Curriculum Review

Proposed Programme Structure and Template of Courses

for

M.Tech. in Energy Studies

Centre for Energy Studies

Indian Institute of Technology Delhi

New Delhi-110016

April 2016

CONTENTS

PROPOSED PROGRAMME STRUCTURE

Programme Code: **JES**

Master of Technology in ***Energy Studies***

Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OE	Total
Credits	30	18	06	54

Programme Core (PC): JES

ESL710	Energy, Ecology and Environment	3-0-0	3
ESL711	Fuel Technology	3-0-0	3
ESL720	Energy Conservation	3-0-0	3
ESL730	Direct Energy Conversion	3-0-0	3
ESL740	Non-conventional Sources of Energy	3-0-0	3
ESL750	Economics and Planning of Energy Systems	3-0-0	3
ESL760	Heat Transfer	3-0-0	3
ESP713	Energy Laboratory	0-0-6	3
JSD801	Major Project Part – 1 (JES)	0-0-12	6
	Total PC	**21-0-18**	**30**

Programme Electives (PE): JES

ESL714	Power Plant Engineering	3-0-0	3
ESL718	Power Generation, Transmission and Distribution	3-0-0	3
ESL722	Integrated Energy Systems	3-0-0	3
ESL732	Bioconversion and Processing of Waste	3-0-0	3
ESL734	Nuclear Energy	3-0-0	3
ESL737	Plasma Based Materials Processing	3-0-0	3
ESL746	Hydrogen Energy	3-0-0	3
ESL755	Solar Photovoltaic Devices and Systems	3-0-0	3
ESL768	Wind Energy and Hydro Power Systems	3-0-0	3
ESL770	Solar Energy Utilization	3-0-0	3
ESL796	Operation and Control of Electrical Energy Systems	3-0-0	3
ESL810	MHD Power Generation	3-0-0	3
ESL840	Solar Architecture	3-0-0	3
ESL850	Solar Refrigeration and Air Conditioning	3-0-0	3
ESL860	Electrical Power Systems Analysis	3-0-0	3
ESL870	Fusion Energy	3-0-0	3
ESL871	Advanced Fusion Energy	3-0-0	3
ESL880	Solar Thermal Power Generation	3-0-0	3
JSS801	Independent Study (JES)	0-3-0	3
JSD799	Minor Project (JES)	3-0-0	3
JSD802	Major Project Part – 2 (JES)	0-0-24	12
MEL815	Applied Combustion	2-0-4	4
MEL816	Analysis of I.C. Engine Processes	3-0-2	4
EEL748	Power Quality	3-0-0	3
EEL899	Distribution Automation	3-0-0	3
CHL722	Fundamentals of Fuel Cell Technology	3-0-2	4

Proposed Semester wise Course Distribution *JES*

SEMESTER	Courses (Number, abbreviated title, L-T-P, Credits)						Lecture Courses	Contact h/week L	T	P	Total	Credits
I	**ESL740** Non-Conventional Sources of Energy (3-0-0) 3	**ESL711** Fuel Technology (3-0-0) 3	**ESL760** Heat Transfer (3-0-0) 3	**ESL750** Economics and Planning of Energy systems (3-0-0) 3	**PE-1** (3-0-0) 3		5	15	0	0	15	**15**
II	**ESL720** Energy Conservation (3-0-0) 3	**ESL710** Energy, Ecology and Environment (3-0-0) 3	**ESP713** Energy Laboratory (0-0-6) 3	**ESL730** Direct Energy Conversion (3-0-0) 3	**PE-2** (3-0-0)3		4	12	0	6	18	**15**
SUMMER	JSD801 Major Project Part 1(JES)						0					
III	**JSD801** Major Project Part-I (JES) (0-0-12) 6	**OE-1** (3-0-0)3	**OE-2** (3-0-0)3				2	6	0	12	18	**12**
IV	**JSD802** Major Project Part-II (JES) (0-0-24) 12						0	0	0	24	24	**12**
	PE-3 (3-0-0)3	**PE-4** (3-0-0)3	**PE-5** (3-0-0)3	**PE-6** (3-0-0)3			4	12	0	0	12	
											Total	**54**

DETAILS OF M.TECH. PROGRAMME IN ENERGY STUDIES

Programme Name: Energy Studies Duration: 2 years (Total Semesters: 4)

Total: 54 credits (Programme Core Courses: 30 + Programme Elective Courses: 18 + Open Elective Courses: 6)

1. Details of Programme Core (PC) Courses (Total: 30 Credits) for the proposed M. Tech. Programme in Energy Studies are given in Table 1

