



European Desalination Society

Desalination with Solar Energy

A 4-day intensive course

May 10–13, 2016, Almería, Spain



Introduction

Desalination of sea and brackish water is a common technique to alleviate the increasing shortage of fresh water in many areas of the world today. Nonetheless, desalination processes require large quantities of energy, so their implementation is jeopardized by a significant environmental impact if fossil fuels are used. In addition, the cost of the different desalination techniques is very closely linked to the costs of energy. Therefore, in a context of continuously rising energy costs and with the impending exhaustion of the conventional energy resources, the development of desalination technologies associated with the use of renewable energies is a very attractive and promising prospect. This is especially true in the case of solar energy, as the regions with greater water shortages tend to be those with higher solar radiation.

Objectives

The general purpose of this 4-day intensive course is to provide experts, professionals and postgraduate students from all around the world with the latest knowledge of the different existing technologies involving the use of solar energy to drive desalination techniques. More specifically, the course will instruct scientists and technicians on the basic principles of desalination using solar energy, the state of the art of the most promising technologies and the experiences acquired so far. Theory lessons will be complemented with visits to the test facilities of Plataforma Solar de Almería operating on solar power production and desalination, which are the most advanced in the Mediterranean area.

What would you learn attending this course?

Attendants to this course will course will be offered:

- A complete review of the current technological status (main components and performance features) and worldwide development of all solar energy technologies for power production (photovoltaics and CSP).
- A complete review of the current technological status and worldwide development of solar technologies for thermal energy collection and supply in the whole temperature range:
 - Flat plat collectors (low temperature)
 - Parabolic trough and linear Fresnel (medium temperature)
 - Tower (central receiver) technologies (high temperature)
- A complete review of conventional and innovative desalination technologies, suitable to be coupled with solar energy.
- A full analysis of cost status for both power/energy and water production with both conventional and solar energy technologies.

They will understand:

- How the thermal storage can convert uncontrollable solar energy into full reliable and dispatchable continuous energy/power.
- Why the nominal installed power should never be used to compare different renewable energy facilities.
- Why despite the strong reduction of cost on PV, this technology cannot solve all problems when dealing with solar desalination.
- All reasons and arguments that justify the necessity of developing suitable and cost effective solar desalination technologies.

And, also, they will learn:

- How to design and assess the performance of static solar collector fields to provide low temperature process heat for specific thermal desalination technologies.
- How to calculate and design parabolic trough solar fields to provide process heat to MED or MSF thermal desalination processes.
- How to design and size solar PV fields for SWRO applications.
- How to select among different PV technologies to specific projects.
- How to assess the water cost of different desalination processes when driven by solar energies.

Venue

The course will take place at one of the best hotels in the centre of Almeria, and one day will be spent on a technical visit to the operating facilities of Plataforma Solar de Almeria (PSA). This research centre, belonging to the public research institution CIEMAT, is one of the biggest and most complete facilities for the research, testing and development of solar technologies and their applications. It is located near the village of Tabernas, about 35 km from Almeria city.



Almeria is a sun-baked province located in the far Southeast corner of the Iberian Peninsula, with the most hours of sun-shine and lowest rainfall in Europe. As a result of this climate, much of the province is comprised of semi-arid desert-like landscape and much of the area is a sparsely populated wilderness. Almeria's skies, with an annual average of 3,000 hours of sunshine, are also the clearest in Europe. This hot climate and the natural protective barrier of Sierra de Gádor means that Almeria is one of the most productive agricultural zones in Europe, with more than 10,000 ha of land cultivated commercially for fruit, vegetables and flowers. Almeria is the location of one of Andalucía's most outstanding wildlife areas and its largest coastal reserve, the Cabo de Gata-Níjar Natural Park.



The provincial capital and port of Almería is overlooked by a vast, sprawling Moorish citadel, the Alcazaba, monument finished in the XI century and the largest Muslim military fortress in Europe.



Also well worth exploring is Almería's old town, peppered with interesting monuments, including a cathedral with an impressive Gothic interior, a 300-year-old hospital and great tapas bars. In addition, a large number of very impressive beaches and modern tourist resorts attract the visitors to the province year round.



