Sustainable Energy

18EE0301T

Syllabus & References

Course Code	18EEO301T	Course Name	SUSTAINABLE ENERGY	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	NIL	Co-requisite Courses	NIL	Progressive Courses	NIL
Course Offering Department	Electrical and Electronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Enrich the students on the basics of solar energy
CLR-2 :	Develop the knowledge in wind energy conversion system
CLR-3 :	Understand the energy generation by biomass
CLR-4 :	Gain knowledge on ocean ,tidal energy
CLR-5 :	Acquire knowledge in fuel cell and its types
CLR-6 :	Apply the concepts of renewable energy in industrial applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Obtain in depth knowledge on solar applications	2	80	75
CLO-2 :	Explain the concepts of wind energy conversion systems and their control	3	80	75
CLO-3 :	Summarize the biomass technologies and calculate the power conversion of biomass digestion	3	80	75
CLO-4 :	Interpret the environmental impacts of ocean and tidal energy	3	80	75
CLO-5 :	Summarize the working principle of fuels cells and its types	3	80	75
CLO-6 :	Infer the knowledge about various types of renewable energy systems	3	80	75

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	M	M	-	-	-	L	-	-	-	-	-	H	M	-
H	M	M	-	-	-	L	-	-	-	-	-	H	M	-
H	M	-	-	-	-	L	-	-	-	-	-	H	M	-
H	M	-	-	-	-	L	-	-	-	-	-	H	M	-
H	M	-	-	-	-	L	-	-	-	-	-	H	M	-
H	M	M	-	-	-	L	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Solar radiation	Wind energy conversion	Biogas	Ocean thermal energy conversion	Fuel Cell
	SLO-2	Beam and diffuse radiation, solar constant, earth	Principles of Wind energy conversion	Energy from Biomass	Principle of OTEC	Basics of Fuel cell
S-2	SLO-1	Sun angles	Nature of the wind	Types of biomass	Lambert law of absorption	Components of fuel cells
	SLO-2	Calculation of angle of incidence	Factors influencing wind	Photosynthesis	OTEC power plant	Difference between batteries and fuel cell
S-3	SLO-1	Attenuation and measurement of solar radiation	Wind data and energy estimation- wind speed monitoring,	Factors affecting digestion system	Open loop system for ocean energy conversion	Types of fuel cells
	SLO-2	Local solar time, derived solar angles, sunrise, sunset and day length	Site selection	Classification of biogas plants	Closed loop system for ocean energy conversion	Ionic conductivity of fuel cell
S-4	SLO-1	Flat plate collectors, concentrating collectors	Power in the wind	Advantages and disadvantages of biogas plants	Single basin	Electronic conductivity in fuel cell
	SLO-2	Solar air heaters, types, solar driers	Betz limit	Factors affecting bio digestion	dual basin ocean energy conversion system	Principle of working of fuel cell
S-5	SLO-1	Storage of solar energy, thermal storage	Components of a wind energy conversion system	Biomass as Renewable Energy Source	Major problems and operational experience Tidal energy	Performance characteristics of fuel cells
	SLO-2	Solar pond , solar water heaters	Torque on wind	Coliring	Site selection of tidal power plant	Selection of fuel cells
S-6	SLO-1	Solar distillation	Wind thrust calculations Repowering concept	Dry Process	Tide Spring tide	Fuel cell stack
	SLO-2	Solar Pond	Horizontal Axis Wind Turbine(HAWT design consideration)	Photosynthesis	Neap tide Tidal range	fuel cell power plant
S-7	SLO-1	Solar heating & cooling of buildings	Tip Speed Ratio	Energy farming	Types of Tidal power plant	Cross section of typical PEM fuel cell
	SLO-2	Solar still, solar cooker	Solidity	Pyrolysis	Advantages and disadvantages of tidal power plant	Storage methods for fuel cells
S-8	SLO-1	Photo voltaic. Types of PV cells	Types of generators and power converters in WECS	Types of Biomass Fuels	Wave Energy	Challenges and trends in fuel cell

