



### Course Plan

|   |                           |
|---|---------------------------|
| Semester: <b>8 - Semester</b>                 | Year: <b>2018-2019</b>    |
| Course Title: <b>Renewable energy sources</b> | Course Code: <b>OE402</b> |
| Total Contact Hours: <b>36</b>                | Duration of ESE: 2 Hours  |
| ESE Marks: <b>50</b>                          | ISE & UT Marks: <b>50</b> |
| Lesson Plan Author: Mr. Pradip Patil          | Last Modified Date:       |
| Checked By: Dr. Sanjay Yadav                  | Last Reviewed Date:       |

### Course Outcomes (COs):

At the end of the course the student should be able to:

1. Identify the need of requirement of renewable energy source
2. Summarize the various available energy sources.
3. Illustrate different technologies essential for conversion of renewable energy sources.
4. Evaluate the performance of energy conversion systems for maximum efficiency
5. Compare the various renewable energy technologies.
6. Select appropriate renewable energy technology for specific application



**Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)**

|  |                        |
|--|------------------------|
| Course Title: Renewable energy sources | Semester: 8 - Semester |
| Course Code: OE402                     | Year: 2018-2019        |

| Course Outcomes (COs) / Program Outcomes (POs)   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|--|---|---|---|---|---|---|---|---|---|----|----|----|
| 1. Identify the need of requirement of renewable energy source                             | 3 |   | 1 | 3 | 1 |   |   |   | 3 | 3  |    | 1  |
| 2. Summarize the various available energy sources.   | 3 |   | 1 | 3 | 1 |   |   |   | 3 | 3  |    | 1  |
| 3. Illustrate different technologies essential for conversion of renewable energy sources. | 3 |   | 1 | 3 | 1 |   |   |   | 3 | 3  |    | 1  |
| 4. Evaluate the performance of energy conversion systems for maximum efficiency            | 3 |   | 1 | 3 | 3 |   |   |   | 3 | 3  |    | 1  |
| 5. Compare the various renewable energy technologies.                                      | 3 |   | 1 | 3 | 3 |   |   |   | 3 | 3  |    | 1  |
| 6. Select appropriate renewable energy technology for specific application                 | 3 |   | 1 | 3 | 3 |   |   |   | 3 | 3  |    | 1  |

**Course Content**

|                    |  |                      |
|--------------------|--|----------------------|
| Course Code: OE402 | Course Title: Renewable energy sources |                      |
| L-T-P: 3-0-0       | Credits: 3                             | Contact Hrs: 36      |
| ISE Marks: 50      | ESE Marks: 50                          | Total Marks: 100     |
| Teaching Hrs: 36   |  | Exam Duration: 2 hrs |

| Content  | Hrs      |
|--|----------|
| <b>Unit - 1</b>  |          |
| <b>Chapter No. Unit 1: Introduction to Energy Sources:</b><br>World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy Utilisation – Renewable Energy Scenario in India and around the World – Potentials - Achievements / Applications – Economics of renewable energy systems   | 6.00 hrs |
| <b>Chapter No. Unit 2: Solar Energy</b><br>Solar Radiation – Measurements of Solar Radiation - Flat Plate and Concentrating Collectors – Solar direct Thermal Applications – Solar thermal Power Generation - Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications                   | 6.00 hrs |
| <b>Chapter No. Unit 3 : Bio - Energy</b><br>Biomass direct combustion – Biomass gasifiers – Biogas plants – Digesters – Ethanol production – Bio diesel – Cogeneration - Biomass Applications  | 6.00 hrs |
| <b>Chapter No. Unit 4: Wind Energy</b><br>Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects   | 6.00 hrs |
| <b>Chapter No. Unit 5: Hydrogen Energy.</b><br>Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles. Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, and application of fuel cells | 6.00 hrs |
| <b>Chapter No. Unit 6: Other Renewable Energy Sources</b><br>Tidal energy, Wave Energy – Open and Closed OTEC Cycles , Small Hydro-Geothermal Energy , Stored hydro energy, Principles of hydro power technology   | 6.00 hrs |



**Text Books (List of books as mentioned in the approved syllabus)**

1. S P Sukhatme, Solar Energy, Fourth, McGraw Hill Education, 2017
2. G.D. Rai, Non-conventional energy sources, Latest - 2018, Khanna Publishers, New Delhi, 2018
3. John Twidell , Renewable Energy Resources, Third, Routledge, 2015

