

## Domain Track Title: Renewable Energy Applications

Track Total Credits (4-8-10): 22 Credits

### Courses Division:

1. CURE2190 Materials for Renewable Energy applications (1-1-0)
2. CURE2191 Renewable Energy Technology for Industrial Process (1-2-0)
3. CURE2192 Micro-grid Design & Implementation (0-2-0)
4. CURE2193 Hybrid Renewable Energy Systems (1-2-0)
5. CURE2194 Solar Off-grid Entrepreneur (1-1-0)
6. CURE2195 project (0-0-6)
7. CURE2196 Internship (0-0-4)

### Domain Track Objectives:

The objectives of these subjects are:

1. To gain the knowledge on different types of materials used in Renewable Energy.
2. To understand the importance of Renewable Energy technology and its applications.
3. To know the applications of solar thermal technology.
4. To become expert in Entrepreneurship.

### 1. Material for Renewable Energy application (30 hrs)

1.1 Basic fundamentals of different types semiconductors (Energy band, charge carriers and their motion, generation, recombination, doping)

1.2 Practice: Crystal structure, phase identification and crystallite size determination of PV materials by XRD (using Biovia MS and phase identification by using relevant software)

1.3 Photovoltaic Cell - Construction & Working (Si based)

1.4 Practice: UV visible analysis of photovoltaic material

1.5 Concept of various types PN junction.

1.6 Practice: Measurement of photo luminescence (PL) behaviour of photovoltaic material

1.7 Role of materials for sustainable development of next generation photovoltaic cells

1.8 Practice: To study crystallites (grain) size and strain through *Williamson-Hall plot* method

<https://www.youtube.com/watch?v=LJ9h77fN4-E&t=1308s>

1.9 Efficiency calculation of solar cell

1.10 Practice: To determine the resistivity of semiconductors by Four probe Method.

<http://vlab.amrita.edu/?sub=1&brch=282&sim=1512&cnt=1>

- 1.11 Nano-Photovoltaic (Graphene/CNT, ZNO, TiO<sub>2</sub>)
- 1.12 Practice: Study of Hall effect (Determination of nature of charge carriers in a semiconductor)  
<http://vlab.amrita.edu/?sub=1&brch=282&sim=879&cnt=4>
- 1.13 Composite materials for solar cell (Graphene/Al, TiO<sub>2</sub>-SiO<sub>2</sub> composite for solar cell)
- 1.14 Perovskite based solar cell (transition metal doped PbTiO<sub>2</sub>)
- 1.15 Dye-sensitized solar cells
- 1.16 Materials (Al/hybrid glass-carbon fiber) for wind energy conversion

**Text Book:**

1. Vincent, D. , Materials for Sustainable Energy, Nature publishing group, 2010.
2. Paranthaman, M. Parans, Wong-Ng, Winnie, Bhattacharya, Raghu N (Eds.), Semiconductor Materials for Solar Photovoltaic Cells, Springer, 2015.

**Reference Book:**

1. Sabu, T., El HadjiMamour, S., Nandakumar, K., Samuel, O., Jihuai, W., Nanomaterials for Solar Cell Applications, Elsevier, 2019.
2. Peter, P. Rogers, Kazi F. Jalal, John A. Boyd, An introduction to sustainable development, Glen Educational Foundation, 2008.

**2. Renewable Energy Technology for Industrial Process (48 hrs)**

- 2.1 Relevance of economic and financial viability evaluation of renewable energy technologies, Renewable Energy Policies of India and in the state of Odisha
- 2.2 Practice: Site visit for acquire knowledge on different renewable energy technologies and it's system
- 2.3 Basics of light to energy conversion and Concept on solar PV
- 2.4 Practice: Measurements and estimation of solar radiation
- 2.5 Concept of mono-crystalline, poly-crystalline, amorphous
- 2.6 Practice: Identify and specify different types of components used in a solar PV system
- 2.7 New generation of Solar cell, working principle and applications
- 2.8 Practice: Simulation of solar cell by using PVSOL software
- 2.9 Effects of parameters on PV module power and efficiency
- 2.10 Practice: VI characteristics of solar cell/module
- 2.11 Concept on Concentrated solar thermal (CST)
- 2.12 Practice: Temperature tracking of solar cell/module
- 2.13 Concentrated solar power (CSP), new technology of solar thermal
- 2.14 Practice: Performance of Solar PV module at varying tilt angle