Table 1: PC Courses

S. No.	Course No.	Course Name	L-T-P	Credits
	Core Courses			
1	ESL710	Energy, Ecology and Environment	3-0-0	3
2	ESL711	Fuel Technology	3-0-0	3
3	ESL720	Energy Conservation	3-0-0	3
4	ESL730	Direct Energy Conversion	3-0-0	3
5	ESL740	Non-conventional Sources of Energy	3-0-0	3
6	ESL750	Economics and Planning of Energy Systems	3-0-0	3
7	ESL760	Heat Transfer	3-0-0	3
8	ESP713	Energy Laboratory	0-0-6	3
9	JSD801	Major Project Part – 1 (JES)	0-0-12	6
Total Credits of Core Courses				**30**

2. A List of Programme Elective (PE) Courses is given in Table 2. Any four courses can be selected by the student.

Table 2: PE Courses

S. No.	Course No.	Course Name	L-T-P	Credits
	Electives Courses			
1	ESL714	Power Plant Engineering	3-0-0	3
2	ESL718	Power Generation, Transmission and Distribution	3-0-0	3
3	ESL722	Integrated Energy Systems	3-0-0	3
4	ESL732	Bioconversion and Processing of Waste	3-0-0	3
5	ESL734	Nuclear Energy	3-0-0	3
6	ESL737	Plasma Based Materials Processing	3-0-0	3
7	ESL746	Hydrogen Energy	3-0-0	3
8	ESL755	Solar Photovoltaic Devices and Systems	3-0-0	3
9	ESL768	Wind Energy and Hydro Power Systems	3-0-0	3
10	ESL770	Solar Energy Utilization	3-0-0	3
11	ESL796	Operation and Control of Electrical	3-0-0	3
12	ESL810	MHD Power Generation	3-0-0	3
13	ESL840	Solar Architecture	3-0-0	3
14	ESL850	Solar Refrigeration and Air Conditioning	3-0-0	3
15	ESL860	Electrical Power Systems Analysis	3-0-0	3
16	ESL870	Fusion Energy	3-0-0	3
17	ESL871	Advanced Fusion Energy	3-0-0	3
18	ESL880	Solar Thermal Power Generation	3-0-0	3
19	JSS801	Independent Study (JES)	0-3-0	3
20	JSD799	Minor Project (JES)	3-0-0	3
21	JSD802	Major Project Part – 2 (JES)	0-0-24	12

S. No.	Course No.	Course Name	L-T-P	Credits
22	MEL815	Applied Combustion	2-0-4	4
23	MEL816	Analysis of I.C. Engine Processes	3-0-2	4
24	EEL748	Power Quality	3-0-0	3
25	EEL899	Distribution Automation	3-0-0	3
26	CHL722	Fundamentals of Fuel Cell Technology	3-0-2	4

SEMESTER WISE PLAN

S. No.	Semester	No. of Credits	Distribution of credits
1.	First	15	12 Credits (PC) and 3 Credits (PE)
2.	Second	18	12 Credits (PC), 3 Credits (PE) and 3 Credits (OE)
3.	Third	9	6 Credits (PC), 3 Credits (OE)
4.	Fourth	12	12 Credits (PE)
	Total Credits :	**54**	

PROGRAMME CORE COURSES

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Energy, Ecology and Environment		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL710		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	For morning course, UG students who have done ESL330 are not allowed.

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. T. C. Kandpal, Prof. M. G. Dastidar, Dr. K. A. Subramanian, Dr. R. Narayanan

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To introduce the concepts of Interrelationship between energy, ecology and environment, Environmental issues related to harnessing and utilization of various sources of energy and Related environmental degradation.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Interrelationship between energy and environment, Sun as a source of energy, nature of its radiation, Biological processes, photosynthesis, Autecology and Synecology, Population, Community Ecosystem (wetland, terrestrial, marine) Food chains, Ecosystem theories. Sources of energy, Classification of energy sources, Environmental issues related to harnessing to fossil fuels (coal, oil, natural gas), geothermal, tidal, nuclear energy, solar, wind, hydropower, biomass, Energy flow and nutrient cycling in ecosystems, Environmental degradation, primary and secondary pollutants. Thermal/ radioactive pollution, air and water pollution, Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, heat and radioactivity disposal, Acid rain, Global warming and greenhouse gases, Ozone layer depletion.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Interrelation between energy, ecology and environment.	2
2	Sun as a source of energy, nature of its radiations.	3
3	Population, Community Ecosystem (wetland, terrestrial, marine)	4
4	Food chains, Ecosystem theories. Sources of energy, Classification of energy sources	5
5	Environmental issues related to harnessing of fossils fuels, Energy flow and nutrient cycling in ecosystem and environmental degradation	5
6	Air and water pollution	8