	SLO-2	Characteristics and working principles of PV	Control schemes for power converters.	Biomass power plant	Wave Characteristics	Efficiency of fuel cell
S-9	SLO-1	Maximum power point tracking methods	Introduction to grid integration of WECS	Biomass cogeneration	Different wave energy convertors, Salter Duck	Applications of fuel cell
	SLO-2	Net metering concepts	Issues in grid integration	Digester design	Oscillating water column and dolphin types	Advantages and disadvantages of fuel cell

Learning Resources	1. Rai ,G.D.,Non Conventional sources of Energy, Khanna Publishers ,5th Edition 2016. 2. Khan. B.H, "Non-Conventional Energy Resources", The McGraw Hills.2nd Edition, 2016	3. O'Hayre, R.P., S. Cha, W. Colella, F.B.Prinz, Fuel Cell Fundamentals, Wiley, NY (2006). 4. https://onlinecourses-archive.nptel.ac.in/.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Sustainable Egy Notes & PPT

(A1) SolarCellsFabricati.pptx
(A2) Solar Egy. Pdf
(A3) Solar Egy. pptx
(A4) Solar Radiation

(A5) Sustainable energy hinde on Unit 1

Unit I

S1/SLO-1 & SLO-2 (A2) PP 4-6
S2/SLO-1 & SLO-2 (A2) PP 7-10 BH Khan PP 58-61
S3 | SLO 2 (A2) PP 10, 11, Book by
S4/SLO-1 (A2) PP 12-14, 16
SLO-2 (A2) PP 17-20
S5 | SLO 1 (A2) PP 20, 21, 22
SLO 2 (A2) PP 23, 24
S6/SLO 1 (A2) PP 25
SLO 2 (A2) PP 23, 24
S7/SLO-1 (A2) PP 26
SLO 2 (A2) PP 28-30
(A5) Solar Still
S8/SLO 1 & SLO 2 (A2) PP 30-32
S9/SLO 1 & SLO 2 (A2) PP 32-36
S3/SLO 1 (A2) PP 6 + (A5) GDRevil PP 64-68 (Book PP 47-51)
(Left measurement of Solar Radiation)

Also read Slide on PP 23, 24, 35, 36, 57, 58 of (A3)
(For working principle of PV
Slide on Page PP 8, 45-50, 69-71 of (A4)

Sustainable Energy Notes & PPTs

(B1) Tidal Power.pdf
(B2) Wind Energy Fundamentals.pdf
(B3) Wind Energy.docx
(B4) Wind Energy.pdf
(B5) Wind Energy.ppt
(B6) Wind Power.ppt

(B7) Sustainable Energy links on Unit 2

Unit 2

S1/SLO-1, SLO-2 } Book G.D.Rai PP192-194 & PP202-205 ; (B4) PP 1-10 (S0 S0)
Book Page 175-177 & 185-888

S2/SLO-1 G.D.Rai PP194-195 Art-G.2.1
Book Page 177-178
SLO-2 (B4) PP13-21

S3/SLO-1 Rai Art-G.3 PP206-210 (Book 189-193)
SLO-2 Rai Art-G.4 PP210-213 (Book 193-196)

S4/SLO-1, SLO-2 → Rai Art-G.2.2 PP195-201 (Book 198-184)
(B4) PP10-12 (So So)

S5/SLO-1 Rai Art-G.5 PP213-216 (Book 196-199)
SLO-2 Rai Art-G.2.3 PP201,202 (Book 184,185)
(B4) PP12,13 (So So)

S6/SLO-1 → (B7)
SLO-2 → Rai Art-G.8.3 PP221-229 (Book 204-212)
→ (B5) PP36-39 (Figures)

(B2) PP13-15,17 (So So)
(B5) PP 24, 25 (So So)
(B6) PP4-7, 14-19 24-28

S7/SLO-1, SLO-2 } Same as above Rai PP221-225
→ SLO-2 (B3) PP21, 22 → Can See

S8/SLO-1 (B5) PP 63-65 & (B7)
SLO-2 (B7)

S9/SLO-1, SLO-2 } (B2) PP27,28 & 38-40
& (B7)