- 2.15 Concept of wind energy, Basic laws and efficiency limit for wind energy conversion
- 2.16 Practice: Modelling of solar cooker
- 2.17 Concept of aerodynamics effects
- 2.18 Practice: Modelling of solar flat plate collector
- 2.19 description of horizontal and vertical axis wind turbine
- 2.20 Practice: Generation of electricity by wind machines
- 2.21 Concept on Biomass, Electricity generation from biomass.
- 2.22 Practice: Maximum power point tracking of a wind turbine
- 2.23 Practice: Performance testing of bio diesel in VCR machine

**Text Books:**

1. D. P. Kothari, K. C. Singal and R. Ranjan, Renewable Energy Sources and Emerging Technologies, Second Edition, PHI Learning Pvt. Ltd, New Delhi, 2011.
2. C. S. Solanki, Photovoltaic – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.

**Reference Book:**

1. V. V. N. Kishore, Renewable Energy Engineering and Technology: principles and practice, Teri, India, 2008.
2. Hakeem, Khalid Rehman, Jawaid, Mohammad, Rashid, Umer (Eds.), Biomass and Bioenergy Applications, Springer, 2014.
3. S. S. Das, D. D. Behera, and A. Pradhan, Clean Energy Products: A Path for Attaining Livelihood Security, Notion Press, and ISBN: 9781636691602, 2020.
4. S. S. Das, D. D. Behera, and N. C. Giri, Clean Energy Applications in Modern World, Notion Press, ISBN: 9781638069560, 2021.

**3. Micro-grid Design and Implementation (36 hrs)**

- 3.1 Practice: Site survey (1 kW or 1MW)
- 3.2 Practice: Sizing of micro grid system (1kW/1MW)
- 3.3 Practice: Single line diagram of micro grid system
- 3.4 Practice: Identify and specify different components used in a micro grid system
- 3.5 Practice: Connection practice of solar modules in a micro grid system
- 3.6 Practice: Designing of micro grid system
- 3.7 Practice: Analysis of micro grid system
- 3.8 Practice: Designing of micro grid system with battery storage
- 3.9 Practice: Performance calculation of micro grid system
- 3.10 Practice: Connection practice of CCR/Inverter in a micro grid system
- 3.11 Practice: Test, record and verify the power quality of a micro grid system

### 3.12 Practice: O & M of micro grid system

#### Text Books:

1. Suneal Deambi, Photovoltaic System Design: Procedures, Tools and Applications, CRC Press, 2018.
2. Miguel Castilla, Antonio Carlos Zambroni de Souza, Microgrids Design and Implementation, Springer, 2019.

#### Reference Books:

1. S. S. Das, D. D. Behera, and N. C. Giri, Clean Energy Applications in Modern World, Notion Press, ISBN: 9781638069560, 2021.
2. Federico Delfino, Renato Procopio, Massimo Brignone, Michela Robba, Mansueto Rossi, Stefano Bracco, Microgrid Design and Operation: Toward Smart Energy in Cities, Artech House, London, 2018

## **4. Hybrid Renewable Energy System (48 hrs)**

4.1 Global scenario of Hybrid renewable energy system, integrated renewable energy systems with input sources

4.2 Practice: Modelling of renewable energy systems

4.3 integrated renewable energy systems with input sources

4.4 Practice: Connection practice of Solar PV-T System

4.5 Selection of technology and components for hybrid renewable systems.

4.6 Practice: Designing of solar PV system (On-grid/Off-grid)

4.7 Concept of hybrid solar PVT system

4.8 Practice: Designing of hybrid solar-thermal system

4.9 Selection of Components for Hybrid solar PV-T system

4.10 Practice: Analysis of hybrid solar-thermal system

4.11 Synchronization process of renewable systems.

4.12 Practice: Connection practice of PV-wind system

4.13 Operation of hybrid PV and wind system

4.14 Practice: Modelling of wind power system

4.15 Concept of hybrid PV and wind system and its components

4.16 Practice: Demonstration of Load curve in the plant

4.17 Load curve

4.18 Practice: Study the dynamic behavior of wind turbines

4.19 Concept of Hybrid PV and hydro system and its components

- 4.20 Practice: Modelling of hydro power system
- 4.21 Concept of hybrid PV and Biomass system and its components
- 4.22 Practice: Chemical composition of biomass system
- 4.23. Practice: Emission testing of bio diesel/bio ethanol in gas analyzer

