**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**
Semester-IV

**Course Title: Wind Energy**
(Course Code: 4346402)

| Diploma programmer in which this course is offered | Semester in which offered |
|---|---|
| Renewable Energy | 4th |

## 1. RATIONALE

The course on Wind Energy is designed to provide students with a comprehensive understanding of the fundamental principles governing the Wind Energy systems and to emphasize the role of wind energy technology and its potential. The course aims to introduce the basic concepts of wind energy and the preliminary analysis to estimate the energy generation from the wind energy systems. Various components involved in the wind energy system are covered. In addition to the various applications of wind energy generation systems, the course also covers the issues related to the integration of this system in the existing network. Thus, the course is intended to provide the foundation for the wind energy generation system. By studying these topics, students will develop a solid foundation in Wind Energy system and gain practical knowledge necessary for their future careers in renewable and electrical engineering.

## 2. COMPETENCY

The purpose of this course is to help the students to attain following industry identified competency through various teaching learning experiences:
**Students will be able to explain the basics of Wind Energy, components of Wind Energy systems, operation of Wind Energy Systems and its integration with the Power System.**

### 1. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:
a) Understand various terminologies and aspects related to Wind Energy.
b) Understand working principle of Wind Energy Systems.
c) Comprehend the power generation in Wind Energy Systems.
d) Understand the challenges related to Wind Energy Systems.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme (In Hours) | | | Total Credits (L+T+P/2) | Examination Scheme | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | Total Marks |
| L | T | P | C | CA | ESE | CA | ESE | |
| 3 | 0 | 2 | 4 | 30 | 70 | 25 | 25 | 150 |

*(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required forth attainment of the COs.*

***Legends**: **L**-Lecture; **T**–Tutorial/Teacher Guided Theory Practice; **P**-Practical; **C**–Credit, **CA**-Continuous Assessment; **ESE** – End-Semester Examination.*

## 5. SUGGESTED PRACTICAL EXERCISES:

The following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Someof the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

| Sr. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Identify various Wind power scenario in India and Gujarat, prepare a map of India with identification of zones appropriate for installation of Wind Farms with table including wind speeds of geographical areas suitable for installation of Wind Farms | 1 | 4 |
| 2 | Identify various parts of a Horizontal Axis Wind Turbine | 2 | 2 |
| 3 | Identify various parts of a Vertical Axis Wind Turbine | 2 | 2 |
| 4 | To Interpret block diagram of a Wind Power Plant | 2 | 2 |
| 5 | Identify different types of Sensors: Anemometer, wind vane, temperature sensors of nacelle, gearbox and generators and vibration sensors. | 2 | 4 |
| 6 | Identify the various parts of a squirrel cage induction generator (SCIG) commonly used in Wind Power Plant | 3 | 2 |

| | | | |
|---|---|---|---|
| 7 | Prepare a report of Wind Power Plant preventive maintenance | 3 | 2 |
| 8 | Prepare a report of Wind Power Plant breakdown maintenance | 3 | 2 |
| 9 | Prepare a report on Challenges in Wind Power Generation | 4 | 4 |
| 10 | Prepare a report on probable solutions & remedies to solve the challenges in Wind Power Generation | 4 | 4 |

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

| Sr.No. | Equipment Name with Broad Specifications | Pr. No. |
|---|---|---|
| 1 | Anemometer | 5 |
| 2 | Wind Vane | 5 |
| 3 | Squirrel Cage Induction Motor | 6 |

## 7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this course competency.

a) Work as a leader/a team member (while doing a micro-project)
b) Follow safety practices while using Electrical supply and electrical equipment.
c) Follow ethical practices.
d) Adhere to safety protocols to ensure the safe installation and maintenance of system.
e) Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

