRES

Presentation of CRES Energy Park
E. Tzen, Wind Energy Dept, CRES
Dr. E. Varkaraki, Hydrogen Dept, CRES



Visit to the demonstration units

Biomass unit
 Geothermal unit
 Hydrogen unit
 Dual Axis Photovoltaic Mover
 PV Pumping unit
 Solar Desiccant Evaporative Cooling System


Practical Visit to the Autonomous Hybrid (PV/Wind) RO unit for seawater desalination

Tutorials / Practical Exercises

Design of the autonomous PV RO system in Aqaba, Design of the Hybrid (PV/Wind) RO of CRES






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ENERGY SOURCES AND SAVING



Agricultural University of Athens

3.5 Participants

The number of the participants was 98 students from several Universities of Greece. Students came from the National Technical University of Athens (NTUA), University of Patras, Technical University of Patras, Technical University of Crete, Technical Institute of Athens, Technical Institute of Pireaus, Agricultural University (AUA), University of Sussex, etc. The level of education was graduate and postgraduate. Several of the students were in elaboration of their thesis on RES desalination, so the interest was very high.

List of Participants

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87	MARGARONIS Dimitris	TEI of Athens	BSc	margisam@gmail.com
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97	STATHOPOULOS Eleftherios	AUA	BSC	akiss7@hotmail.com
98	PASISIS Ioannis	AUA	MSC	pirate2000gr@hotmail.com

3.6 Lecturers' comments and feedback on the course

CRES and AUA faculty are attending the course with enthusiastic response with regards to the topic and the course structure proposed. The course has been organised with a good balance between theory and practice. The lectures in all the fields are provided a general overview of the technologies, technical part, applications, economics, market and applications. The students have the opportunity to discuss with experts from all the fields and in several cases they ask for further assistance on their thesis studies. In some of the lectures (photovoltaic, General Desalination I lectures), part of the theory analysis should be reduced and replaced by more practical knowledge (for instance more design examples).

3.7 Students' feedback on the course

The practical tutorials, regarding the design of the autonomous RES desalination plants and the visits to the RES and desalination plants pilot units and to the 500 kW wind turbine, were the most impressed part of the courses for the students. As concluded from the assessment forms and from discussions with the students, they were enthusiastic and pleasant with the opportunity to participate in a seminar regarding RES Desalination (not very common subject at least for Greece).

As they mention, the only problem with their attendance was that they have to be absent from their Universities and it was difficult for them to spend so many days out from their lessons.

Annex 3.1: Photos from the Course and the Visits

Photos from the theoretical course



Photos from CRES Wind Park, Energy Park







4. Course in Portugal

4.1 LNEG background in Renewables and Desalination

From the early 80's, research in Renewable Energies became one of the main activities of LNEG (former INETI), a public research institute created in the late 70's. The development of research activities in different vectors of renewable energies, wind, wave, biomass or solar, has crossed the field of desalination in different projects, mainly in its connection with solar thermal or solar PV technologies (solar pond, small RO-PV unit, humidification/dehumidification, solar fed double effect heat pump coupled to MED process, Organic Rankine cycle for heat and power purposes in desalination).

Together with research activities, LNEG has long promoted training courses in different fields of renewable energies, both to technical, professional or scholarship audiences. One of the most recent examples of such activities is the participation of LNEG in the Master in Energy & Environment Engineering of the Sciences College of Lisbon University.

4.2 Justification of the course

While the teaching of renewable energy sciences is becoming widespread within engineering courses programmes, desalination has not been treated yet at University level.

The collaboration of LNEG in the Master in Energy & Environment Engineering of the Sciences College of Lisbon University established the opportunity to offer classes, within the framework of PRODES project, on Desalination technologies and their ability to be linked with different renewable energy technologies, has previewed in WP3 of the project.

Considering the country's geographical potential for the use of desalination, with the southern region of Algarve being the one gathering the major potential both from the side of water resources (existence of saline intrusion problems, high seasonal loads, etc) and economic activities (tourism is the main economic activity), the course is also being offered to students of the Master in Mechanical Engineering - Energy & Building, at the University of Algarve.

4.3 Implementation of the course

The first edition of the course took place throughout the first semester of 2009/2010, both at LNEG and FCT/UL facilities, integrated in the Master in Energy & Environment Engineering of the Faculty of Sciences of the University of Lisbon.



Fig.1 INETI – Solar XXI Building



Fig.2 Faculty of Sciences-UL

The course has been advertised by leaflet disseminated in the University by the head of the Master programme.

The course structure followed the programme developed in Task 3.2, yet shortened considering both the overlapping of RE issues and the available time load for PRODES classes, provided in ten weekly 2 hr classes.

