SYLLABUS OF THE ONLINE COURSE ABOUT SOLAR THERMAL POWER PLANTS. TOWER, FRESNEL & DISH

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I. DETAILED PROGRAM OF THE ONLINE COURSE

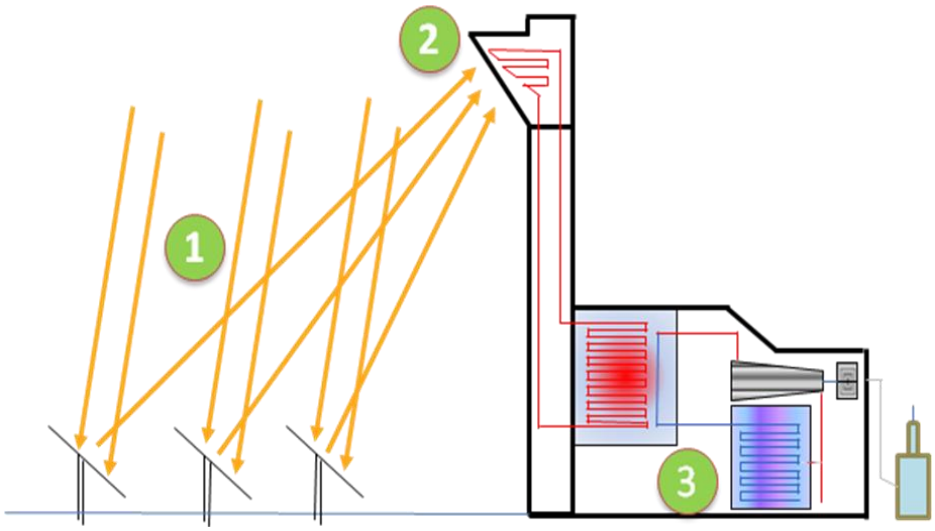
1. GENERAL PURPOSE:

The purpose of this online course is to present the basic principles of the various technologies that currently exist to convert solar radiation into thermal energy at temperatures above 150 °C, delving into three of the technologies: the tower technology, the fresnel technology and the parabolic dish technology, from which we will analyze its operation, components, energy balance and commercial applications.

2. SPECIFIC OBJECTIVES TOWER TECHNOLOGY:

Specific Objective: Tower technology (Central Receiver).

Basic description of the operating principle of the towers technology, depending on the working fluid and its configuration. For each type of plant we will present explanatory diagrams and specific technical characteristics of each. In addition we would include information technologists and operating plants



AGENDA
• Molten salts • Water – steam • Air

<u>Specific Objective</u>: Solar field. Heliostats.

On this point we will add photographs and sketches of real equipment and auxiliary systems (LOC, trackers, hydraulic, etc.)

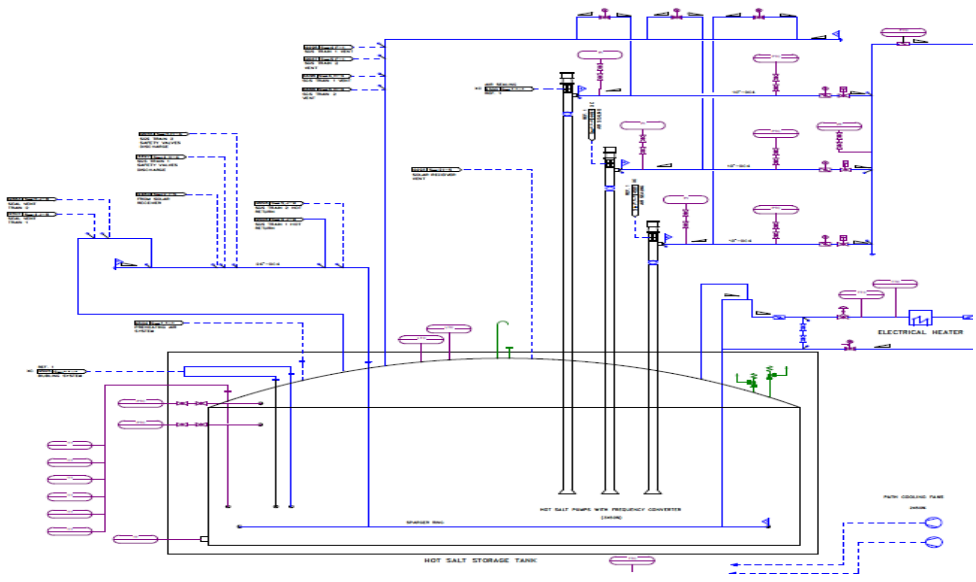
AGENDA
• Main Characteristics • Components • Commercial models

<u>Specific Objective</u>: Central receiver and tower

On this point we will add photographs and sketches of each system

AGENDA
• Design Basis • Types: o Tubular o Volumetric • Performance

<u>Specific Objective</u>: Thermal storage



On this point we will add photos and diagrams, engineering drawings of each of the elements (resistors, distribution rings, instrumentation, etc.)