## 8. UNDERPINNING THEORY:

The major underpinning theory is given below based on the higher UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

| Unit | Unit Outcomes (UOs) | Topics and Sub-topics |
|---|---|---|
| **Unit I Introduction to Wind Energy** | **1a.** Understand History of Wind Energy and devices used for measuring wind direction and velocity<br>**1b.** Explain different types of Wind Turbine | **1.1** Wind Energy History<br>**1.2** Energy Conversion in Wind Power Plant<br>**1.3** Advantages and Limitations of Wind Power Plant<br>**1.4** Selection of Site for Wind Power Plant<br>**1.5** Devices for measuring direction and velocity of Wind: Wind Vane and Anemometer<br>**1.6** Horizontal axis and Vertical axis Wind Turbine |
| **Unit II Principle of Wind Energy** | **2a.** Explain principle of rotation of wind turbine rotor<br>**2b.** Comprehend power control in HAWT<br>**2c.** Understand Classification of Wind Electric System | **2.1** Aerodynamic drag and lift principle for rotation of wind turbine rotor<br>**2.2** Mathematical equation of Wind Power:<br>• Wind Duration Curve<br>• Height vs Wind Velocity Curve<br>• Relation among wind velocity, air mass and wind power<br>**2.3** Important terms regarding wind power generation:<br>• Efficiency of wind turbine<br>• Swept area<br>• Cut in wind speed<br>• Rated Wind speed<br>• Cut out wind speed<br>• Maximum designed speed<br>**2.4** Power Control in Horizontal Axis |

| | | |
|---|---|---|
| | | Wind Turbine<br>**2.5** Classification of Wind Electric System |
| **Unit III**<br>**Wind Turbine and its Subsystem** | **3a.** Understand Block Diagram of Wind Power Plant<br>**3b.** Explain Wind Turbine Subsystem<br>**3c.** Describe schemes of Electrical Generation<br>**3d.** Understand Electrical Generators used in Wind Power Plant | **3.1** Block Diagram of Wind Power Plant<br>**3.2** Wind Turbine Subsystem:<br>• Foundation<br>• Tower<br>• Nacelle<br>• Hub and Rotor<br>• Drivetrain: Gearbox and Generator<br>• Electronics and Control: Yaw, Pitch, Braking, Cooling<br>**3.3** Schemes for Electrical Generation:<br>• CSCF<br>• VSCF<br>• VSVF<br>**3.4** Types of Wind Power Plant on the basis of Gear Arrangement<br>**3.5** Electrical Generators used in Wind Power Plant:<br>• Synchronous Generator<br>• Induction Generator |
| **Unit IV Wind Farm** | **4a.** Describe various types of Wind Farm<br>**4b.** Explain connection scheme of Wind Farm<br>**4c.** Comprehend challenges in Wind Power Generation<br>**4d.** Understand Wind Power Scenario in India and Gujarat | **4.1** Types of Wind Farm:<br>• On-Shore Wind Farm<br>• Shore line Wind Farm<br>• Off-Shore Wind Farm<br>**4.2** Connection scheme of Wind Farm<br>**4.3** Challenges in Wind Power Generation:<br>• Environmental impact<br>• Wind Turbine Noise<br>• Integration of Wind Power into Grid<br>**4.4** Major Wind Farms of Gujarat State<br>**4.5** Wind power scenario in the India and Gujarat |

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

| Unit No. | Unit title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Introduction to Wind Energy | 10 | 8 | 6 | 2 | 16 |
| II | Principle of Wind Energy | 12 | 8 | 8 | 4 | 20 |
| III | Wind Turbine and its Subsystem | 14 | 8 | 8 | 8 | 24 |
| IV | Wind Farm | 08 | 6 | 2 | 2 | 10 |
| Total | | 42 | 30 | 24 | 16 | 70 |