The gorgeous city of Granada is located very close to Almeria. Many daily buses and trains do the trip from Almeria in about two hours. The visit of world-class monuments such as the Alhambra (in addition to many other monuments), is really worth to be consider and would deserve a full additional day (please, notice that it is highly recommended to acquire the Alhambra tickets in advance by internet; you can do it at the official site here).



Lecturers:

The course will be given by researchers and scientists from Plataforma Solar de Almería (CIEMAT-PSA):

- **Dr. Ing. Julián Blanco.** Course director. Associate Director of PSA and coordinator of EERA JP-CSP. Spanish alternate member of Executive Committee of SolarPACES. Responsible of Solar Desalination Unit of PSA from 2002 to 2013. Large experience in the coordination and development of international R&D projects. Author of 10 books, 24 chapters, 86 scientific papers and more than 180 contributions to International Congresses and Symposiums. Author of 5 patents. He was also awarded with the “Grand European Prix for Innovation Award”, in 2004.
- **Dr. Diego-César Alarcón-Padilla.** Head of Solar Desalination Unit of CIEMAT and Operating Agent of SolarPACES Task VI (Solar Energy and Water Processes and Applications). Coordinator of the Sub-programme STE+D (Solar Thermal Electricity + Desalination) within EERA CSP (Concentrating Solar Power) Joint Programme. Senior researcher with extensive experience in European R&D Pro-

jects related with the combination of solar thermal energy with desalination processes. He has published more than 35 scientific papers in the field of solar energy and water treatment, co-author of three books in the field of solar desalination.

- **Dr. Guillermo Zaragoza.** Coordinator of the Renewable Energy Desalination Action Group of the European Innovation Partnership on Water (European Commission). Senior researcher with extensive working experience in the application of renewable energy to desalination, including solar distillation and its combination with agriculture and water treatment. He has participated in several European R&D Projects on solar energy and desalination. Has published more than 45 scientific papers and co-authored three books in the subject.

Course Program

DAY 1 Introduction to Solar Energy and Desalination

08:30–09:00	Registration and documents distribution
09:00–09:15	Opening and Introduction to the course (Miriam Balaban / Julian Blanco)
09:15–10:00	Fundamentals of Solar Energy (Diego Alarcón) Sun-Earth relationships. Basic equations Solar radiation components and distribution Solar radiation measurement devices Solar radiometric databases Solar radiation prediction based on satellite images
10:00–11:00	Water desalination: Fundamentals, conventional technologies and research trends (Diego Alarcón) Basic equations and relevant parameters Thermal desalination: multi-stage flash evaporation (once-through and brine recirculation), multi-effect distillation (LT-MED and TVC-MED) and mechanical vapor compression Membrane desalination: Reverse osmosis and electrodialysis Research trends: forward osmosis, capacitive deionization, etc. Current world outlook
11:00–11:30	Coffee break
11:30–12:30	Low temperature solar collector fundamentals (Diego Alarcón) Static solar collectors: flat plate, CPC and evacuated tube collectors Efficiency assessment of a static solar collector Computer aided design of static solar collector fields Static solar collector field calculation. Development and explanation of static solar collector calculations (energy delivered, solar field dimensioning, etc) considering the different technologies available

- 12:30–13:30 PV fundamentals (Julian Blanco)
 Performance and current status of different PV technologies: cell efficiency and cost evolution.
 PV array characteristics: solar radiation and temperature influence
 Largest existing PV plants worldwide. Capacity factor of PV compared with CSP plants
 Sun tracking and concentrating PV: status and latest developments
 Practical exercises. How to compare offers based on different PV technologies.
- 13:30–14:30 Lunch (at hotel Tryp Indalo)
- 15:00–16:00 Linear focusing Concentrating solar technologies (Julian Blanco)
 Medium temperature solar thermal collectors: Parabolic troughs and linear Fresnel technologies. Main characteristics and technical data.
 Parabolic troughs commercial power plants: history and current status. Commercial Linear Fresnel plants: worldwide status. Energy storage in solar plants: molten salt State of the Art technology.
- 16:00–17:00 Point focusing Concentrating solar technologies (Julian Blanco)
 Central Receiver system: main characteristics & basic components.
 Commercial tower power plants: history and current status. Latest developments of central receiver systems and current worldwide status. Parabolic troughs versus tower technology status and assessment.
- Free dinner at the hotel (from 20:00 till 23:00)

