



Ciemat
Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas



*Unidad
de Formación*



European Desalination Society

Desalination with Solar Energy

A 4-day intensive course

September 12–15, 2017, 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. Theoretical lessons will be complemented with practical exercises and visits to the test facilities of Plataforma Solar de Almeria 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 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 Almeria 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 Almeria'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. Former head of the 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, 96 scientific papers and more than 200 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 Projects related with the combination of solar thermal energy with desalination processes. He has published more than 47 scientific papers in the field of solar energy and water treatment, co-author of four books in the field of solar desalination.

- **Dr. Guillermo Zaragoza.** Coordinator of working groups on Renewable Energy Desalination in the European Innovation Partnership on Water (European Commission) and in The European Water Platform (WssTP). Senior researcher in CIEMAT, 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 60 scientific papers and co-authored three books in the subject. He is a member of the board of directors of the EDS.

Course Program Schedule

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	Why solar desalination? (Julian Blanco) Current status water and energy problems. Water-Energy Nexus: available options and solutions. Worldwide development of renewables: benefits and reasons behind. The role of renewables in the 21st century.
10:00–11:00	Fundamentals of Solar Energy (Diego Alarcón) Sun-Earth relationships. Solar radiation components and distribution. Basic equations. Solar radiation measurement devices. Solar radiometric forecast tools.
11:00–11:30	Coffee break
11:30–12:30	Water desalination: Fundamentals, conventional technologies and research trends (Diego Alarcón) Basic equations and relevant parameters. Thermal desalination: multi-stage flash evaporation, multi-effect distillation and vapor compression (mechanical and thermal). Membrane desalination: Reverse osmosis, electrodialysis, forward osmosis and membrane distillation. Current world outlook.
12:30–13:30	Low temperature solar collector fundamentals (Diego Alarcón) Static solar collectors: flat plate, CPC and evacuated tube collectors Efficiency assessment of an individual static solar collector. Computer aided design of static solar collector fields:

thermal performance assessment. Development and explanation of static solar collector calculations (energy delivered, solar field dimensioning, etc.) considering the different technologies available

13:30–14:30 Lunch (at hotel Tryp Indalo)

15:00–16:00 Concentrating solar technologies (Julian Blanco)
Medium temperature solar thermal collectors: Parabolic troughs and Linear Fresnel technologies. Main characteristics and technical data. Thermal energy storage in solar plants. Central Receiver system: main characteristics & basic components. Latest developments of central receiver systems and current worldwide status. Parabolic troughs versus tower technology status and assessment. Worldwide power plant status.

16:00–17:00 PV fundamentals (Julian Blanco)
Performance and current status of different PV technologies: cell efficiency and cost evolution. Largest existing PV plants worldwide. Capacity factor of PV compared with CSP plants. Concentrating PV: status and latest developments.

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: components and analysis of energy consumption. Systems for energy recovery at small-scale. PV-RO characteristics and energy performance. Pilot plant experiences. Global outlook and costs discussion.

10:00–11:00 Practical exercises (Julian Blanco)
PV-RO calculation. Design procedure of solar field size and configuration considering commercial PV panels. Procedure and methodology for commercial PV panel selection.

11:00–11:30 Coffee break

11:30–12:30 Low capacity solar thermal distillation systems I (Guillermo Zaragoza)
Solar stills.
Humidification – Dehumidification (HDH) systems. Pilot plants and commercial products.

12:30–13:30 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.

