ENERGY RESOURCES AND TECHNOLOGY

ENME 414

Lecture	**: 3**	**Year : IV**
Tutorial	**: 1**	**Part : I**
Practical	**: 3/2**	

Course Objectives:

The objective of this course is to provide key concepts of energy, including different energy resources and renewable energy technologies. The course emphasizes on design and evaluation of energy systems, energy storage technologies and energy efficiency measures, and assessment of sustainable energy solutions in the context of Nepal.

1 Introduction to Energy Resources (6 hours)

- 1.1 Basic concepts of energy
- 1.2 Energy resources and utilization
- 1.3 Energy flow analysis: Sankey diagrams and basic energy balance concepts
- 1.4 Classification of energy resources
- 1.5 Conventional and non-conventional commercial energy resources
- 1.6 Commercial and non-commercial energy resources
- 1.7 Energy scenario and security: Global and Nepal energy scenario, energy mix and energy security
- 1.8 Environmental impacts and sustainability

2 Solar Energy (8 hours)

- 2.1 Basics of solar energy
  - 2.1.1 Solar radiation fundamentals and solar geometry (Solar angles)
  - 2.1.2 Measurement of solar radiation and measuring instruments
  - 2.1.3 Solar resource assessment at a site
- 2.2 Solar thermal
  - 2.2.1 Principles of solar thermal energy conversion and solar collectors
  - 2.2.2 Solar water heating systems (Active and passive; Flat plate and evacuated tube)
  - 2.2.3 Solar drying and cooking systems (Concept and types)
  - 2.2.4 Overview of concentrating solar power (CSP) systems
- 2.3 Solar PV
  - 2.3.1 Working principle of PV cells and types of PV technologies
  - 2.3.2 Current-Voltage (I-V) and Power-Voltage (P-V) characteristics for different temperature and radiations

2.3.3 PV modules and arrays, standard test conditions (STC), nominal operating cell temperature (NOCT) and array losses.
2.3.4 Performance factors: Effects of shading and basic layout considerations (Tilt, orientation, spacing, tracking)
2.3.5 PV system components and basic design for captive solar PV applications and solar water pumping
2.3.6 PV system configurations: off-grid, grid-connected and hybrid systems

3 Bio Energy (5 hours)

3.1 Bio-energy and biomass resources
3.2 Biomass to energy conversion processes
3.3 Energy from industrial and municipal waste
3.4 Biogas plants
3.4.1 Working principle
3.3.2 Components and construction
3.3.3 Types of digesters
3.3.4 Factors affecting biogas generation
3.5 Biomass pyrolysis and gasification process and their applications in industries

4 Wind Energy (4 hours)

4.1 Wind energy resources, measurement techniques and site assessment
4.2 Principles of wind energy conversion, wind power density and Betz's limit
4.3 Types and characteristics of wind turbines and their components
4.4 Wind turbine control systems including pitch, stall, yaw control and power electronics
4.5 Wind farming: Wind turbulence, locations (Offshore and onshore), concept of wind and solar hybrid power plants for mini-grid applications

5 Micro and small hydro power systems (7 hours)

5.1 Principle of hydropower systems, components and classifications
5.2 Hydro turbines for micro and small hydro power plants: Principle, selection methods
5.3 Micro and mini hydropower system
5.3.1 Application in the context of Nepal
5.3.2 Site investigation or feasibility study
5.3.3 Different methods of head and flow measurement
5.3.4 Construction, operation and maintenance with focus on mechanical system
5.3.5 Electrical transmission and distribution system
5.4 Hydropower system sizing and design consideration, flow duration curve

6 Non-conventional Sources and Nuclear Energy (6 hours)

6.1 Geothermal energy
6.2 Energy from co-generation (CHP) and its application in industries
6.3 Hydrogen energy
  6.3.1 Fuel cells and hydrogen fuel system
  6.3.2 Hydrogen production processes
  6.3.3 Infrastructure requirement for hydrogen production, storage and utilization
6.4 Nuclear energy
  6.4.1 Nuclear reactions
  6.4.2 Nuclear fission and fusion technologies
  6.4.3 Nuclear power plant and working principle
  6.4.4 Health hazards, radiation protection and shielding
6.5 Emerging renewable energy technologies

7 Energy Storage System (4 hours)

7.1 Different forms of energy storage: Electrical, mechanical, chemical, thermal, and their applications
7.2 Battery fundamentals and types: Lead-acid, lithium-ion, LFP, NMC, flow batteries, with basic operation and characteristics
7.3 Super-capacitor: Construction, working principle, performance features and applications
7.4 Smart grids: Concept, components and role in modern power systems
7.5 EV integration: G2V and V2G concepts
7.6 Recent advancements in energy storage technologies and emerging trends

8 Energy Efficiency and Financial Analysis (5 hours)

8.1 Energy conservation, energy efficiency and energy management
8.2 Energy saving measures in industry and other sectors
8.3 Energy star ratings and industrial efficiency standards.
8.4 Energy audit concept, needs and types
8.5 Financial analysis of an energy project (NPV, IRR and Payback), levelized cost of energy (LCOE), case study to a sample renewable energy project

Tutorial (15 hours)

1. Sizing of solar thermal collectors for water heating and cooking
2. PV system basic design for water pumping for drinking and irrigation purpose
3. PV system basic design for domestic and commercial applications to run electrical appliances, estimation of energy generation
4. Biogas plant sizing and estimation of energy potential for household and institutional use
5. Wind power density and energy estimation from given wind data, basic sizing of small wind systems for rural applications

6. System sizing and design for major components of micro and mini-hydropower system
7. Financial analysis of energy projects: NPV, IRR, payback period and LCOE
8. Case studies on renewable energy and energy efficiency projects

Practical **(22.5 hours)**

1. Measurement of solar radiation using a pyranometer or reference cell and analysis of solar angles for a specific location
2. Assemble a small PV system, measure I-V characteristics of solar panels under different conditions, and analyze the effects of shading and tilt angle
3. Study and evaluation of the performance of a solar water heating system under different operating conditions
4. Study of the construction, working principle and operation of a biogas plant through a field visit (Visit to near suitable site)
5. Study of the construction, components and operation of a wind turbine through a field visit (Visit to near suitable site)
6. Study of the layout, components and operation of a micro or small hydropower system through a field visit (Visit to near suitable site).
7. Conduct an energy audit of a small building or industry, identify energy losses and propose energy efficiency improvement measures.

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1	6	10
2	8	10
3, 4	9	10
5	7	10
6	6	10
7, 8	9	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Garg, H. P., Prakash, J. (2007). Solar energy: Fundamentals and applications. McGraw-Hill Education.
2. Rai, G. D. (2010). Non-conventional sources of energy. Khanna Publishers.
3. Boyle, G. (2012). Renewable energy: Power for a sustainable future. Oxford University Press.
4. Bureau of Energy Efficiency. (2015). Energy efficiency in electrical utilities. Bureau of Energy Efficiency.
5. Alternative Energy Promotion Centre. Relevant research papers and publications.