**Text Books:**

1. S. Sukhatme and J. Nayak: Solar Energy: Principle of Thermal collection and storage, Third Edition ( Tata McGraw-Hill, 2008)
2. C. S. Solanki: Solar Photovoltaic – Fundamentals, Technologies and Applications, PHI.

**Reference Books:**

1. Ersan Kabalci, Hybrid Renewable Energy Systems and Microgrids,
2. V. N. Kishore, Renewable Energy Engineering and Technology: principles and practice, Teri, India, 2008.
3. N. C. Giri, S. R. Nayak, S. P. Mishra, and S. N. Sahu, Project Management and Smart Electrical Systems, ISBN 9798587652200, Amazon; 1st edition, 27 December 2020.

**5. Solar Off-grid Entrepreneur (30 hrs)**

- 5.1 MNRE schemes and state wise subsidy process
- 5.2 Practice: Identify and specify different types of Solar PV Off grid products
- 5.3 Cost of different solar off grid systems components
- 5.4 Practice: Costing sheet preparation
- 5.5 Selection criteria of suitable components
- 5.6 Practice: Proposal preparation with payment terms and condition
- 5.7 Assessment of business development
- 5.8 Practice: Analysis and assessment of project cost
- 5.9 Economic profile and power consumption trends
- 5.10 Practice: Customer financial strength calculation
- 5.11 Government and private bank funding systems
- 5.12 Practice: Identify the customer requirements for solar home lightning systems
- 5.13 Solar off grid system manufacturers and suppliers
- 5.14 Right equipment should be installed in right place
- 5.15 Attend and resolve customer queries
- 5.16 Entrepreneurship skill

**Text Books:**

1. Rameshwari Pandya, Skill Development and Entrepreneurship in India, 2016.

2. Joseph P. Oconnor, Off Grid Solar, Second edition, Old Sequoia Publishing, 2016.
3. Poornima Charantimath, Entrepreneurship Development and small Business Enterprises, Third edition, Pearson, 2018.

**Reference Books:**

1. C. S. Solanki: Solar Photovoltaic – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.
2. Michael Boxwell -- Solar Electricity Handbook - 2014 Edition: A Simple Practical Guide to Solar Energy.

Domain Track Course outcomes:

Upon successful completion of this subject, students should be able to

1. Know in depth of materials of Sustainable energy products and it's applications.
2. Explain basics of Renewable energy technologies and it's applications.
3. Increased awareness about solar thermal technology.
4. Become industry-ready in Entrepreneurship.

**Domain Syllabus:****Session Plan for the Entire Domain:****1. Material for Renewable Energy Application (30 hrs)**

Session 1. Basic fundamentals of different types semiconductors (Energy band, charge carriers and their motion, generation, recombination, doping)

<https://www.youtube.com/watch?v=ethnHSgVbHs>

<https://www.youtube.com/watch?v=Yu2YpVtuOds>

Session 2. Practice: Crystal structure, phase identification and crystallite size determination of PV materials by XRD (using Biovia MS and phase identification by using relevant software)

<http://vlab.amrita.edu/?sub=1&brch=282&sim=370&cnt=1>

Session 3 .Photovoltaic Cell - Construction & Working (Si based)

<https://www.youtube.com/watch?v=sXcsKzJyIrA>

Session 4. Practice: UV visible analysis of photovoltaic material

<https://www.youtube.com/watch?v=s5uIVQGFDE4>

<https://www.youtube.com/watch?v=a9fSg2TREag>

Session 5. Concept of various types PN junction

<https://www.youtube.com/watch?v=4SlfaocMfdA>

Session 6. Practice: Measurement of photoluminescence (PL) behaviour of photovoltaic material