- 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. Collector technology selection and solar field design criteria for LT-MED systems. Collector technology selection and solar field design criteria for high-temperature MED systems (TVC-MED, ABS-MED and ADS-MED).
- 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 Almeria old city
- 20:30 Dinner in a downtown restaurant
- 23:00 Return to the hotel (by bus)



Photo group at PSA from a previous course

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)	

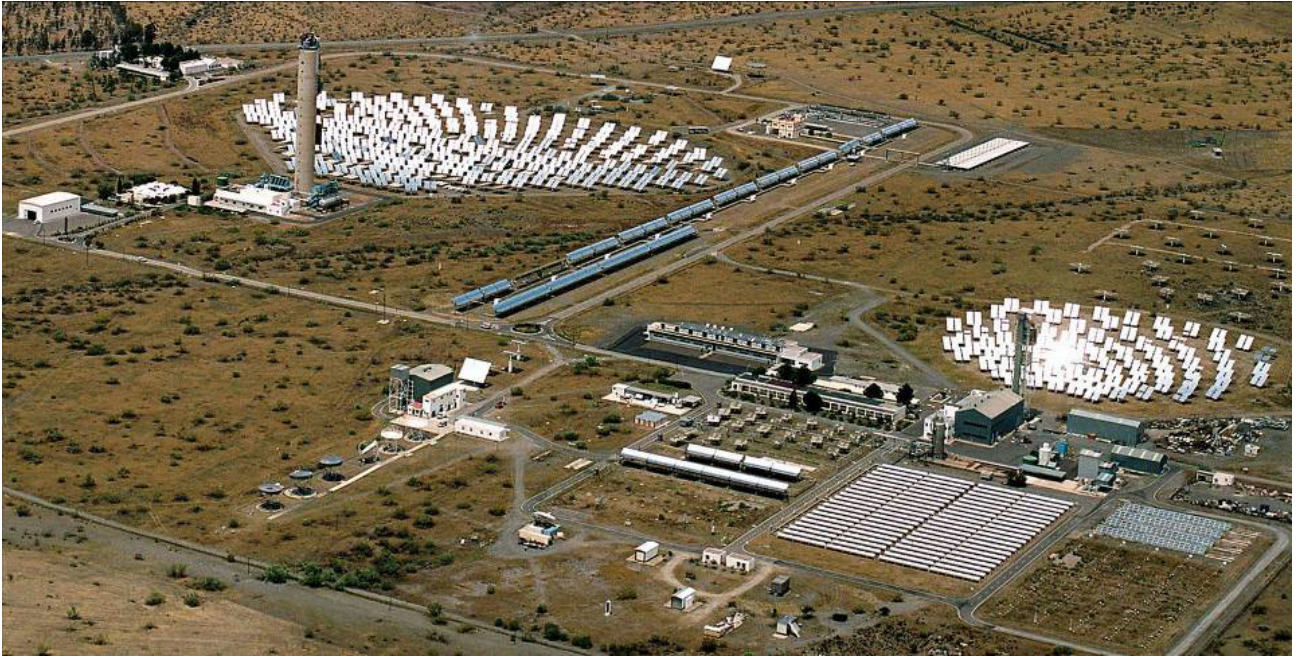
DAY 4 Solar Desalination. Economics and driven forces behind

09:00–10:00	Desalination concentrate management (Guillermo Zaragoza) Brine disposal: options and limitations. Systems for zero liquid discharge and role of solar energy. Product recovery and energy generation from brines. Salinity gradient solar ponds and synergies with desalination.
10:00–11:00	Concentrating solar power and desalination (Julian Blanco) CSP and desalination: benefits and drawbacks. Power and water configurations: water and power production ratios. Cooling options assessment. Impact on overall plant performance. CSP+D case study.
11:00–11:30	Coffee break
11:30–12:30	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.
12:30–13:00	Course closure. Final comments and open 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)



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

Desalination with Solar Energy

A 4-day intensive course

September 12–15, 2017, Almería, Spain

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

PLEASE REGISTER BY AUGUST 15 2017

REGISTRATION FORM

Surname _____ Name _____

Address _____

Country _____ Telephone _____

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Registration fee

	Before August 1, 2017	After August 1, 2017
<input type="checkbox"/> EDS member	€ 2000	€ 2500
<input type="checkbox"/> Non-member	€ 2200	€ 2700
<input type="checkbox"/> Students (document from university)	€ 1800	€ 2000

The fee includes 5 nights accommodation, lunches, coffee, dinners, course Workbook and USB flash drive.

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

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