7	Pollution from stationary and mobile sources,	3
8	Biological effects of radiation, heat and radioactivity disposal,	7
9	Global warming and greenhouse gases	3
10	Ozone layer depletion	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Thermodynamic cycles
1	Industrial ecology
3	Terrestrial ecosystem
5	Phosphorous cycle , Sulphur cycle
6	Water pollution abatement techniques
9	Carbon sequestration
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. G. M. Masters, W. P. Ela, Introduction to Environmental Engineering and Science, Prentice Hall, 2007.
2. D. Nevers, Air Pollution Control Engineering, McGraw Hill, 2001.
3. A. Mackenzie, A. S. Ball, S. Virdee, Instant Notes: Ecology, BIOS Scientific Publishers Ltd., 2001.
4. F. Armstrong, K. Blunde, Energy Beyond oil, Oxford University Press, 2007.
5. G. T. Miller, Spoolman S., Environmental Science, Yolanda Cossio, 2010.
6. J. L. Chapman, W. J. Reiss, Ecology Principles and Applications, Cambridge University Press, 2008.

20. **Resources required for the course** (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. **Design content of the course** (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Fuel Technology			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL711			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES & JEN
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	-----

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	-----

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course**
	Prof. D. K. Sharma, Prof. M. G. Dastidar, Dr. K. A. Subramanian

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	To give an idea about different solid, liquid, gaseous fuels, their origin, composition, classification, combustion and conversion processes.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Solid, liquid and gaseous fuels, Coal as a source of energy and chemicals in India, Coal preparation and refining, Carbonization, Gasification and liquefaction of coal and lignite, Principle of combustion, Petroleum and its derived products, Testing of liquid fuels, Petroleum refining processes, Inter-conversion of fuels, Natural gases and its derivatives, sources, classes, potential, Gas hydrates, Combustion appliances for solid, liquid and gaseous fuels, Introduction to nuclear fuels, RDF, Bio-fuels, etc.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Principles of Combustion	2
2	Solid, liquid and gaseous fuels	4
3	Coal as a Source of Energy and Chemicals in India	3
4	Coal Preparation	5
5	Carbonization	2
6	Gasification	3
7	Liquefaction of coal and lignite	4
8	Petroleum, properties and its derived products	4
9	Inter-conversion of fuels	3
10	Gaseous fuels including natural gas and uses	3
11	Combustion of solid, liquid and gaseous fuels	5
12	Types of combustion	2

13	Introductionto nuclear fuels	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
6	Liquefaction & Gasification of coal & lignite
9	Inter-conversion of fuels
11	Kinetics of combustion
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. J. G. Speight, Chemistry and Technology of Coal, CRC Press, 2012.
2. J. G. Speight, Chemistry and Technology of Petrolium, CRC Press, 2012.
3. D. M. Indra, Petrolium Refining technolgy, CBS Publishers and disytributors, 2015.

4. S. Sarkar, Fuels and Combustion, Orient Longman, 2009.
5. F. Peter, Fuels and Fuel Technology, Wheatan & Co. Ltd., 2002.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Energy Conservation			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL720			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course**
	Prof. S. C. Kaushik, Dr. Dibakar Rakshit

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	There is very good scope for saving energy, by using it judiciously. During these days of saving the environment, energy conservation plays a vital role. The government of India has passed Energy Conservation Act-2003 and Energy Conservation Building Code (ECBC-2007), in this regard. By observing energy efficient measures there is tremendous scope of saving energy in industry, built environment, transport etc.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Introduction, Thermodynamics of energy conservation, Energy and exergy concepts, Irreversibility and second law analysis and efficiency of thermal systems such as mixing, throttling, drying and solar thermal systems, Thermal power plant cycles. Refrigeration and air conditioning cycles, thermal insulation in energy conservation, energy conservation through controls, electric energy conservation in building heating and lighting, energy efficient motors, Tariffs and power factor improvement in electrical systems, Energy conservation in domestic appliances, transport, energy auditing, energy savings in boilers and furnaces, energy conservation Act, Energy conservation in small scale domestic appliances and agriculture.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	1
2	Thermodynamics of energy conservation, Energy and exergy concepts	4
3	Irreversibility and second law analysis and efficiency of thermal systems such as mixing, throttling, drying and solar thermal systems	4
4	Thermal power plant cycles, refrigeration and air conditioning cycles	5
5	Thermal insulation in energy conservation, energy conservation through controls	4
6	Electric energy conservation in building heating and lighting, energy efficient motors, energy savings in boilers and furnaces	12
7	Tariffs and power factor improvement in electrical systems,	4
8	Energy Auditing	4

9	Energy Conservation Act	2
10	Energy conservation in small scale domestic appliances and agriculture.	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Laws of Thermodynamics and energy conservation
1	Conventional view of Energy conservation
2	Concepts of Heat engine, Heat pump, refrigerator and air conditioner.
2	Concept of entropy and irreversibility
3	Factors responsible for irreversible processes
7	Electricity tariff regulation and control
8	Energy management and auditing
9	Energy conservation act and E.C.B.C
10	Simple energy conservation measures in the agricultural, transport and domestic sector
10	Energy conservation aspects in the industries

