



Introduction to Energy Systems, Vectors, Storage and Generation

LEARNING OBJECTIVES

The objectives of the course are to analyze the entire energy cycle from primary sources to useful effects, based on the definition of energy system, energy vector, energy conversion and transformation. The course aims to provide students with the tools for a correct and exhaustive analysis and assessment of energy systems based on the criteria of energy sustainability.

COURSE DESCRIPTION

In the first part (Lesson 1), in addition to introducing the course, we define the concept of energy system considering the entire energy cycle, we illustrate the elements that compose it and provide the criteria for analysis from a point of view of sustainability.

In the second part (Lessons 2 to 5) we analyze the primary energy sources, classifying them according to sustainability (renewable and non-renewable), providing the main characteristics in terms of availability, potential and possible uses.

In the third part (Lessons 6 to 10), starting from the need for energy transportation and storage, the concept of energy vector is defined, analyzing the main characteristics in terms of energy storage capacity and transportation and of process efficiency currently most used.

In the fourth part (Lessons 11 to 13) we analyze the processes of energy conversion and transformation for the production of energy vectors for final uses.

1 Energy System

- Definition of an energy system
- Characteristics of energy systems
- Analysis of energy systems: set-up an energy analysis in terms of efficiency and effectiveness

2 Primary energy sources (Part I)

- Description of Fossil Fuels (Coal, Oil, Natural gas)
 - ✓ energy characteristics;
 - ✓ emissions
 - ✓ availability;
 - ✓ distribution.

3 Primary energy sources (Part II)

- Nuclear energy



- ✓ energy characteristics;
- ✓ emissions
- ✓ availability;
- ✓ distribution.
- Solar energy and Wind energy
 - ✓ energy characteristics
 - ✓ availability;

4 Primary energy sources (Part III)

- Biomass
 - Biomass definition
 - Biomass supply chain
 - Type of biomass
 - physical characteristics
 - chemical characteristics
 - energy characteristics
- Geothermal energy
 - energy characteristics;
 - emissions
 - availability;
 - distribution.
- Hydro energy
 - energy characteristics;
 - availability;
 - distribution.

5 Primary energy sources (Part IV)

- Energy characteristics, availability and distribution of ocean energy:
 - Tidal energy
 - Wave energy
 - Marine currents' energy
 - Thermal gradients
 - Salinity gradients

6 Energy vectors (Part I)

- Introduction of the Energy vector concept.
- Definition of energy transportation and storage.
- Definition of Energy vector.
- Analysis of transported and stored forms of energy.
- Presentation of main energy vectors.
- Analysis of energy transportation on:
 - Dedicated networks.
 - Non dedicated networks.



7 Energy vectors (Part II)

- Characteristics analysis as energy vector of:
 - coal
 - natural gas.
 - electricity
- Assessment of energy costs for energy transportation.

8 Energy vectors (Part III)

- Electricity Storage: Batteries
 - Battery classification
 - Definition of the working principle of the main electric batteries.
 - Classification of the accumulators.
 - Definition of the main operating characteristics of electric batteries
 - Assessment of energy costs for Electricity Storage: Batteries

9 Energy vectors (Part IV)

- electricity storage
 - Super-capacitors
 - Definition of the working principle
 - energy storage characteristics
 - Pumped storage hydroelectric
 - Definition
 - Assessment of energy costs for Electricity Storage in Batteries
- Hydrogen storage:
 - Compressed
 - Storage capacity
 - Assessment of energy costs for compressed hydrogen storage
 - Liquefied
 - Storage capacity
 - Assessment of energy costs for liquefied hydrogen storage
 - Metal hydrides
 - Description of the working principle and energy storage characteristics of hydrides.
 - Hydrides classification
 - Storage capacity
 - Assessment of energy costs for liquefied hydrogen storage

10 Energy vectors (Part V)

- Hydrogen storage in Ammonia (hydrides)
 - Description of the working principle and energy storage characteristics of ammonia.
 - Storage capacity
 - Assessment of energy costs for hydrogen storage in ammonia



- Carbon Nanotubes
 - Definition
 - Storage capacity
 - Assessment of energy costs for carbon nanotubes hydrogen storage
- Hydrogen transportation
 - mode of transport
 - Assessment of energy costs for hydrogen transportation
- Thermal energy transportation and storage
 - mode of transport and storage
 - Assessment of energy costs for transport and storage of Thermal energy
- Mechanical energy transportation and storage
 - mode of transport and storage
 - Assessment of energy costs for transport and storage of Mechanical energy

11 Energy conversion systems

- Analysis of the characteristics and classification of energy vectors' production plants.
- Definition and analysis of distributed and centralized energy production plants.
- Definition of energy co-generation.
- Definition and description of Smart Energy Networks.

12 Hydrogen production

- Description and classification of hydrogen production processes:
 - Reforming
 - Coal gasification
 - Partial oxidation of hydrocarbons
 - Electrolysis
 - Photo electrolysis
 - Solar Thermolysis (Thermochemical water splitting)

13 Biofuels

- Biofuels production processes
 - Thermochemical processes
 - types of biomass usable
 - Processes and technologies
 - Characteristics and efficiency
 - Biochemical processes
 - types of biomass usable
 - Processes and technologies
 - Characteristics and efficiency