<https://www.youtube.com/watch?v=GqivfoW32rg&t=7s>

<https://www.youtube.com/watch?v=uZqXXafYoME>

Session 7. Role of materials for sustainable development of next generation photovoltaic cells

<https://www.youtube.com/watch?v=HEgYLOoE5MQ&feature=youtu.be>

Session 8. Practice: Make a solar cell – TiO<sub>2</sub>/Raspberry based

<https://www.youtube.com/watch?v=WHTbw5jy6qU>

Session 9. Efficiency calculation of solar cell

<https://www.youtube.com/watch?v=IxFIewx54Ok>

<https://www.youtube.com/watch?v=IkVLQALtdQw>

Session 10. Nano-Photovoltaic (Graphene/CNT, ZNO, TiO<sub>2</sub>)

<https://www.youtube.com/watch?v=j4u09hi9DXI&t=150s>

<https://www.youtube.com/watch?v=BKomGuejwRA&t=55s>

<https://www.youtube.com/watch?v=Y2vvTPc30fE>

Session 11. Practice: Calculate the sun position at a given place and time and thereby study the variation in power production in a solar photovoltaic panel with respect to the change in incidence angle

<http://vlab.amrita.edu/?sub=77&brch=298&sim=1629&cnt=1>

Session 12. Composite materials for solar cell (Graphene/Al, TiO<sub>2</sub>-SiO<sub>2</sub> composite for solar cell)

<https://www.youtube.com/watch?v=BKomGuejwRA>

<https://www.youtube.com/watch?v=qDviZVbf7AA>

<https://www.youtube.com/watch?v=qvxH0RuaTpY&feature=youtu.be>

Session 13. Practice: Specific charge/discharge characteristics of a Lithium-ion (Li-ion) battery

<http://vlab.amrita.edu/?sub=77&brch=270&sim=1540&cnt=1>

Session 14. Perovskite based solar cell (transition metal doped PbTiO<sub>2</sub>)

<https://www.youtube.com/watch?v=NSItaUCG46E>

Session 15. Dye-sensitized solar cell

<https://www.youtube.com/watch?v=8hertoGXWtE>

[https://www.youtube.com/watch?v=CWEKfxBc4\\_8](https://www.youtube.com/watch?v=CWEKfxBc4_8)

Session 16. Materials (Al/hybrid glass-carbon fiber) for wind energy conversion.

<https://www.youtube.com/watch?v=0uLmVDTwsno>

<https://www.youtube.com/watch?v=xyjLd957ITk>

## **2. Renewable Energy Technology for Industrial Process (48 hrs)**

Session 18. Relevance of economic and financial viability evaluation of renewable energy technologies

[https://youtu.be/X9x\\_fSU2a6U](https://youtu.be/X9x_fSU2a6U)

Session 19. Practice: Site visit for acquire knowledge on different renewable energy technologies and it's system

Session 20. Basics of light to energy conversion and Concept on solar PV

<https://youtu.be/vzBkgMONIFo>

<https://youtu.be/1gta2ICarDw>

Session 21. Practice: Measurements and estimation of solar radiation

Session 22. Concept of mono crystalline, poly crystalline, amorphous

<https://youtu.be/Fip520UdeNU>

Session 23. Practice: Simulation of solar cell

Session 24. New generation solar cell, working principle and applications

[https://youtu.be/8t\\_DFI4O6v4](https://youtu.be/8t_DFI4O6v4)

Session 25. Practice: Identify and specify different types of components using in a solar PV system

Session 26. Practice: VI characteristics of Solar cell/module

Session 27. Working principle and applications

<https://youtu.be/ZYO83TkM0To>

Session 28. Practice: Temperature tracking of solar cell/module

Session 29. Effects of parameters on PV module power and efficiency

<https://youtu.be/JTDSPjDSrS8>

Session 30. Practice: Performance of Solar PV module at varying tilt angle

Session 31. Concept on Concentrated solar thermal (CST)

<https://youtu.be/tdivW7inP0k>

[HAND-NOTES-ON-SOLAR-THERMAL-ENGINEERING-pdf](#)



Session 32. Practice: Modelling of solar cooker

<https://www.youtube.com/watch?v=WPwDwjsAp4U&t=84s>

Session 33. Concentrated solar power (CSP)

<https://youtu.be/N1-zjbRqYXk>

Session 34. Practice: Modelling of solar flat plate collector

<https://www.youtube.com/watch?v=XWvr3OT1E1c>

<https://www.youtube.com/watch?v=s-Ysg6Xaf3c>

<https://www.youtube.com/watch?v=70Z5UNoywyE&t=223s>

Session 35. Concept of wind energy, Basic laws and efficiency limit for wind energy conversion.

