Renewable Energy

1. **Course number and name:** 020ERNES5 Renewable Energy

2. **Credits and contact hours:** 6 ECTS credits, 3x1:15 contact hours per week

3. **Name(s) of instructor(s) or course coordinator(s):** Bassam Riachi

4. **Instructional Materials:** PowerPoint slides

   Textbooks/References:
   - Renewable and efficient electric power systems, G. M. Masters, 20040.
   - Principles of energy conversion, Archie W. Culp. Jr.,19790.
   - Powerplant Technology, M. M. El-Wakil, 1984.

5. **Specific course information:**
   a. **Catalog description:**
   This course provides an overview of the latest technologies and developments in renewable energies, as well as the diversity of their applications. It aims to make students aware of the potentials and specificities of renewable energies in terms of electricity generation. What are these energy resources? How to capture and transform them? In what form they can be used? In this course are examined: The current state of renewable energies in the world and future prospects, Energy cycle on earth; Solar energy, availability conversion and applications of solar energy, thermal and photovoltaic systems; Wind power, availability, development and conversion methods; Hydroelectric power, conversion methods, types of hydraulic turbines; Biomass, sources, conversion methods; Geothermal energy, geothermal energy level, type of systems; Energy storage, electrical batteries, fuel cells, pumped storage system. Also, Socio-economic analysis and lifecycle analysis of renewable energy systems are provided.

   b. **Prerequisite:** None.

   c. **Required** for ME students.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   By the end of the course, the students will be able to:
   - List and describe the primary renewable energy resources and technologies.
   - Apply fundamental theories and equations to solve renewable systems engineering problems.

- Analyze and identify the main renewable energy sources and their operating modes.
- Design and model renewable energy conversion systems.

b. PIs addressed by the course.

PI	1.1	1.2	1.3	2.1	2.2	4.2	7.1	7.2
Covered	x	x	x	x	x	x	x	x
Assessed	x	x	x	x	x	x	x	x

7. Brief list of topics to be covered

- Course introduction, (1 Lecture)
- **Part A: Hydro-Electric Power Plants:** Principle of operation of hydropower plants. Principles and methods of open channel flow discharge measurement. Hydrograph, Flow Duration Curves, Power Duration Curves and Mass Storage plots. Design of open channels, penstocks, settling basins, spillways, stilling basins and outworks. Technologies of Dams and basic design of gravity dams, Main turbine technologies, control, operation and basic design of: Pelton, Francis and Kaplan turbines. Technologies and design of electric generators for hydropower electric plants (13 Lectures)
- **Part B: Wind Energy:** History on the use of wind energy; Power in the wind ; Wind turbine site assessment basics; Wind characteristics, wind histogram, Weibull and Rayleigh statistics; Basics of wind turbine design, Betz and Glauret limits, power coefficient Cp and tip speed ratio TSR; Basics of aerodynamics and wind turbine blade design; Wind turbine gear box and alternator design ;Wind turbine control systems, power curve and performance; Wind turbine towers; Wind Farms; Wind turbine monitoring; Diagnosis and prognosis of wind turbine failure, (10 Lectures)
- **Part C: Solar Energy:** *Photovoltaic (PV) solar cells*: introduction to solar calculations; Basic semiconductor physics; PV I-V curve; Impact of temperature and insolation on I-V curves; Shading impact on I-V curve; Main photovoltaic technologies. *PV systems:* Estimation and types of loads and their characteristics; Design of Grid-connected and Stand-alone PV Systems; Batteries and inverters; Hybrid Systems. Specific Purpose Photovoltaic Applications. Cost estimation of PV Systems. Life cycle analysis, (10 Lectures)
- **Part D: Thermal Solar Systems:** Development of solar thermal energy uses. Different technologies of solar thermal panels for domestic hot water production: Unglazed collectors, flat plate collectors, evacuated tube collector. Operating conditions and design. Efficiency and performance, (2 Lectures)
- **Part E: Biomass and Environment:** Resources and characteristics of different types of biomass. Biomass to renewable energy processes: Chemical process (hydrolysis,

liquefaction, pyrolysis, and gasification), Thermochemical process (methanation), and biological process (compost). Sustainability & Resilience. Bioenergy & Environment, Criteria Pollutants, Carbon Footprint (5 Lectures).

- **Part F: Geothermal Energy:** Geothermal resources. Geothermal heating and air conditioning applications. Low-temperature geothermal applications for heat generation. High-temperature geothermal power production: Natural or flash-based geothermal installations. Design and calculation of geothermal processes, (2 Lectures)
- **Part G: Energy Storage:** Existing technologies; Principle of operation, performance and efficiencies of: Fuel cells, super capacitors, compressed air, flywheels, chemical batteries, hydraulic storage. (3 Lectures)