***Legends:*** *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note****: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a. Create a quiz to test students' understanding of fundamental concepts related to wind energy, including terminology, principles, and historical developments.
b. Ask students to create detailed diagrams or models illustrating the different parts of a wind turbine, explaining the function of each component.
c. Use online simulation tools or software to allow students to virtually design and test their own wind turbines
d. Provide data on wind speeds and turbine specifications. Ask students to calculate the expected energy output of a wind turbine using relevant formulas and concepts.
e. Invite a professional from the wind energy industry to speak to the class. Allow students to ask questions and learn about current trends, challenges, and career opportunities.
f. Explore the environmental impact of wind energy on wildlife.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Guide student(s) in undertaking micro-projects.
b) Show animation/ video related to course content.
c) Visit nearby biogas power plant

## 12. SUGGESTED PROJECT LIST

***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Design and create miniature wind turbine blades using various materials.
b) Build a small wind turbine generator using a DC motor and simple materials.
c) Design and build a miniature wind turbine tower using materials like PVC pipes or popsicle sticks.
d) Explore the electrical components of a wind turbine, such as controllers and inverters.
e) Build a device to measure wind speed using simple sensors (anemometer).
f) Investigate the materials commonly used in wind turbine blades.
g) Create a data logger to record wind speed, temperature, and other relevant data.
h) Create an educational presentation or workshop on wind energy for local schools or community group.

## 13. SUGGESTED LEARNING RESOURCES

| Sr. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 1 | Determine applications of various types of Wind Energy Systems | Joshua Earnest, Sthuthi' Rachel | ISBN: 978-9388028493 Publication: PHI Learning, New Delhi, 2019 |
| 2 | Wind Power Plants and Project Development | Tore Wizelius Joshua Earnest | ISBN: 978-8120351271 Publication: PHI Learning |
| 3 | Renewable Energy Systems | David M. Buchla, Thomas E. Kissell, Thomas L. Floyd | ISBN: 978-9332586826 Publication: Pearson Education |
| 4 | Wind Electrical Systems | S. N. Bhadra , S Banerjee , D Kastha | ISBN: 978-0195670936 Publication: Oxford |
| 5 | Wind Power in Power Systems | Thomas Ackermann | ISBN: 978-0470974162 Publication: Wiley |
| 6 | Non Conventional Energy Sources | G. D. Rai | ISBN: 978-8174090737 Publication: Khanna Publishers |

## 14. SOFTWARE/LEARNING WEBSITES

- QBladeCE_2.0.6.4_win
- https://etap.com/product/wind-turbine-generator-software
- https://www.ul.com/software/openwind-wind-farm-modeling-and-layout-design-software
- https://windsim.com/software/
- https://www.nrel.gov/research/re-wind.html
- https://www.energy.gov/eere/wind/wind-energy-basics
- https://niwe.res.in/
- https://www.india.gov.in/website-national-institute-wind-energy

## 15. PO-COMPETENCY-CO MAPPING:

| Semester IV | Wind Energy (Course Code: 1346402) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **POs** | | | | | | |
| **Competency & Course Outcomes** | PO 1 Basic & Discipline specific knowledge | PO 2 Problem Analysis | PO 3 Design/ development of solution | PO4 Engineering Tools, Experimentation Testing | PO 5 Engineering practices for society, sustainability & environment | PO 6 Project Management | PO 7 Life-long learning |
| ***Competency*** | To help individual to understand their role and responsibilities for depth Understanding of Solar Photo Voltaic system | | | | | | |
| Course Outcomes<br>CO1 Understand various terminologies and aspects related to Wind Energy | 2 | -- | -- | -- | 1 | -- | -- |
| CO2 Understand working principle of Wind Energy Systems | 2 | -- | -- | -- | -- | -- | 2 |
| CO3 Comprehend the power generation in Wind Energy Systems | -- | -- | 2 | -- | 1 | -- | -- |
| CO4 Understand the challenges related to Wind Energy Systems | -- | 2 | 1 | -- | -- | -- | -- |

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

**GTU Resource Persons**

| Sr. No. | Name and Designation | Institute | Contact No. | Email |
|---|---|---|---|---|
| 1. | **Chitrang K. Vyas**<br>Lecturer Electrical Engg. | AVPTI, Rajkot | 7405744810 | ckv.avp@gmail.com |
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