**References**

1. Godfrey Boyle , Renewable Energy: Power for a Sustainable Future, Third, Oxford University Press, U.K., 2012
2. Freris. L.L., Wind Energy Conversion Systems, Prentice Hall, UK, 1990
3. David M. Mousdale, Introduction to Biofuels, CRC Press, Taylor & Francis Group, USA, 2010
4. B. H. Khan, Non-Conventional Energy, Second, Tata McGraw-Hill, New Delhi, 2017



### Chapterwise Plan

|  |                                |
|--|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b>           |                                |
| Chapter Number and Title: <b>Unit 1: Introduction to Energy Sources:</b> | Planned Hours: <b>6.00 hrs</b> |

### Learning Outcomes:-

At the end of the topic the student should be able to:

|   | Topic Learning Outcomes   | COs | BL |
|---|---|-----|----|
| 1 | Explain renewable energy scenario in india and around the world.                        | CO2 | L2 |
| 2 | Describe the challanges and problems associated with the use of various energy sources. | CO3 | L3 |

### Lesson Schedule

| Lecture No. - Portion covered per hour                                     | Planned Delivery Date | Actual Delivery Date |
|--|-----------------------|----------------------|
| 1. Introduction to Energy Sources:   | 01-01-2019            |                      |
| 2. World Energy Use  | 04-01-2019            |                      |
| 3. Reserves of Energy Resources  | 07-01-2019            |                      |
| 4. Environmental Aspects of Energy Utilization                             | 08-01-2019            |                      |
| 5. Reserves of Energy Resources – Potentials - Achievements / Applications | 14-01-2019            |                      |
| 6. Renewable Energy Scenario in India and around the World                 | 11-01-2019            |                      |
| 7. Review Lecture  | 15-01-2019            |                      |



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|--|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b> |                                |
| Chapter Number and Title: <b>Unit 2: Solar Energy</b>          | Planned Hours: <b>6.00 hrs</b> |

**Learning Outcomes:-**

**At the end of the topic the student should be able to:**

|   | Topic Learning Outcomes   | COs | BL    |
|---|---|-----|-------|
| 1 | Apply the knowledge of thermodynamics and heat transfer principles to evaluate the performance of solar renewable energy systems. | CO3 | L4,L4 |
| 2 | Distinguish between flat plate and concentrated collectors for solar system.  | CO5 | L3    |
| 3 | Calculate actual solar radiation outside the earth atmosphere for different days.   | CO4 | L3    |

**Lesson Schedule**

| Lecture No. - Portion covered per hour  | Planned Delivery Date | Actual Delivery Date |
|---|-----------------------|----------------------|
| 1. Solar Energy - Solar Radiation, Measurements of Solar Radiation            | 18-01-2019            |                      |
| 2. Flat Plate and Concentrating Collectors, Solar direct Thermal Applications | 21-01-2019            |                      |
| 3. Fundamentals of Solar Photo Voltaic Conversion, Solar Cells                | 22-01-2019            |                      |
| 4. Solar PV Power Generation  | 25-01-2019            |                      |
| 5. Solar PV Application   | 28-01-2019            |                      |
| 6. Solar Thermal Power Generation   | 01-02-2019            |                      |
| 7. Review Lecture   | 04-02-2019            |                      |



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|--|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b> |                                |
| Chapter Number and Title: <b>Unit 3 : Bio - Energy</b>         | Planned Hours: <b>6.00 hrs</b> |

**Learning Outcomes:-**

**At the end of the topic the student should be able to:**

|   | Topic Learning Outcomes  | COs | BL    |
|---|--|-----|-------|
| 1 | Suggest design factors for development of biogas plant using agriculture waste.  | CO4 | L4    |
| 2 | Explain ethanol production method by using sugarcane biomass.                    | CO2 | L2    |
| 3 | Suggest engine modification for diesel engine to operate using biodiesel fuel.   | CO3 | L4,L4 |
| 4 | Comment on automotive engine performance with emission of ethanol blended engine | CO4 | L3    |