DAY 2 Solar Desalination. Technological status

- 09:00–10:00 Photovoltaic and reverse osmosis (Guillermo Zaragoza)
 Conventional RO systems
 Energy recovery
 Characteristics and energy performance
 Pilot plant experiences
 Costs and conclusions
- 10:00–11:00 Low capacity solar thermal distillation systems I (Guillermo Zaragoza)
 Solar Stills.
 Humidification – Dehumidification (HDH) systems
 Pilot plants and commercial products
- 11:00–11:30 Coffee break
- 11:30–12:30 Low capacity solar thermal distillation systems II: Membrane Distillation (Guillermo Zaragoza)
 Fundamentals and configurations
 Membranes and modules
 Energy balance and coupling with solar energy
 Experience with MD prototypes

- 12:30–13:30 Desalination Concentrate Management (Guillermo Zaragoza)
 Brine disposal
 Salinity gradient solar ponds
 Brine minimization towards zero liquid discharge
 Product recovery and energy generation from brines
- 13:30–14:30 Lunch (at hotel Tryp Indalo)
- 15:00–16:00 High capacity solar thermal distillation systems.
 The PSA experience (Diego Alarcón)
 Review of worldwide experiences in indirect solar thermal desalination. The STD Project: LT-MED & TVC-MED powered by parabolic trough solar collectors (Phase I). Double-effect absorption heat pumps coupled to multi-effect distillation plants (ABS-MED, Phase II)). The AQUASOL Project: LT-MED powered by CPC static solar collectors. Absorption Heat Pump – MED plants powered by low-aperture parabolic trough collectors.
- 16:00–17:00 Practical exercises. (Diego Alarcón)
 Parabolic trough solar field calculation. Practical case of TVC-MED plant coupled to a parabolic trough solar field. Design procedure of solar field size and configuration considering commercial parabolic trough collectors.
- 17:30 Departure to downtown Almeria (by bus)
- 18:00 Guided visit to old Almeria city
- 20:00 Free time
- 21:00 Dinner in a downtown restaurant
- 23:00 Return to hotel (by bus)

DAY 3 Practical Work and visit at Plataforma Solar de Almeria

- 09:00 Departure from hotel Tryp (by bus)
- 10:00 Arrival to Plataforma Solar de Almeria and welcome
- 10:00–10:30 Welcome and brief introduction of PSA (official PSA video can be seen [here](#))
- 10:30–12:30 Technical visit to solar power production facilities at PSA (central receiver and parabolic trough)
- 12:30–14:30 Detailed technical visit to PSA solar desalination facilities (MED plant, MD pilot plants, CSP+D test-bed)
- 14:30–16:00 Lunch (at Las Eras restaurant in Tabernas)
- 16:00–17:00 Return to Tryp Indalo hotel
- Free dinner at the hotel (from 20:00 till 23:00 h)



