PSN College of Engineering and Technology
An Autonomous Institution, Affiliated to Anna University
Approved by AICTE, Accredited by NAAC with A+ Grade

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE PLAN
(Regulation 2022)

Version: 1 **Updated on: 29.05.2024** **No. of pages: 12**

Subject Name & Code	Hybrid Energy Technology & EE606701
Course Type	Program Elective
Programme	B.E. EEE (UG)
Year/Semester/Section	III Year / V Semester
Nature of Course/Credit	Theory / 3
Course Coordinator	Mrs. V.Jenitha, AP/ EEE

VISION AND MISSION OF THE INSTITUTE & DEPARTMENT

	Vision	Mission	
Institute	To emerge as a pioneer institute inculcating engineering education, skills, research, values and ethics.	**IM-1**	To achieve greater heights of excellence in technical knowledge and skill development through innovative teaching and learning practices.
		IM-2	To develop the state of art infrastructure to meet the demands of technological revolution.
		IM-3	To improve and foster research in all dimensions for betterment of society.
		IM-4	To develop individual competencies to enhance innovation, employability and entrepreneurship among students.
		IM-5	To instill higher standards of discipline among students, inculcating ethical and moral values for societal harmony and peace.
Department	To emerge as pre-eminence program for quality Electrical and Electronics Engineering Graduates	**DM-1**	To enable quality infrastructure for advanced knowledge and skills towards learning under congenial environment for global placement, higher studies, research and entrepreneurship.
		DM-2	To stimulate the process of critical thinking and problem solving with special focus on research capabilities.
		DM-3	To enhance professional ethics, values and standards to meet the demands of society

1. PRE REQUISITES

- Conventional and Alternate Energy Sources
- Power Electronics

2. COURSE DESCRIPTION

This course introduces the knowledge about different types of hybrid energy systems, analyze the various electrical generators used for the Wind Energy Conversion Systems and design the power converters used in SPV Systems.

3. CARRIER OPPORTUNITIES:

Job Description

- Graduates may find employment in wind and solar energy companies.
- Can able to be an Area sales manager- Power Electronic Engineer, service In-charge

4. SYLLABUS

UNIT–I	INTRODUCTION TO HYBRID ENERGY SYSTEMS	Hrs
Hybrid Energy Systems – Need for Hybrid Energy Systems – Solar-Wind-Fuel Cell-Diesel, Wind, Biomass-Diesel, Micro Hydel - PV, Ocean and geyser energy - Classification of Hybrid Energy systems – Importance of Hybrid Energy systems – Advantages and Disadvantages - Environmental aspects of renewable energy - Impacts of renewable energy generation on the environment - Present Indian and international energy scenario of conventional and RE sources - Ocean energy, Hydel Energy - Wind Energy, Biomass energy, Hydrogen energy - Solar Photovoltaic (PV) and Fuel cells: Operating principles and characteristics.		**9**
UNIT-II	**ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS)**	**Hrs**
Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).		**9**
UNIT-III	**POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS**	**Hrs**
Power Converters for SPV Systems - Line commutated converters (inversion-mode) - Boost and buck boost converters- selection of inverter, battery sizing, array sizing - Analysis of SPV Systems – Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems.		**9**
UNIT –IV	**ANALYSIS OF POWER CONVERTERS FOR HYBRID ENERGY SYSTEMS**	**Hrs**
Introduction to Power Converters – Stand-alone Converters -AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters - Bi-Directional Converters - Grid-Interactive Inverters - Matrix converter – Merits and Limitations.		**9**
UNIT–V	**CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS**	**Hrs**
Hybrid Systems- Range and type of Hybrid systems – Performance Analysis – Cost Analysis – Case studies of Diesel-PV, Wind-PV-Fuel-cell, Micro-hydel-PV, Biomass-Diesel-Fuel-cell systems.		**9**

Total: 45Period

5. COURSE OUT COMES

CO's	CO – STATEMENTS	Blooms level	PO's
CO 1	Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.	K1	1,2,3,4,6,7,12
CO 2	Select a suitable Electrical machine for Wind Energy Conversion Systems and simulate wind energy conversion system	K2	1,2,3,4,5,6,7,10,12
CO 3	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for SPV systems.	K4	1,2,3,4,5,6,7,12
CO 4	Analyze the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid energy systems.	K4	1,2,3,4,5,6,7,12
CO 5	Interpret the hybrid renewable energy systems with its case study.	K5	1,2,3,6,7,12

6. INSTRUCTIONAL LEARNING OUTCOMES

UNIT	LEARNING OUTCOMES
I	The outcome will be assessed through assignment-1, Class test -1, MCQ Test-1, CAT-1.
II	The outcome will be assessed through assignment-2, Class test - 2, MCQ Test-2, CAT-1.
III	The outcome will be assessed through assignment-3, Class test - 3, MCQ Test-3, CAT-2.
IV	The outcome will be assessed through assignment-4, Class test - 4, MCQ Test-4, CAT-2.
V	The outcome will be assessed through assignment-5, Class test - 5, MCQ Test -5, CAT-3.