[https://www.youtube.com/watch?v=qSWm\\_nprfqE](https://www.youtube.com/watch?v=qSWm_nprfqE)

Session 36. Practice: Generation of electricity by wind machines

Session 37. Concept of aerodynamics effects,description of horizontal and vertical axis wind turbine

<https://www.youtube.com/watch?v=65k2Nh8YHFI>

<https://www.youtube.com/watch?v=A-k2YGrpATo&t=13s>

Session 38. Practice: Maximum power point tracking of a wind turbine

Session 39. Practice: Performance testing of bio diesel in VCR machine

[https://www.youtube.com/watch?v=b1PbQ7jjVVM&list=PLniBGjZYcl478NRpoWh-YF\\_f2E90HZzda](https://www.youtube.com/watch?v=b1PbQ7jjVVM&list=PLniBGjZYcl478NRpoWh-YF_f2E90HZzda)

<https://www.youtube.com/watch?v=rrldwVGmmy4&t=161s>

[https://www.youtube.com/watch?v=KZ35K05SA7g&list=PLniBGjZYcl478NRpoWh-YF\\_f2E90HZzda&index=7](https://www.youtube.com/watch?v=KZ35K05SA7g&list=PLniBGjZYcl478NRpoWh-YF_f2E90HZzda&index=7)

### **3. Micro grid Design and Implementation (36 hrs)**

Session 41. Practice: Site survey (1 kW or 1MW)

Session 42. Practice: Sizing of micro grid system (1kW/1MW)

Session 43. Practice: Single line diagram of micro grid system

Session 44. Practice: Identify and specify different components used in a micro grid system

Session 45. Practice: Connection practice of solar modules in a micro grid system

Session 46. Practice: Designing of micro grid system

Session 47. Practice: Analysis of micro grid system

Session 48. Practice: Designing of micro grid system with battery storage

Session 49. Practice: Performance calculation of micro grid system

Session 50. Practice: Connection practice of CCR/Inverter in a micro grid system

Session 51. Practice: Test, record and verify the power quality of a micro grid system

Session 52. Practice: O & M of micro grid system

#### **4. Hybrid Renewable Energy Systems (48 hrs)**

Session 53. Global scenario of Hybrid renewable energy system, integrated renewable energy systems with input sources

[https://youtu.be/j\\_fViOJbJLk](https://youtu.be/j_fViOJbJLk)

<https://youtu.be/TD0jZciQcaE>

Session 54. Practice: Modelling of renewable energy systems

Session 55. Selection of technology and components for efficient hybrid renewable systems

<https://youtu.be/ALsOcGkrev0>

Session 56. Practice: Connection practice of Solar PV-T System

Session 57. Concept on hybrid solar PVT system and it's components

<https://youtu.be/hseYnkOOghI>

Session 58. Practice: Designing of solar PV system (On-grid/Off-grid)

Session 59. Synchronization process of renewable systems

[https://youtu.be/COz\\_w510nOw](https://youtu.be/COz_w510nOw)

Session 60. Practice: Designing of hybrid solar-thermal system

Session 61. Operation of hybrid solar-thermal system

<https://youtu.be/Lm7kmCaoeC4>

Session 62. Practice: Analysis of hybrid solar-thermal system

Session 63. Concept of hybrid PV and wind system and it's components

<https://youtu.be/rPm-JHeD5Z0>

Session 64. Practice: Connection practice of PV-wind system

<https://www.youtube.com/watch?v=eIzsUKcq3tw&t=9s>

Session 65. Operation of hybrid PV and wind system

<https://youtu.be/s458bCI8u2Q>

Session 66. Practice: Modelling of hybrid PV and wind power system

<https://www.youtube.com/watch?v=gzwDdo3iuSY>

Session 67. Load curve

[https://youtu.be/OQsk\\_4oqFmc](https://youtu.be/OQsk_4oqFmc)