Photo group at PSA from a previous course

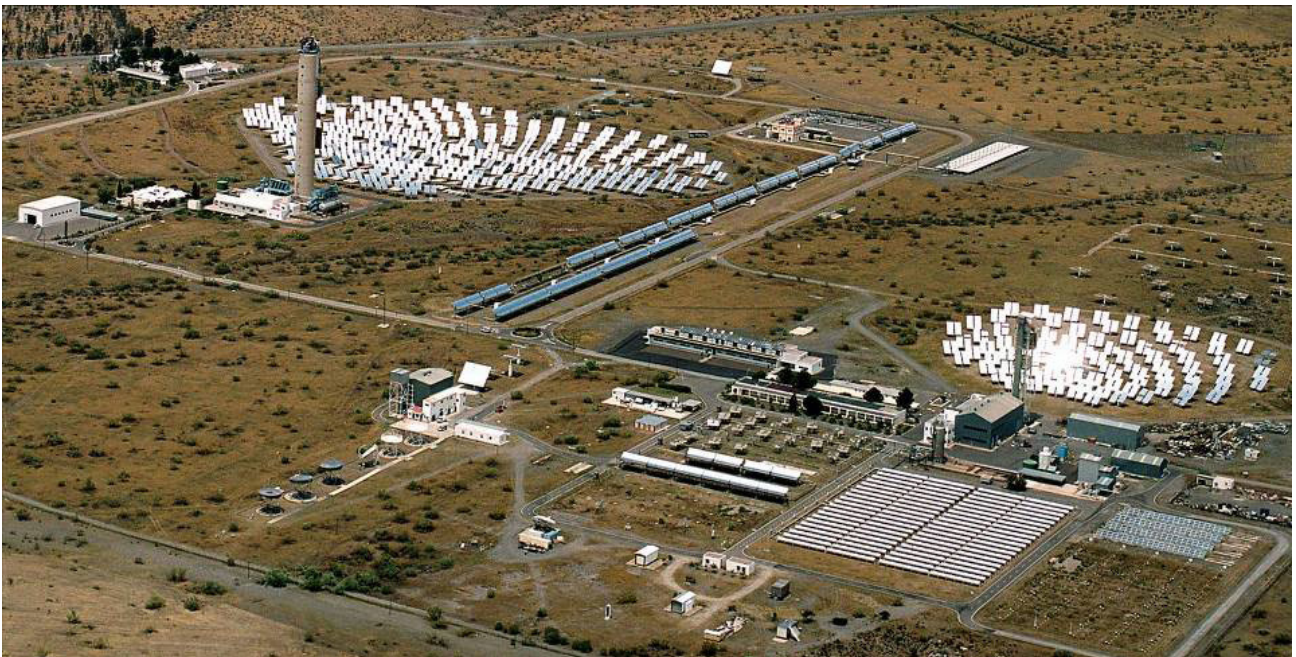
DAY 4 Solar Desalination. Economics and driven forces behind

- 09:00–10:00 Concentrating Solar Power and Desalination (Julian Blanco)
CSP and Desalination: benefits and drawbacks
Power and water configurations: water and power production ratios.
CSP+D case study of Port Safaga (Egypt).
Cooling options assessment. Impact on overall plant performance.
Comparative power consumption and levelized energy and water costs
- 10:00–11:00 Economical aspects of desalination using solar energy (Julian Blanco)
Cost calculation methodology
Seawater reverse osmosis case study analysis
Seawater multi-effect distillation case study analysis
Power generation by parabolic trough plant. Case study analysis
Power generation by photovoltaic plant. Case study analysis
CSP+D cost estimation
Practical exercises
- 11:00–11:30 Coffee break

- 11:30–13:00 Why solar desalination? (Julian Blanco)
The population factor
Current status water and energy problems
The water-energy implications: available options and solutions
Worldwide development of renewables: benefits and reasons behind
Existing tools for renewable deployment
The role of renewables in the 21st century
Final discussion
- 13:00 End of course activities and program

In addition, to those who will not depart immediately:

- 13:30 Lunch (at hotel Tryp Indalo)
Free dinner at the hotel (from 20:00 till 23:00 h)



Plataforma Solar de Almería (PSA) in Tabernas, Almería (Spain)

Desalination with Solar Energy

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May 10–13, 2016, Almería, Spain

Lecturers Dr. Julián Blanco, Dr. Diego-César Alarcón-Padilla, Dr. Guillermo Zaragoza

REGISTRATION FORM

Surname _____ Name _____

Address _____

Country _____ Telephone _____

Fax _____ Email _____

Registration fee

EDS member € 2500

Non-member € 2700

The fee includes 5 nights accommodation, lunches, coffee, dinners, course Workbook and CD.

Payment can be made by:

Credit card

Bank Transfer to be sent to the address below and a copy emailed to us.

Please take care of your own bank charges

Account name: European Desalination Society
Account No. 11863.19

Banca Monte dei Paschi di Siena
67100 L'Aquila, Italy
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