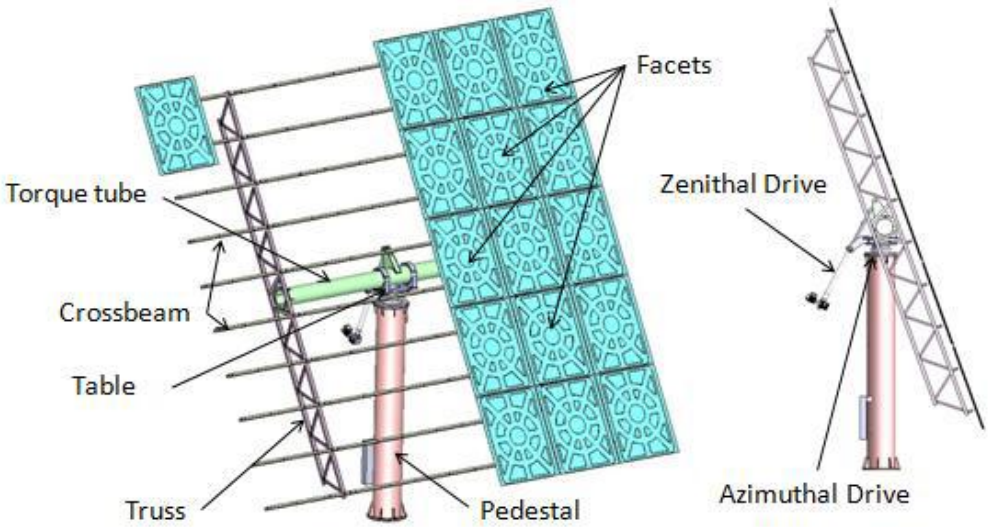
AGENDA
• Design Basis • Main equipment: o Pumps o Tanks o Molten salts

<u>Specific Objective</u>: Power Block

At this point in addition to engineering diagrams we will include real photos of installations and an idea of the main suppliers. We may also include P & IDs and PFDs engineering that give an idea of the process. Also we would include mass and energy balances for the specific conditions of the tower, without going into great detail on the turbine itself.

AGENDA
• Steam Generation System. Design Basis • Steam Turbine • Auxiliary Systems

<u>Specific Objective</u>: Conceptual Design. Solar field. Heliostat field



On this section we will discuss the iterative design process of the solar field and the limits of the technology.

AGENDA
• Layout o Optical Efficiency o Shadows o Atmospheric attenuation • Design procedure • Design limits

<u>Specific Objective</u>: Conceptual Design. Power Block

On this point we will provide several examples of distribution of the power island, in form of drawings and photos, as well as the basic design criteria for the principals systems.

AGENDA
• Layout • Main equipment design

<u>Specific Objective</u>: Conceptual Design. Investment and operation cost

This section will give the student a rough idea of the weights of each item for a typical commercial plant, both investment and operating.

AGENDA
• CAPEX Estimation • OPEX Estimation

<u>Specific Objective</u>: Conceptual Design. Levelized Cost of Electricity (LCOE)

Methodology and typical LCOE calculations with updated estimates.

AGENDA
• Technical Characteristics • Contractual Features • Simulation tool: SAM

<u>Specific Objective</u>: Operation & Maintenance

Basic description of the operation of a Tower Plant.

AGENDA
• Operation modes & strategies • Start-up • Solar field operation • Thermal Storage operation • Shut down

3. SPECIFIC OBJECTIVES PARABOLIC DISH:

Specific Objective:

AGENDA
• Historical evolution • Systems description • Concentrator design • Heat exchanger • Regenerator • Cylinder • Stirling engine • Performance calculations • Solar input • Power output • Performance • System costs estimation

4. SPECIFIC OBJECTIVES LINEAR FRESNEL:

Specific Objective:

AGENDA
• Systems description • Performance calculations • System costs estimation • Commercial development

II. METHODOLOGY

Prior to the start of the week, students will be provided with the text of the various topics.

III. GENERAL REFERENCES

1. Benz, N. et al., 2008.”Advances in Receiver Technology for Parabolic Troughs”. In: Proceedings of 14th International SolarPACES Symposium on Solar Thermal Concentrating Technologies, Las Vegas, EEUU.

2. Duffie, J.A. y Beckman, W.A., 1991, “Solar Engineering of Thermal Processes”. Ed. John Wiley & Sons, (2ª Edición), New York, EEUU. ISBN: 0-471-22371-9.

3. García Casals, X., 2001, “La energía solar térmica de alta temperatura como alternativa a las centrales térmicas convencionales y nucleares

4. Harats, Y., and Kearney, D., 1989, “Advances in Parabolic Trough Technology in the SEGS Plants”, ASME Int. Solar Energy Conference., San Diego, CA.

5. Herrmann, U. y Nava, P., 2008, “Performance of the SKAL-ET collector of the Andasol power plants”. In Proceedings of 14th International SolarPACES Symposium on Solar Thermal Concentrating Technologies, Las Vegas, EEUU.

6. Kelly, B. y Kearney, D., 2006, “Thermal Storage Commercial Plant Design Study for a 2-Tank Indirect Molten Slat System”, Report No. NREL/SR-550-40166, NREL, Colorado