**Lesson Schedule**

| Lecture No. - Portion covered per hour | Planned Delivery Date | Actual Delivery Date |
|--|-----------------------|----------------------|
| 1. Bio – Energy - Introduction         | 05-02-2019            |                      |
| 2. Biomass direct combustion           | 11-02-2019            |                      |
| 3. Biomass gasifies                    | 12-02-2019            |                      |
| 4. Biogas plants – Digesters           | 15-02-2019            |                      |
| 5. Ethanol production                  | 18-02-2019            |                      |
| 6. Bio diesel – Cogeneration           | 22-02-2019            |                      |
| 7. Review Lecture                      | 25-02-2019            |                      |



|  |                                |
|--|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b> |                                |
| Chapter Number and Title: <b>Unit 4: Wind Energy</b>           | Planned Hours: <b>6.00 hrs</b> |

**Learning Outcomes:-**

**At the end of the topic the student should be able to:**

|   | Topic Learning Outcomes   | COs | BL |
|---|---|-----|----|
| 1 | Explain constructional features of various types of wind energy systems.      | CO1 | L2 |
| 2 | Suggest factors consider for site selection to establish wind energy systems. | CO3 | L4 |
| 3 | Derive the mathematical expression for wind power.                            | CO4 | L4 |
| 4 | Calculate wind power and turbine power for various wind mill heights.         | CO4 | L4 |

**Lesson Schedule**

| Lecture No. - Portion covered per hour               | Planned Delivery Date | Actual Delivery Date |
|--|-----------------------|----------------------|
| 1. Wind Energy - Wind Data and Energy Estimation     | 26-02-2019            |                      |
| 2. Types of Wind Energy Systems                      | 01-03-2019            |                      |
| 3. Wind Energy Systems – Performance, Site Selection | 04-03-2019            |                      |
| 4. Wind Turbine Generator                            | 08-03-2019            |                      |
| 5. Wind Turbine Generator Application                | 11-02-2019            |                      |
| 6. Safety and Environmental Aspects                  | 12-03-2019            |                      |
| 7. Review Lecture                                    | 15-03-2019            |                      |





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|--|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b> |                                |
| Chapter Number and Title: <b>Unit 5: Hydrogen Energy.</b>      | Planned Hours: <b>6.00 hrs</b> |

**Learning Outcomes:-**

**At the end of the topic the student should be able to:**

|   | Topic Learning Outcomes  | COs | BL |
|---|--|-----|----|
| 1 | Explain advance hydrogen production and storage methods for industrial applications. | CO3 | L2 |
| 2 | Suggest engine design modifications to operate vehicle using hydrogen fuel.          | CO5 | L5 |
| 3 | Describe various types of fuel cells with design principle and operational features. | CO1 | L3 |

**Lesson Schedule**

| Lecture No. - Portion covered per hour  | Planned Delivery Date | Actual Delivery Date |
|---|-----------------------|----------------------|
| 1. Hydrogen Energy - Introduction   | 22-03-2019            |                      |
| 2. Hydrogen Production methods  | 25-03-2019            |                      |
| 3. Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, Hydrogen as alternative fuel for vehicles. | 26-03-2019            |                      |
| 4. Design principle and operation of fuel cell  | 29-03-2019            |                      |
| 5. Types of fuel cells  | 01-04-2019            |                      |
| 6. Conversion efficiency of fuel cell, and application of fuel cells.   | 02-04-2019            |                      |



|   |                                |
|---|--------------------------------|
| Course Code and Title: <b>OE402 / Renewable energy sources</b>          |                                |
| Chapter Number and Title: <b>Unit 6: Other Renewable Energy Sources</b> | Planned Hours: <b>6.00 hrs</b> |

**Learning Outcomes:-**

**At the end of the topic the student should be able to:**

|   | Topic Learning Outcomes                                       | COs | BL |
|---|---|-----|----|
| 1 | Describe tidal and wave energy as a renewable energy source.  | CO6 | L3 |
| 2 | distinguish between open and close OTEC energy system cycles. | CO6 | L4 |

**Lesson Schedule**

| Lecture No. - Portion covered per hour  | Planned Delivery Date | Actual Delivery Date |
|---|-----------------------|----------------------|
| 1. Tidal energy Introduction            | 05-04-2019            |                      |
| 2. Wave Energy                          | 08-04-2019            |                      |
| 3. Open and Closed OTEC Cycles          | 09-04-2019            |                      |
| 4. Small Hydro-Geothermal Energy        | 12-04-2019            |                      |
| 5. Stored hydro energy                  | 15-04-2019            |                      |
| 6. Principles of hydro power technology | 16-04-2019            |                      |

**Date:**

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