Session 68. Practice: Demonstration of Load curve in the plant

<https://www.youtube.com/watch?v=b-ka2qObhzk>

Session 69. Concept of hybrid PV and hydro system and its components

<https://youtu.be/9qu5ryJBIII>

Session 70. Practice: Modelling of hydro power system

<https://www.youtube.com/watch?v=gdOaG8cKLuw>

Session 71. Concept of hybrid PV and Biomass system and its components

<https://youtu.be/XboxQHJPD4>

Session 72. Practice: Chemical composition of biomass system

Session 73. Practice: Study the dynamic behavior of wind turbines

<https://www.youtube.com/watch?v=aSwGUVqrBMQ>

Session 74. Practice: Emission testing of bio diesel/bio ethanol in gas analyser

## **5. Solar Off-Grid Entrepreneur (36 hrs)**

Session 75. MNRE schemes and state wise subsidy process

<https://www.youtube.com/watch?v=xKxrkht7CpY>

<https://www.youtube.com/watch?v=xlXZmNUYcfI>

Session 76. Practice: Identify and specify different types of Solar PV Off grid products

<https://www.youtube.com/watch?v=JJYyD3oNd8w>

Session 77. Cost of different solar off grid systems components and Selection criteria of suitable components.

<https://youtu.be/bxFX7C383ig>

Session 78. Practice: Costing sheet preparation

Session 79. Selection criteria of suitable components

<https://youtu.be/HLV07G37rh0>

Session 80. Practice: Proposal preparation with payment terms and condition

Session 81. Assessment of business development

[https://youtu.be/RgNV2D2c5\\_w](https://youtu.be/RgNV2D2c5_w)

Session 82. Practice: Analysis and assessment of project cost

Session 83. Economic profile and power consumption trends

[https://youtu.be/L5v9jt4\\_ho](https://youtu.be/L5v9jt4_ho)

Session 84. Practice: Customer financial strength calculation

Session 85. Government and private bank funding lightning systems

<https://youtu.be/dJLbD7f5cDk>

Session 86. Practice: Identify the customer requirements for solar home lightning systems

Session 87. Solar off grid system manufacturers and suppliers

<https://youtu.be/2R3ahfcB68g>

Session 88. Right equipment should be installed in right place

<https://youtu.be/cG3bkKJGzoc>

Session 89. Attend and resolve customer queries

[https://youtu.be/hilb4v\\_dnck](https://youtu.be/hilb4v_dnck)

Session 90. Entrepreneurship skill

[https://youtu.be/CFtN\\_S1ekF4](https://youtu.be/CFtN_S1ekF4)

List of Projects/papers/jobs/products to be done in domain:

1. Study on Perovskite based material for the application of Solar cell
2. Preparation of solar based material and it's characterization
3. Efficiency enhancement of solar cell using rare earth materials
4. Design and development of solar powered lamps/street lights.
5. Design and development of solar auto tracking system
6. Design and development of solar powered water pumping system
7. Design and development of solar operated grass trimmer
8. Design and development of solar powered pesticide sprayer
9. Design and development of solar powered leaf plate making machine
10. Design and development of solar powered bicycle
11. Design and development of solar powered sugarcane juice machine

12. Design and fabrication of solar dryer
13. Design and development of solar parabolic trough concentrator for water heating purpose
14. Design and development of solar cooker (box type or dish type)
15. Design and development of solar powered poly house system
16. Design and development of solar desalinization system
17. Design and development of solar operated blacksmith blower
18. Design and development of portable solar mobile charging station
19. Design and development of solar tree
20. Design and development of evacuated type of solar collector of water heating system
21. Design and development of torque control of wind turbine using energy analysis method
22. Analysis and design of generator side control of wind turbine
23. Design and development of micro-hydro power plant
24. Design and development of wind power system
25. Performance testing and comparison test of bio diesel in VCR Engine