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

1. L.C. Wittie, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publishing Company, 1988.
2. T. D. Eastop and D. R. Croft, Energy Efficiency for Engineers and Technologists, Longman Group UK Ltd., 1st edition, 1990.
3. W.C. Turner, Energy Management Hand Book, The Fairmont Press, 3rd edition, 1997.
4. S.C. Kaushik, S.G. Pathi and V.S. Reddy, Energy Conservation Awareness and Opportunities, Arihant Prakashan Pvt. Ltd., 2010.
5. Energy Saving in Industry – Real life case studies, Petroleum Conservation Research Association, 2011.
6. P. L. Dhar, Engineering Thermodynamics, Reed-Elsevier India Pvt. Ltd., 2008.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies
2.	**Course Title**	Direct Energy Conversion
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3 **Non-graded Units** ---
5.	**Course number**	ESL730
6.	**Course Status** (Course Category for Program):	

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	---

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	12% with ESL360
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course** Prof. A. Ganguli, Prof. V. Dutta, Dr. Vamsi Krishna, Dr. R. Narayanan, Dr. R. Uma	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To Provide adequate inputs on a variety of issues relating to Direct Energy conversion Systems.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Basic science of energy conversion, Indirect verses direct conversion, Physics of semiconductor junctions for photovoltaic and photo-electrochemical conversion of solar energy, Fabrication and evaluation of various solar cells in photovoltaic power generation systems, Technology and physics of thermo-electric generations, Thermal-electric materials and optimization studies, Basic concepts and design considerations of MHD generators, Cycle analysis of MHD systems, Thermonic power conversion and plasma diodes, Thermo dynamics and performance of fuel cells and their applications.

15. Lecture Outline (with topics and number of lectures)

Module no.	**Topic**	**No. of hours**
1	Introduction	2
2	Physics of semiconductors junctions for P.V.& Photo-electrochemical conversion	4
3	Fabrication and evaluation of various solar cells and their applications.	6
4	Technology and Physics of Thermoelectric generations, Multi stage generators.	5
5	Thermoelectric materials and optimization studies.	3
6	Thermionic power conversion and plasma diodes.	4
7	Basic concepts and design considerations of MHD generators	5
8	Cycle analysis of MHD systems	3
9	Thermodynamics and performance of fuel cells and their applications	10
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Semiconductors: types, fermi level-n junction, metal semiconductor junction
1	Energy forms and units
1	Thermodynamics : reversible and irreversible processes, enthalpy, laws of thermodynamics, thermodynamic power cycles
1	Vectors and vector operations
4	Thermoelectricity
6	Plasma definition
6	Derivation of richardson-dushman equation & space-charge limited current
7	Lorentz force, local form of ohm's law in j, e and σ form, concept of source impedance in generators, maximum power transfer theorem
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. S. S. L. Chang, Energy Conversion, Prentice Hall, 1963.

2. S. W. Angrist, Direct Energy Conversion, Pearson, 1982.
3. R. J. Rosa, Magneto hydrodynamic Energy Conversion, Springer, 1987.
4. V. S. Bagotsky, Fuel Cell Problems and Solutions, John Wiley & Sons, 2009.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Non-Conventional Sources of Energy		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL740		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	14% with ESL 340
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course**
	Prof. T. C. Kandpal, Dr. R. Uma, Dr. K. A. Subramanian, Dr. R. Narayanan, Dr. Vamsi Krishna

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	The Course will create awareness among students about Non-Conventional sources of energy technologies and provide adequate inputs on a variety of issues.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Types of non-conventional sources, Solar energy principles and applications, efficiency of solar thermal and PV systems, Biomass: generation, characterization, Biogas: aerobic and anaerobic bio-conversion processes, microbial reactions purification, properties of biogas. Storage and enrichment, Tidal and wind energy potential and conversion efficiency, Mini/micro hydro power: classification of hydropower schemes, classification of water turbine, Turbine theory, Essential components of hydroelectric system, system efficiency, Fusion: Basic concepts, fusion reaction physics, Thermonuclear fusion reaction criteria, Confinement schemes, Inertial and magnetic confinement fusion, Current status, Geothermal: Geothermal regions, geothermal sources, dry rock and hot aquifer analysis Geothermal energy conversion technologies, OTEC.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction, Solar energy basics, Solar thermal systems	7
2	Solar heating/ cooling of buildings	3
3	Solar thermal power generation, Solar P.V.	4
4	Biomass: Generation, Characterization	5
5	Bio gas: Aerobic and Anaerobic bio conversion processes, Microbial reactions purification, Properties of biogas Storage and Enrichment	6
6	Tidal and wind energy	3
7	Fusion: Introduction, Basic concepts, Fusion reaction physics, Thermonuclear reaction criterion, Confinement schemes, Inertial and	5

