Course title: Variable Energy and Decentralized Systems– Resources, Technologies, Applications			
Course code: DSE 112	**No. of credits:** 3	L-T-P:39-6-0	**Learning hours:** 45
Pre-requisite course code and title (if any): N.A.			
Department: Department of Sustainable Engineering			
Course coordinator: Dr. Ramkishore Singh		**Course instructor(s):** Prof. Naqui Anwer and Dr. Ramkishore Singh	
Contact details: ramkishore.singh@terisas.ac.in			
Course type: Core		**Course offered in:** Semester 2	

Course description:

This course has been designed to inculcate the design and assessment principles used for variable energy systems and technologies and their applications. Further, students will be taught about different energy conversion procedures and address the difficulties arising due to variable nature of energy sources and its impact on economic viability. Also, students will be made aware of recent advances on the conversion technologies and future prospective.

Course objectives:

1. To get students understand and familiarize with energy resource assessment procedure for different variable energies and their potential.
2. To inculcate skills required for designing the technologies to harness and utilize variable energy sources.
3. To introduce students with different thermal and power applications of variable energy conversion technologies and systems.

Module	Topic	L	T	P
1.	**Solar Energy resources and measurements** o Solar energy resources: Availability, Sun-Earth relationship, Solar time, Solar radiation on horizontal and tilted surfaces, Solar radiation measurement instruments	4		
2.	**Solar thermal Energy Conversion:** o Flat Plate collectors Modelling and performance improvement o Designing process of Solar Compound Parabolic Concentrators o System sizing methodology and heating and cooling applications of solar thermal conversion technologies, low and medium temperature applications o Impact of variable nature of energy source on design and costs	6	2	
3.	**Concentrating Solar Thermal Power Generation:** o Solar concentrator and CSP systems, o Principles and limitations of CSP systems, o Solar thermal power plant technologies and applications	4		
4.	**Fundamentals of semiconductors and solar cells:** o Introduction to semiconductors, Charge carriers in semiconductors, carrier concentration and distribution, Generation of charge carriers, PN junction and space charge region, Energy band diagram and junction potential, Quantitative analysis of PN junction, PN junction under illumination, Manufacturing process of crystalline and multi-crystalline silicon PV cell, Solar cell design and characterisation, STC and NOCT, Effect of temperature and radiation on cell performance	8		
5.	**Photovoltaics technologies and applications:** o Cell to module design o Components of balance of system (i.e. inverter, mounting structure, storage etc.) o Solar PV plant designing and safety measures (e.g. earthing, surge and lighting arrester) o Grid tied system and net metering o Standalone PV plant design considerations	5	2	

	○ Design recommendations and costs			
6.	**Wind Energy resources, Conversion Processes and Technologies:** ○ Wind energy resource: Assessment, Global wind system, Physics of wind, wind speed measurement and distribution, Spatial wind resources assessment tools, ○ Overview of vertical and horizontal axis wind turbines ○ Wind turbine aerodynamics: Momentum models, vortex models, hybrid models, limitations of different models, ○ Wind turbine structural dynamics considerations ○ Peak power limitation ○ Modern Turbine subsystems ○ Applications of wind power and energy ○ Impact of variable nature on the design and cost of the system	8	2	
7.	**Tidal power and wave energy resources, Conversion Processes and Technologies:** ○ Tidal phenomenon, Principles of tidal barrage design and operation, extracting energy from tidal currents ○ Ocean wave energy: Principle of ocean wave generation, Shore and near shore waves energy converters, Offshore wave energy conversion devices `	2 2		
	Total	39	6	

Evaluation criteria

Assignment1: 10% (after Module 4)
Assignment 2: 10% (after Modules 6)
Minor test 1: 10% (after Module 4)
Minor test 2: 10% (after Module 6)
Major test: 60% (after all module)

Learning outcomes:

This course inculcates the skills that shall make the students to:

1. be able to assess the resources of energy potential of variable energies sources i.e. solar, wind, tidal and wave energies
2. be able to understand essential design principles used for developing the systems and technologies required for harnessing variable energy resources.
3. be able to assess the performance of variable energy conversion and utilization system and technologies.
4. be able to identify the applications of solar thermal collectors, solar PV systems and wind turbines
5. be able to design and implement the system and devices used for converting wave and tidal power into electrical energy.

Pedagogical approach

A combination of class-room interactions, tutorials, practical and assignments.

Materials

Recommended readings

Text Books

1. *Energy Conversion. 2nd edition (2017). Edited By D. Yogi Goswami, Frank Kreith, CRC Press*
2. *Renewable Energy Focus Handbook (2009) by Gianfranco Pistoia, Preben Maegaard, Bent Sorensen, Mukesh Doble, Shang-Tian Yang, Harsh K. Gupta, Aldo Vieira da Rosa, Paul Breeze, Truman Storvick, Soteris Kalogirou, Roy Sukanta. Academic Press*
3. *Solar Photovoltaics – Fundamentals, Technologies and Applications. (2011). C. S. Solanki, 2nd ed. PHI Learning*
4. *GSES Manual. (2013). Grid connected PV Systems Design and Installation. Global Sustainable Energy Solutions Pty. Ltd, GSES India Sustainable Energy Pvt. Ltd.*

Reference Books

1. *Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).*
2. *S Sukhatme and J Nayak, "Solar Energy: Principles of Thermal Collection and Storage", Third Edition (Tata McGraw Hill, 2008)*
3. *Handbook of photovoltaic science and engineering, ed. A. Luque and S. Hegedus (John Wiley and Sons, 2010)*
4. *Photovoltaic system engineering, R. A. Messenger and A. Abtahi, 3rd ed. (CRC Press, 2010)*
5. *TERI Energy Data Directory (TEDDY) 2020-21 (TERI Press, 2021)*

Journals

- Applied Energy
- Renewable and Sustainable Energy Reviews
- Solar Energy
- Solar Energy compass
- Applied Solar Energy
- Journal of Energy Resources Technology
- Nature Energy
- Renewable Energy

Additional information (if any): NA

Student responsibilities:
Attendance, feedback, discipline: as per university rules

Course Reviewers

1. Prof. Atul Sharma
   RGIPT Jais, Amethi U.P.

2. Dr. Siva Reddy V
   Director (Technical)
   National Institute of Solar Energy (NISE)

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   Associate Professor
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