7. PROGRAMME EDUCATIONAL OBJECTIVES (PEO's)

The graduates of Electrical and Electronics Engineering will be able to,

- Apply their knowledge and skills to provide solutions to electrical and electronics engineering problems in industry and governmental organizations or to enhance student learning in educational institutions.
- Work as a team with a sense of ethics and professionalism and communicate effectively to manage cross-cultural and multidisciplinary teams.
- Update their knowledge continuously through lifelong learning that contributes to personal, organizational, and societal growth.

8. PROGRAM OUTCOMES [PO's]

PO's No	KNOWLEDGE	STATEMENTS	APPLIANCE
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	Theory/ Practical / Project work
2	Problem Analysis	Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	Theory / Practical / Projects
3	Design / Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	Theory / Practical / Projects
4	Conduct Investigations of Complex Problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	Theory / Practicals
5	Modern Tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including	Theory / Practical / Project work

		prediction and modeling to complex engineering activities with an understanding of the limitations.	
6	The Engineer and Society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	Theory / Industrial visit / In plant training
7	Environment and Sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	Theory / Industrial Visit/ In plant Training
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Theory / Industrial visit / In plant training
9	Individual and Team Work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	Projects
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Projects/ Seminar/ Mini Project
11	Project Management and Finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Projects
12	Life-long Learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Projects / Higher Studies

9. PROGRAMME SPECIFIC OBJECTIVE (PSO's)

PSO1	To apply fundamental knowledge to identify, formulate and investigate various real-time problems of power systems and simulations.
PSO2	To apply recent techniques along with modern software tools for designing, simulating and analyzing electrical and renewable energy systems.

10. CO- PO MAPPING

CO's NO	COURSE OUTCOME	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.	3	3	2	1	-	2	2	-	-	-	-	2	1	3
CO2	Select a suitable Electrical machine for Wind Energy Conversion Systems and simulate wind energy conversion system	3	3	2	2	1	2	2	-	-	1	-	2	2	3
CO3	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for SPV systems.	3	3	2	2	2	2	2	-	-	-	-	2	2	3
CO4	Analyze the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid energy systems.	3	3	2	2	2	2	2	-	-	-	-	2	2	3
CO5	Interpret the hybrid renewable energy systems with its case study.	3	3	2	-	-	1	2	-	-	-	-	2	2	3

11. TEXT BOOK & REFERENCE BOOK LIST

Sl. No	Description	Legend
Text Book(s):		
1	Md. Rabiul Islam, Md. Rakibuzzaman Shah, Mohd Hasan Ali, "Emerging Power Converters for Renewable Energy and Electric Vehicles", CRC Press, First Edison, 2021.	T1
2	Hybrid Renewable Energy Systems and Micro grids. Netherlands: Elsevier Science, 2020.	T2
3	Hybrid Energy System Models. Netherlands: Elsevier Science, 2020.	T3
Reference Book(s):		
1	Hybrid Renewable Energy Systems, United States: Wiley, 2021.	R1
2	Kircicek, Y., Aktas, A. Solar Hybrid Systems: Design and Application. United States: Elsevier Science, 2021	R2
3	Luo, Y., Shi, Y., Cai, N. Hybrid Systems and Multi-energy Networks Internet. Netherlands: Elsevier Science, 2020.	R3

12. Web Resources

Sl. No	Topic	Web link
1.	Wind energy conversion system	https://www.carboncollective.co/sustainable-investing/wind-energy-conversion-system-wecs

2	Case study of Diesel-PV hybrid energy	https://f.hubspotusercontent10.net/hubfs/5328912/Solvest_February2021/Doc/Diesel-Solar-Controller-Case-Study.pdf

13. E- learning / NPTEL

14.

NPTEL/ OTHER UNIVERSITY video lectures related to syllabus:	
Video	https://youtu.be/zYeYN80SJCY https://youtu.be/yn8puYIuVeI https://youtu.be/tpSeT0-qOJU
Lecture Notes	1) https://www.rcet.org.in/uploads/files/LectureNotes/eee/S8/EE6-POWER%20ELECTRONICS%20FOR%20RENEWABLE%20ENRGY%20SYSTEMS/UNIT%205.pdf 2) https://www.rcet.org.in/uploads/files/LectureNotes/eee/S8/EE6-POWER%20ELECTRONICS%20FOR%20RENEWABLE%20ENRGY%20SYSTEMS/UNIT%201.pdf 3) https://rcet.org.in/uploads/academics/regulation2021/rohini_69386442482.pdf