	magnetic confinement fusion.	
8	Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system	6
9	Geothermal: Geothermal regions, Types of geothermal resources, Analysis of geothermal resources, Geothermal energy conversion technologies.	3
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1-2	Law of gravitation (Planetary motion)
3	Conservation laws including Bernoulli's equation, Basic understanding of handling viscosity, turbulence and friction in fluid flows
3	Types of solar energy converter
5	Electron states in semiconductors, Impurities and doping, Semiconductor under equilibrium and bias, Drift and diffusion
6	Understanding of basic concepts of conduction, convection and radiation heat transfer
7	Basics of plasma physics, Scattering cross-sections, Single particle motion in a tempo-spatially uniform electric and magnetic fields

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

1. J.Twidell and T.Weir, Renewable Energy Resources, Taylor and Francis Group 2007
2. G.N.Tiwari and MK Ghosal, Renewable Energy Resources Basic Principles and Application, Narosa Publishing House 2005.
3. J.A.Duffie and WA Beckman, Solar Engineering and Thermal Processes, 2nd Edition John Wiley and sons. 2001.
4. G.N.Tiwari, Solar Energy, Narosa Publishing House, 2002.
5. R.A.Gross, Fusion Energy, John Wiley and Sons, 1984.
6. Weston M. Stacey, Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, 2nd edition, Wiley- VCH Publication.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies		
2.	**Course Title**	Economics and Planning of Energy Systems		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL750		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	ESL340/ESL740/ESL330/ESL710

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	10% with ESL 742
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course** Prof. G. N. Tiwari, Prof. T. C. Kandpal, Dr. Ashu Verma	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To enable students undertake financial feasibility evaluation studies of energy technologies and to discuss various issues involved and techniques used in energy planning. It is also envisaged to provide relevant inputs on energy-economy-environment interaction related policy studies.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Relevance of financial and economic feasibility evaluation of energy technologies and systems, Basics of engineering economics, Financial evaluation of energy technologies, Social cost benefit analysis, Case studies on techno-economics of energy conservation and renewable energy technologies. Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models. Energy – economy interaction, Energy investment planning and project formulation. Energy pricing. Policy and planning implications of energy – environment interaction, Clean development mechanism. Financing of energy systems. Energy policy related acts and regulations. Software for energy planning.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Relevance of financial and economic feasibility evaluation of energy technologies and systems	1
2	Basics of engineering economics	4
3	Financial evaluation of energy technologies	2
4	Social cost benefit analysis	2
5	Case studies on techno-economics of energy conservation and renewable energy technologies	3
6	Energy demand analysis and forecasting	6
7	Energy supply assessment and evaluation	2
8	Energy demand – supply balancing	2
9	Energy models	2
10	Energy – economy interaction	2
11	Energy investment planning and project formulation	2

12	Energy pricing	3
13	Policy and planning implications of energy – environment interaction, Clean development mechanism	4
14	Financing of energy systems	2
15	Energy policy related acts and regulations	2
16	Software for energy planning	3
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1-3	Basics of at least one of the software: RETScreen, System Advisor Model, HOMER, PVSyst.
6-8	Basic Statistics – mean, mode, median, standard deviation, standard error of the mean, Central limit theorem, Interval estimates, Hypothesis testing, Least square regression, correlation.
9-10	Renewable energy programmes in India, Jawaharlal Nehru National Solar Mission (JNNSM)
9-10	Integrated Energy Policy (India)
9-10	Electricity Act, Energy Conservation Act, Energy Conservation Building code
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. M. Kleinpeter, Energy Planning and Policy, John Wiley & sons, 1995.
2. R. Codoni, H. Park and K.V. Ramani, Integrated Energy Planning: A Manual, Vols. I, II & III. Asian and Pacific Development Centre, Kuala Lumpur, 1985.
3. J. Parikh, Energy Models for 2000 and Beyond, Tata McGraw Hill Publishing Company Limited, 1997.
4. M.S.Kumar, Energy Pricing Policies in Developing Countries: Theory and Empirical Evidence, International Labor Organization, 1987.
5. M. Munasinghe and P. Meir, Energy Policy Analysis and Modeling, Cambridge University Press, 1993.
6. A.V.Desai, Energy Planning, Wiley Eastern Ltd., 1990.
7. H.Campbell and R.Broron, Benefit-Cost Analysis, Cambridge University Press, 2003.
8. 8. C.S.Park, Contemporary Engineering Economics, Prentice Hall Inc., 2002.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Heat Transfer			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL760			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course**
	Prof. S. C. Mullick, Prof. S. C. Kaushik, Prof. T. C. Kandpal, Dr. K. A. Subramanian, Dr. Dibakar Rakshit.