Table 1. Lectures timetable:

<i>Lecture Argument</i>	<i>Type of lecture</i>	<i>Date and duration</i>	<i>Lecturers</i>
Introduction Conventional desalination processes and technologies.	Theoretical	24 th September 2009, 2hrs	P. Horta
Renewable energies in relation to desalination Other renewable energy sources and desalination	Theoretical	1 st October 2009, 2hrs	P. Horta
Solar Stills Solar Ponds Solar Thermal Membrane Distillation	Theoretical	8 th October 2009, 2hrs	P. Horta
High capacity solar thermal distillation Solar thermal humidification/dehumidification	Theoretical	15 th October 2009, 2hrs	P. Horta
Design and operation of desalination plants powered by renewable energy	Theoretical	29 th October 2009, 2hrs	P. Horta
Mass and energy balances in thermal desalination processes, with basic design	Tutorial	5 th November 2009, 2hr	P. Horta

Lecture Argument	Type of lecture	Date and duration	Lecturers
Design of low temperature ($T < 80^{\circ}\text{C}$) solar thermal fields to be coupled to a membrane distillation / humidification-dehumidification desalination system Design of intermediate ($80^{\circ}\text{C} < T < 200^{\circ}\text{C}$) solar thermal fields to be coupled to a multi-effect distillation (MED) plant	Tutorial	12 th November 2009, 2hrs	J. Farinha Mendes
Solar photovoltaic and desalination Process design of a conventional membrane desalination process (RO) Design of a solar photovoltaic field to be coupled to a RO desalination plant	Tutorial	26 th November 2009, 2hr	P. Horta
Wind energy and desalination Design of a wind energy field to be coupled to a RO desalination plant	Tutorial	3 rd December 2009, 2hrs	P. Horta
Economic and sustainability issues of desalination powered by renewable energy Overview of demonstration installations.	Theoretical	10 th December 2009, 2hr	P. Horta

The course was attended by a maximum of 26 students. The attendance statistics is represented in figure 2.

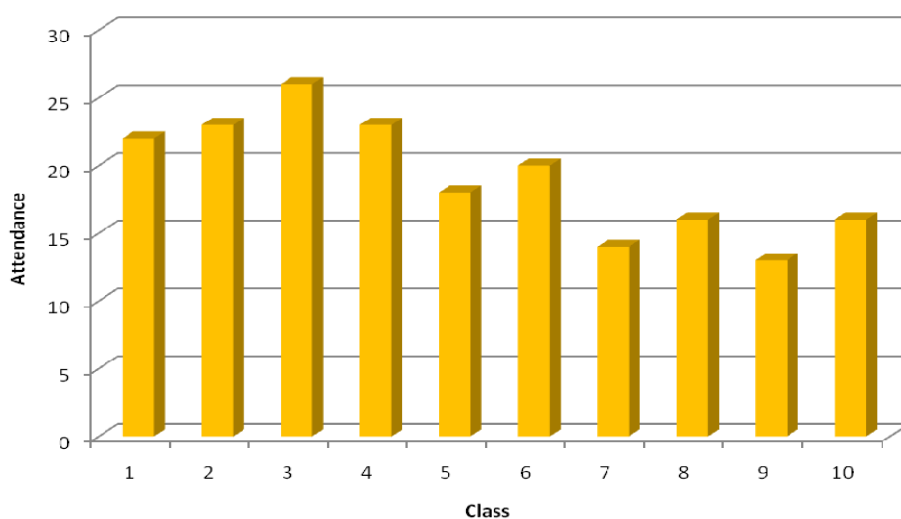


Fig. 2 Attendance statistic Lisbon course



Fig.3 – PRODES lectures at Lisbon

PRODES course attendance was credited with 3 ECTS credits (together with another optional lecture for the 2nd semester, to be delivered by the University), upon a final evaluation consisting on a practical final work.

This final work has the objective of designing a RE+Desalination plant under one of three different situations:

- water feeding of a 5 star hotel with Golf course and 100 bedrooms;
- water feeding of an isolated community (without electric grid) with 25 inhabitants;
- water feeding for a 50000 inhabitants city.

The choice of location, RE technology, layout and Desalination technology is free. The works are to be developed in groups with 2/3 members, and will be presented by March 1st 2010. A total of 10 groups were formed, assuring an even distribution of themes.

4.4 Lecturers' comments and feedback on the course

The PRODES course raised a strong interest among the students, mainly due to the novelty of the desalination topics.

4.5 Students' feedback on the course:

By the time of final works presentation, an inquiry will be distributed among all the students.

4.6 Plans for the next courses

The second Prodes course for students will be held at Algarve, in the week 22-26 February 2010.

The course will follow a 5 X 6 hr programme, following the topics defined in PRODES U-course programme.