MAGAZINE & JOURNALS

Magazine	**Hybrid energy system-** https://www.sciencedirect.com/topics/engineering/hybrid-energy-system
Journals	**Wind energy conversion -** https://ieeexplore.ieee.org/document/9944886

15. LESSON PLAN

S.No	Unit	Topic to be covered	Hours Needed	Cummulative hours	Mode of Teaching (BB/PPT/Others)	Text/ Ref. Book
I		INTRODUCTION TO HYBRID ENERGY SYSTEMS				
1	I	Hybrid Energy Systems – Need for Hybrid Energy Systems – Solar-Wind-Fuel Cell-Diesel	1	1	PPT	T2
2		Wind, Biomass-Diesel, Micro Hydel - PV, Ocean and geyser energy	1	2	smart Board	T2
3		Classification of Hybrid Energy systems	1	3	smart Board	R1
4		Importance of Hybrid Energy systems – Advantages and Disadvantages	1	4	smart Board	T2
5		Environmental aspects of renewable energy - Impacts of renewable energy generation on the environment	1	5	NPTEL Video	T2

6		Present Indian and international energy scenario of conventional and RE sources - Ocean energy, Hydel Energy - Wind Energy	1	6	Group Discussion	T2
7		Biomass energy, Hydrogen energy	2	8	NPTEL Video	T2
8		Solar Photovoltaic (PV) and Fuel cells: Operating principles and characteristics	1	9	smart Board	R2
II		**ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS)**				
9	II	Review of reference theory fundamentals	1	10	smart Board	T2
10		Construction, Principle of operation of Squirrel Cage Induction Generator (SCIG)	2	12	seminar	T2
11		Analysis of Squirrel Cage Induction Generator (SCIG)	1	13	smart Board	T2
12		Construction, Principle of operation of Doubly Fed Induction Generator (DFIG)	2	15	NPTEL Video	T2
13		Analysis of Doubly Fed Induction Generator (DFIG)	2	17	Quiz	T2
14		Construction, Principle of operation of Permanent Magnet Synchronous Generator (PMSG)	1	18	PPT	T3
III		**POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS**				
15	III	Power Converters for SPV Systems	1	19	Google classroom	T1
16		Line commutated converters (inversion-mode)	2	21	smart Board	T1
17		Boost and buck boost converters	2	23	smart Board	T1
18		selection of inverter, battery sizing, array sizing	1	24	Quiz	T1
19		Analysis of SPV Systems	1	25	smart Board	T1
20		Block diagram of the solar PV systems	1	26	PPT	T1
21		Types of Solar PV systems: Stand-alone PV systems	1	27	PPT	R2
22		*Hybrid Electric Vehicle*	1	28	PPT	Web
IV		**ANALYSIS OF POWER CONVERTERS FOR HYBRID ENERGY SYSTEMS**				
23	IV	Introduction to Power Converters	1	29	smart Board	T1
24		Stand-alone Converters	1	30	Quiz	T1
25		AC-DC-AC converters: uncontrolled rectifiers	2	32	NPTEL video	T3
26		PWM Inverters	2	34	PPT	T1
27		Bi-Directional Converters	1	35	smart Board	T1

28		Grid-Interactive Inverters	1	36	seminar	T1
29		Matrix converter – Merits and Limitations	1	37	PPT	T1
30		*Hybrid Power train*	1	38	Google classroom	Web
V		**CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS**				
31	V	Hybrid Systems- Range and type of Hybrid systems	1	39	Quiz	T2
32		Performance Analysis – Cost Analysis	1	40	PPT	T2
33		Case study of Diesel-PV	2	42	Assignment	web
34		Case study of Wind-PV-Fuel-cell	2	44	Group Discussion	web
35		Case study of Micro-hydel-PV	2	46	Case study	web
36		Case study of Biomass-Diesel-Fuel-cell systems	1	47	Group Discussion	web
37		*Hydrogen production from hybrid source*	1	48	PPT	Web

*** Content beyond the syllabus** **Total hours: 45 + 3 = 48 hours**

16. CONTENT DELIVERY METHODOLOGIES

Smart board, PPT, seminar, Quiz, Google Classroom, Group Discussion, Assignment, case study and NPTEL Videos

17. ASSIGNMENTS

Assignment 1 **Submission Due date: 17.06.2024**

Qn. No.	PART B	CO	BL
1	Generalize the working of Biomass energy with a neat diagram and explain in detail the various conversion process takes place with it.	CO1	3
2	What is Hybrid energy system? Classify the different types of Hybrid Energy system with a neat sketch?	CO1	3