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	Heat Transfer is possible by conduction, convection, radiation. The subject has a wide application. It is gaining importance continuously. The present one is a fundamental course which provides adequate concepts and prepares the students for undertaking calculations of heat transfer rate through different mechanisms

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	General heat conduction equation with heat generation, Analysis of extended surfaces, transient (and periodic) heat conduction, Two dimensional heat conduction problems and solutions, Theory of convective heat transfer, Boundary layer theory, Heat transfer in duct flows laminar and turbulent, Boiling, condensation and heat exchangers, Laws of thermal radiation, Radiation heat transfer between black and grey bodies, Numerical solutions of radiation network analysis, Thermal circuit analysis and correlations for various heat transfer coefficients, Overall heat transfer.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	2
2	General Heat conduction Equation	2
3	Analysis of Extended Surfaces	2
4	Transient and Periodic Heat Conduction	4
5	Two Dimensional Heat conduction problems	4
6	Theory of Convective Heat Transfer	3
7	Boundary Layer Theory	2
8	Heat Transfer in duct flows	2
9	Boiling, condensation & Heat Exchangers	4
10	Radiation Heat Transfer Laws & Heat exchangers	4

11	Radiation shield and shape factors	3
12	Numerical solutions of radiation network analysis	3
13	Thermal circuit Analysis and problems	3
14	Overall Heat Transfer and heat transfer coefficients	2
15	Numerical problems and solutions	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Kinetic theory of matter and Basic law of thermodynamics
1	Heat and work transfer, coefficient of conduction, convection and radiation
1	Different methods and principles of temperature, flow and heat flux measurements.
6	Basics of Velocity, thermal and concentration Boundary Layer and elements of fluid mechanics
9	Basic heat and mass transfer in boiling and condensation
9	Phase change characteristics of substances with respect to temperature
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. R.W.Seath, Process Heat transfer Principles & Applications, Academic Press, Elsevier Ltd, 2007.
2. A.F.Mills and V.Ganesan, Heat Transfer, 2^{nd} Edition, Publ. Dorling Kindeasle (India) PVT. Ltd, 2009.
3. F.P.Incropera, D.P.DeWitt, Fundamentals of Heat and Mass Transfer, John Wiley & Sons, 1998.
4. Doebelin, E.O. 1990. Measurement Systems Application and Design, 4th ed.. McGraw-Hill (self study)
5. J.P.Holman, Experimental methods for Engineers, McGraw-Hill; 7th edition (self study)

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Energy Laboratory			
3.	**L-T-P structure**	0-0-6			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESP713			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	JES
Programme Elective for:	---
Open category Elective for all other programs (No if Institute Core)	---

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	30% with ESP 700
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Almost all faculty are involved	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** In order to supplement various topics related to energy aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy studies programme for better understanding of the subjects. The experiments based on science/engineering principles are so designed so as to provide students enough stimulation for further investigation.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Laboratory experiments on solar energy utilization: thermal and photo-voltaic application;: Biomass and coal characterization; Wind energy utilization; Performance characteristics of silicon-controlled rectifier, operational amplifier etc., Energy efficiency and conservation

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction of experiments by concerned faculty in Labs.	20
2	Study of Characteristics of Francis Turbine	3
3	Characterization of solid fuel (Proximate Analysis)	3
4	Determination of calorific value of solid fuel	3
5	Performance study of heat pump system & Thermoelectric Generator and Refrigerator	3
6	Heat Pipe Heat Exchanger and its efficiency	3
7	Performance of Photo-voltaic Thermal titles	3
8	Performance of Solar Still	3
9	I-V Characteristics a Solar Cell	3
10	To study the performance and emission characteristics of a diesel engine for biodiesel-diesel blend	3

11	To study the performance and emission characteristics of a spark ignition engine for ethanol/butanol-gasoline blend.	3
12	Photovoltaic-Roof Top on Synergy Building	3
13	Power generation using fuel cell technology	3
14	Fractional distillation of Petroleum	3
15	Plasma Simulation – Computer Experiments	3
16	Study of a simple DC plasma discharge characteristics	3
17	Investigation of plasma characteristics using a single Langmuir probe	3
18	Study of Characteristics of Francis Turbine	3
	Course Total	**68**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Basic principles of thermal and electrical transducers and equipment and knowledge about measurement errors

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

1. H.P.Garg and T.C.Kandpal, Laboratory Manual on Solar Thermal Experiments, Narosa Publishing House, New Delhi, 1999.
2. D.P.Kothari and D.K.Sharma, Energy Engineering: Theory and Practice. S. Chand Publisher, New Delhi, 2000.
3. Doebelin, E.O. 1990. Measurement Systems Application and Design, 4th ed. McGraw-Hill (self study)
4. J.P.Holman, Experimental methods for Engineers, McGraw-Hill; 7th edition (self-study)