Sustainable Egy Notes & PPTs

(C1) APznzaah (pdf)
(C2) Biomass energy
(C3) Bioenergy PPT(1).pdf
(C4) Biomass energy.docx
(C5) Biomass ppt.pptx
(C6) Biomass.docx
(C7) Bioenergy PPT.pdf
(C8) Sustainable Energy links - on Unit-3

Unit 3

S1/SLO-1 (C6) PP1
SLO-2 (C6) PP4-5
S2/SLO-1 (C6) PP1-3
SLO-2 (C6) PP3-4
S3/SLO-1 (C6) PP5,6
SLO2-2 (C6) PP6-9
S4/SLO-1 (C6) PP10-11
SLO-2 (C8)
S5/SLO1, SLO2 } (C8)
S6/SLO1, SLO2 } (C4) PP9-12
S7/SLO1 (C4) PP1-2
SLO2 (C4) PP3-4
S8/SLO1 (C4) PP6-8 + (C8)
SLO2 (C8)
S9/SLO1, SLO2 } (C8)

Sustainable Energy Notes & PPTs

(D1) Ocean.ppt

(D2) Oceanenergy.pdf

(D3) Ocean-energy.ppt

(D4) Oceanenergy-Converters.pptx

(D5) OTEC.docx

(D6) Tidal Power.pdf

(D7) Sustainable Energy links on Unit 4

Unit 4

S1/SLO1 (D5) PP1

SLO2 (D6) PP24, D5 PP2-4

+DesktopNoti (1 Page) or (D7) link (PP1-3)

S2/SLO1 (D7) } GD Rai Art. 9.2.1 PP393-396 (Book PP376-379)

SLO2

S3/SLO1 (D5) PP5-6 So So

SLO2 (D2) PP14, 15

GDRai PP396-400 (Book PP379-383) Art 9.2.2-9.2.4

S4/SLO1, SLO2/GD Rai PP416-149 (Book PP399-402)

Khan PP169-171 So So

(D5) PP10-16 → included in S7

(D7) → 2 Pages

S5 → (D7) GD Rai PP 404 (Book PP387) 402 (PP385)

S6/SLO1 } (D5) PP6-8 ; Tidal Range Khan PP169 GD Rai PP 405-408 (Book PP389-391)

SLO2 }

S7/SLO1 } (D5) PP9-16 (PP12 for SLO2)

SLO2 }

S8/SLO1 (D5) PP16

SLO2 (D5) PP16-17

S9/SLO1 (D5) PP18-23

SLO2 (D5) PP 23-26

Sustainable Energy Notes & PPTs

(E1) Fuel Cell
(E2) Fuel Cell - [redacted]
(E3) Sustainable Energy links on Unit 5

Units

S1/SLO1 - (E1) PP1-7 (E2) PP9
GDRai PP444,445 (art.10.1,10.2) (Book Page 427, 428)

Khan PP192 Art 12.1

SLO2 - (E2) PP 3,4 GDRai as above SLO1

S2/SLO1 - GDRai PP41,42 (art 1.10), 445 (Book Page 428)
↳ Book Page 24,25

SLO2 - (E3)

S3/SLO1 - (E1) PP12-27, (E3) PP8-14, GDRai PP448-454 (art 10.23-10.24)
↳ Book Page 431-437

SLO2 - (E3)

S4/SLO1 - (E3)

SLO2 - (E1) PP9-11, 28, GDRai PP445-447 (art 10.2.2) Book Page 428-430

S5/SLO1 - (E1) PP29 (E3) - PP15-23 Khan PP197 (art 12.1.8)

SLO2 - ~~Khan PP200 (Art 12.1.12)~~ E3

S6/SLO1 - (E3)

SLO2 - Khan PP200 (Art 12.1.12)

S7/SLO1 - Khan PP194,195 (Art 12.1.5)

SLO2 - (E3); Khan PP203-204 (Art 12.2.3)

S8/SLO1 - (E3)

SLO2 - (E1) PP32, GDRai Art 10.2.6 PP454-458 Book PP437-441

Khan PP198 (Art 12.1.10)

S9/SLO1 - (E1) PP36-37, GDRai PP.465-466 Art 10.2.9 (Book PP 448-449)

SLO2 - (E1) PP 8, 35 GDRai
↳ PP 454 Art 10.2.5 Book PP 434