

PRINCIPLES OF ENERGY STORAGE

5th - 9th June 2017
Madrid (Spain)



COURSE

- Overview of Energy Storage Technologies
- Environmental and Safety Aspects
- Storage in Hydrogen and Hydrides
- Electrochemical Storage (Batteries)
- Thermal Storage
- Compressed Air Energy Storage (CAES)
- Hydro Pumped Storage
- Kinetic Energy Storage (Flywheels)
- Superconducting Magnet Energy Storage (SMES)
- Energy Storage with Supercapacitors
- Grid Integration of Energy Storage Technologies

Complete Course Duration: 30 hours
(25% of the course will take place in CIEMAT Laboratories)



VENUE & SCHEDULE

CIEMAT. Av. Complutense 40, Madrid (Spain)
Mon-Thu: From 9:00h to 18:00h;
Fri: From 9:00h to 15:00h
(The course will be in English language)

INSCRIPTION & ADDITIONAL INFORMATION

Training in Energy and Environment: M^a Carmen Muñoz Ray:
er.ma.bt@ciemat.es (www.ciemat.es)
Phone: +913466748/6295 ; Fax: 913466297

PRICES & CALENDAR

- GENERAL TOPICS + MODULE 1 + MODULE 2 (30h): 1000 €
- GENERAL TOPICS + MODULE 1 (16h): 500 €
- GENERAL TOPICS + MODULE 2 (16h): 500 €

Monday 5 th	Tuesday 6 th	Wednesday 7 th	Thursday 8 th	Friday 9 th
GEN. TOPICS (I)	MODULE 1	GEN. TOPICS (I) GEN. TOPICS (II)	MODULE 2	GEN. TOPICS (II)
MODULE 1	MODULE 1	MODULE 2	MODULE 2	

Reduction of 50% will be provided for residents in Latinamerica and unemployed people (prove required)

DIRECTION & COORDINATION

Direction: Dr. Marcos Lafoz . Division of Electric Engineering
Coordination: Mirian Bravo Taranilla. CIEMAT Training Unit

DOCUMENTATION & CERTIFICATION

Technical documentation will be provided to the attendants as well as a Certificate of Assistance

COURSE AIMED AT

Professionals in the energy sector who want to learn about energy storage technologies, specially their practical and operation details.

The course may also be of interest for people working in institutions related to teaching or researching in this area.



METHODOLOGY

The course will review the fundamentals, technologies and applications of the different technologies of energy storage in one part of lectures based on presentations. The distinguishing character of this course is that comprises some visits to the CIEMAT laboratories to complement the theoretical explanations with practical demonstrations of most of the technologies covered. Moreover, some examples run in practical sessions with simulation will help to understand the particular characteristics of the storage alternatives and their operation when connected to the electric grid.

The course is structured in three modules and participants have three options for attending the course depending on their preferences and time availability (see prices & calendar):

Option A: General Topics (Introduction, Environment and safety, Grid connection) + Module 1 (Hydrogen and Batteries)+ Module 2 (Thermal Storage, CAES, pumped-hydro and fast energy storage).

Option B: General Topics + Module 1

Option C: General Topics + Module 2



Teachers

- | | |
|----------------------------|---------------------------|
| L. García-Tabarés (CIEMAT) | J.M. Amarilla (CSIC) |
| L. Arribas (CIEMAT) | J. Cuenca (CIEMAT) |
| Y. Benito (CIEMAT) | E. Mejuto (CIEMAT) |
| F. J. Saiz (CNH2) | E. Rojas (CIEMAT) |
| F. Leardini (UAM) | J.I. Pérez (UPM) |
| A. Quejido (CIEMAT) | M. Lafoz (CIEMAT) |
| T. González (CIEMAT) | P. Moreno-Torres (CIEMAT) |
| N. Vela (CIEMAT) | G. Navarro (CIEMAT) |
| E. García (IMDEA Energía) | M. Blanco (CIEMAT) |



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Energy Storage is becoming a powerful tool for energy management, since it allows decoupling generation from consumption, performing both under the best conditions or efficiency and cost. The different technologies of energy storage, some competitors, some complementary, being at different stage of development, aim at becoming solutions at different power scales to modify the energy production/consumption scenario.

The goal of this course is to provide a review of the different existing technologies, their present situation and their particular applications, either from a theoretical and a practical approach with demonstrations at the laboratory and examples with a simulation tool for a better understanding of their fundamentals and operation, which provides a distinguishing character to the course. Grid connection schemes and potential effects in it will be also analysed. Furthermore, the course will be also complemented with an introduction to environmental and safety issues. Main factors, which affect their development and implementation such as regulatory, market and environmental aspects, will be finally considered.

The course will review the following technologies:

Chemical Storage in Hydrogen: Gas, liquid and solid states as well as components with a high content of hydrogen (ammonia, methane, methanol or methanoic acid) will be considered as suitable system for hydrogen storage in moving or stationary sources.

Chemical Accumulators (Batteries): They store energy in chemical form and presently they are the most widely used systems in most industrial, transportation or renewable energy generation sectors.

Thermal Storage: Its high capacity allows considering some renewable energies and particularly concentrated solar energy, as manageable within the present energy production scheme.

Compressed Air and Hydro Pumping: They represent massive storage systems that have been used for many years, although there is still space for new developments aimed at increasing their present efficiency.

Fast Energy Storage Systems: With applications where a fast response is critical by themselves or in combination with other technologies. They include storage in Superconducting Magnets, Flywheels and Supercapacitors.

CONTENTS

GENERAL TOPICS

Introduction:

Description of Energy Storage System and their applications.

Environmental and Safety Aspects:

Impacts, challenges and security issues

Grid connection of different technologies:

Frequency and voltage regulation / Power electronics / Hybrid energy storage / Control strategies

MODULE 1

Storage in Hydrogen:

Liquid & Gas H₂; Storage in Metal Hydride; Carbon Materials; Solid Fuels with high H₂ content; Ammonia; Methane and other Organic Compounds.

Electrochemical Storage:

Batteries: Lead Acid; Lithium-ion; Alkaline; Redox-Flow; Laboratory Demonstration

MODULE 2

Thermal Storage:

Thermal storage in solar concentration plants.

Compressed Air (CAES) and Hydro Pumped Storage:

CAES: Fundamentals; Basic parts; Technologies; Commercial applications.

Hydro Pumped Storage: Fundamentals; Basic Parts; Technologies; Commercial Applications; Computer Simulation.

Fast Energy Storage Systems:

Superconducting Magnets Energy Storage (SMES), Flywheels and Supercapacitors: Fundamentals; Basic Parts; Technologies; Commercial Applications; Laboratory Demonstration.

 *Unidad de Formación*