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	Yes
20.5	Equipment	Yes
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	Laboratory experiments
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

PROGRAMME ELECTIVE COURSES

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Power Plant Engineering		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL714		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester
11.	**Faculty who will teach the course** Prof. S. C. Mullick, Dr. K. A. Subramanian.	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** Power plants include Steam Turbine Plants (which includes Nuclear or Solar Thermal), Gas Turbine Plants, I.C. Engines, or Hydro Plants. The course will make it possible for the students to have a clear understanding of these technologies to be able to (i) select an appropriate type of plant for given requirements under different situations (ii) select suitable components/ equipments (iii) understand the operation of these plants/equipments.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Types of thermal power stations, Steam power stations based on fossil fuels, Economy and thermal scheme of the steam power stations, Thermal power plant equipment boilers, super heaters, super critical steam generator, economizers, feed water heater, condensers, combustion chamber and gas loop, turbines, cooling towers, etc. Gas turbine power stations, Combined cycle power plants, Internal combustion engine plant for peak load, standby and start up, Elements of hydropower and wind turbine, Elements of nuclear power plants, Nuclear reactors and fuels. Recent advances in power plants (IGCC, super critical power plants, etc.). Case studies, Introduction to solar power generation, Sterling engine, Decentralized power technologies.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Steam power stations	12
2	Gas turbine power stations	10
3	Internal combustion engine plant	6
4	Hydropower and wind turbine	4
5	Nuclear power plants	5
6	Recent advances in power plants	3
7	Introduction to solar power generation, Sterling engine, Decentralized power technologies	2

	Course Total	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Thermodynamic cycle for all heat engines
1,2	Velocity triangles of turbine blades
2,3	Enthalpy of formation, heat of reaction and adiabatic flame temperature
1,2,3,4	Numerical problems in power plant with CCS system
6	Hybrid power plants
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. F. T. Morse, Power Plant Engineering, D. Van Nostran, New York, 1953.
2. M. M. El-Wakil, Power Plant Technology, Tata McGraw-Hill, 1984.
3. P. K. Nag, Power Plant Engineering, Tata McGraw-Hill, 2008.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	Photos and videos of Power plant
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Blackboard, LCD projector, OHP
20.7	Site visits	Power Plant Visit (optional)
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	25%
21.2	Open-ended problems	15%
21.3	Project-type activity	35%
21.4	Open-ended laboratory work	Nil
21.5	Others (please specify)	Analysis of data from case study available in literature and self-designed power plant (virtual)

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies		
2.	**Course Title**	Power Generation, Transmission and Distribution		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL718		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	10% with EEL796, 10% with EEL794
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course** Prof. T S Bhatti, Dr. Ashu Verma

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** The subject will enhance the understanding of the students on power system dynamic stability, generation control, AC and DC transmission, and reactive power control, distribution systems along with conventional and intelligent controls.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Generation: Synchronous generator operation, Power angle characteristics and the infinite bus concept, dynamic analysis and modeling of synchronous machines, Excitations systems, Prime-mover governing systems, Automatic generation control; Auxiliaries: Power system stabilizer, Artificial intelligent controls, Power quality; AC Transmission: Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission; HVDC transmission: HVDC converters, advantages and economic considerations, converter control characteristics, analysis of HVDC link performance, Multi-terminal DC system, HVDC and FACTS; Distribution: Distribution systems, conductor size, Kelvin's law, performance calculations and analysis, Distribution inside and commercial buildings entrance terminology, Substation and feeder circuit design considerations, distribution automation, Futuristic power generation.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Synchronous generator operation, Power angle characteristics and the infinite bus concept, dynamic analysis	4
2	modeling of synchronous machines, Excitations systems, Prime-mover governing systems, Automatic generation control	9
3	Power system stabilizer, Artificial intelligent controls, Power quality;	6
4	Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission	4
5	HVDC converters, advantages and economic considerations, converter control characteristics, analysis of HVDC link performance, Multi-terminal DC system, HVDC and FACTS	9
6	Distribution systems, conductor size, Kelvin's law, performance calculations and analysis, Distribution inside and commercial buildings entrance terminology	4
7	Substation and feeder circuit design considerations, distribution automation, Futuristic power generation	6

	Course Total	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Basics of different type power generating stations
2,4,5	AC power transmission basic: Voltage level, conductor size, conductor material, active and reacting power
3	Power Quality
6	Overhead and underground distribution lines
7	Components of a distribution substation
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. A. J. Wood and B. F. Wollenberg, Power Generation, Operation, and Control. John Wiley & Sons, 2003.
2. P. M. Anderson and A. A. Fouad, Power System Control and Stability, Wiley-IEEE Press, 2002.
3. O. I. Elgerad, Electric Energy Systems Theory: An Introduction, T M H Edition, 1982.