Assignment 2 **Submission Due date: 05.07.2024**

Qn. No.	PART B	CO	BL
1	Compute the Clarke's transformation and park's transformation	CO2	4
2	Describe the construction and working principle of PMSG with a neat diagram. Mention its advantages and disadvantages.	CO2	4

Assignment 3 **Submission Due date: 09.08.2024**

Qn. No.	PART B	CO	BL
1	Classify the types of solar PV system and describe in brief with a neat diagram.	CO3	2
2	Discuss in detail how to select the inverter.	CO3	2

Assignment 4 **Submission Due date: 30.08.2024**

Qn. No.	PART B	CO	BL

1	Illustrate the working of Matrix converter with a neat diagram. Mention its merits and Demerits.	**CO4**	**2**
2	Describe the Grid Interactive Inverter with a neat sketch.	**CO4**	**2**

Assignment 5 **Submission Due date: 20.09.2024**

Qn. No.	PART B	CO	BL
1	Employ the case study of Wind-PV-Fuel-cell in detail.	**CO5**	**3**
2	Employ the case study of Micro-hydel-PV in detail.	**CO5**	**3**

18. ASSIGNMENT RUBRICS

Quality	Marks
Submission on Date	2
Understanding	3
Solving Skills/Presentation	3
End results with correct units conversions / Conclusion	2

19. MAPPING COs with ASSIGNMENTS

CO's	CO - STATEMENTS	A1	A2	A3	A4	A5
EE606701.1	Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.	3				
EE606701.2	Select a suitable Electrical machine for Wind Energy Conversion Systems and simulate wind energy conversion system		3			
EE606701.3	Design the power converters such as AC-DC, DC-DC, and AC-AC converters for SPV systems.			3		
EE606701.4	Analyze the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid energy systems.				3	
EE606701.5	Interpret the hybrid renewable energy systems with its case study.					3

20. ASSESSMENT METHODOLOGIES

ssessment Tool		Description
CONTINIOUS ASSESSMENT	**40%**	CAT – I(8marks), CAT – II(8marks), CAT –III(4marks) will be considered for 20 marks, class test- 5marks, MCQ 10 marks, Assignments-5 marks,
END SEMESTER EXAMINATION	**60%**	End semester Examination for 100 marks Converted to 60marks
Course End Survey		At the end of the Course, will be evaluated

21. DISTRIBUTION OF PORTIONS FOR ASSESSMENT TESTS

Assessments		**Portion**	**% of weight age**
CONTINIOUS ASSESSMENT	CAT – I	Unit-I & Unit-II	50
	CAT – II	Unit-III& Unit - IV	
	CAT-III	Unit-V	
	Class test(5)	Unit – I to Unit - V	12.5
	Assignments (5)	Unit – I to Unit - V	12.5
	MCQ	Unit – I to Unit - V	25
End Semester		Unit - 1 to 5	100

22. MARK ALLOTMENT FOR CO ASSESSMENT

COs	**CAT - I**	**CAT - II**	**CAT-III**	**Assignment**	**Class test**	**MCQ**	**End Semester**
CO1	25			10	26	6	100
CO2	25			10	26	6	
CO3		25		10	26	6	
CO4		25		10	26	6	
CO5			50	10	26	6	
Marks Converted to	20(4*5)			5	5	10	60

23. CONTENT BEYOND SYLLABUS

UNIT	**TOPICS TO BE COVERED**	**Hrs Taken**

3	*Hybrid Electric Vehicle*	**1**
4	*Hybrid Power train*	**1**
5	*Hydrogen production from hybrid source*	**1**

24. NAMELIST:

S.NO	REGISTER NUMBER	NAME
1	95222204001	Abinesh R
2	95222204002	Anto Sharon A
3	95222204003	Chandru Iyappan M
4	95222204004	Chinnamani M
5	95222204005	Elangovan T
6	95222204006	Gopinath T
7	95222204007	Gowtham B
8	95222204011	Murugan V
9	95222204012	Nathan K
10	95222204013	Nijanthan K
11	95222204014	Palanivel M
12	95222204015	Parthiban S
13	95222204016	Rajish T
4	95222204018	Rakul T
15	95222204019	Sanjith A
16	95222204020	Sivakumar R
17	95222204021	Sridharan K
18	95222204023	Ulaganathan C S
19	95222204301	Devadersh R
20	95222204302	Dyson T
21	95222204303	Gajendran M
22	95222204304	Ganesh A

23	95222204305	Ram kumar B
24	95222204306	Thomas Antony Dafrin X
25	95222204307	Vinish S

Signature	**Prepared by:**	**Approved by:**		
Name :	**Mrs. V.Jenitha**	**Ms.A.Shiny Pradeepa**	**Dr.S.P.Umayal**	**Dr. V. Manikandan**
Designation:	Assistant Professor / EEE	HoD / EEE	Dean - Academic	Principal