4. C. K. Kim, V. K. Sood, G. S. Jang, J. Lim, J. Lee, HVDC Transmission: Power Conversions Applications in Power Systems, Wiley – IEEE Press, 2009.
5. T. Gonen, Electric Power Transmission System Engineering Analysis and Design, CRC Press, 2009.
6. P. Kundur, Power system stability and control, McGraw-Hill, 1994.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	Some typical examples

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Integrated Energy Systems			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL722			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. T. C. Kandpal, Prof. S. C. Kaushik, Dr. K. A Subramanian

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To introduce the pattern of fuel consumption, energy demand, various renewable sources of energy and modern applications.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Pattern of fuel consumption: agricultural, domestic, industrial and community needs, Projection of energy demands, Substitution of conventional sources by alternative sources and more efficient modern technologies, Potential, availability as well as capacity of solar, wind, biogas, natural gas, forest produce, tidal, geothermal, mini-hydro and other modern applications, Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Pattern of fuel consumption	4
2	Projection of energy demands	4
3	Alternative sources and more efficient modern technologies	12
4	Hybrid and integrated energy systems	8
5	Total energy concept and waste heat utilization	8
6	Energy modeling to optimize different systems	6
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times ‘T’)		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Integration of various energy sources and systems: basic approaches
2	Integrated energy villages case studies
3	Basics of Economics and benefits of integrated energy systems
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. L. Barrtom, Renewable Energy Sources for fuels and Electricity, Island Press 1993.
2. T. Ohta, Energy Technology, Pergamon Press 1994.
3. J. Twidel, T. Weir, Renewable Energy Resources, E&FN Spon., 1986.
4. R. Hunter, G. Elliot, Wind-Diesel Systems, Cambridge University Press, 1994.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	LCD Projector, OHP and Black Board Facilities

20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies		
2.	**Course Title**	Bioconversion and Processing of Waste		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL732		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. M. G. Dastidar, Prof. D. K. Sharma, Dr. K. A. Subramanian	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To give an idea about different biomass and other solid waste materials as energy source and their processing and utilization for recovery of energy and other valuable products. A comprehensive knowledge of how wastes are utilized for recovery of value would be immensely useful for the students from all fields.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Biomass and solid wastes, Broad classification, Production of biomass, photosynthesis, Separation of components of solid wastes and processing techniques, Agro and forestry residues utilization through conversion routes: biological, chemical and thermo chemical, Bioconversion into biogas, mechanism, Composting technique, Bioconversion of substrates into alcohols, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to biomass and other solid wastes	1
2	Classification of solid wastes	2
3	Biomass wastes, Compositions, Characteristics, Properties, Structural Components	4
4	Production of Biomass and Biomass wastes, Photosynthesis	2
5	Utilization of wastes as feed stocks for chemicals	4
6	Preprocessing techniques and separation of components for feed stocks preparation	3
7	Thermo chemical conversion of wastes into solid, liquid gases through pyrolysis and gasification	6
8	Combustion principles and appliances for utilization of solid wastes	6
9	Bioconversion of wastes into biogas, alcohols and other products	9

10	Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons	3
11	Fuel combustion into electricity, case studies	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	**Description**	**No. of hours**
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	**Description**	**No. of hours**
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	**Description**
1-3	Fuels and chemicals from cellulose
4-5	Fuels and chemicals from Hemicellulose
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. S.Samir, R.Zaborsky, Biomass Conversion Processes for Energy and Fuels, New York, Plenum

Press, 1981.
2. H.D.Joseph, P.Joseph, H.John, Solid Waste Management, New York, Van Nostrand, 1973.
3. G.Tchobanoglous, H.Theisen, S.V.Tchobanoglous, G.Theisen, H.V.Samuel, Integrated Solid Waste management: Engineering Principles and Management issues, New York, McGraw Hill, 1993.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Power point projector and OHP, Black Board Facilities
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Nuclear Energy			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL734			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. A. Ganguli, Prof. R. P. Sharma, Dr. R. Narayanan, Dr. R. Uma	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** Due to the rapidly growing energy needs of the country, India has made definite moves towards exercising the nuclear option for large-scale energy generation in the coming years. Simultaneously, India has become a full partner in the seven nation international consortium formed for proving the viability of nuclear fusion as a large scale energy option by making success of project ITER (International Thermonuclear Experimental Reactor) being set up in France. To further the needs of the country in this direction a National Fusion Program has also been set up within the country. In view of these developments, it is appropriate that a course on basic nuclear energy be available for students interested in large scale energy options both for India and globally. The course treats the basics of both nuclear fission and fusion, and energy generation using these methods; it is suitable for students from interdisciplinary background.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Introduction: Scope of nuclear energy (fission and fusion energy), typical reactions. Basics Concepts: Binding Energy of a nuclear reaction, mass energy equivalence and conservation laws, nuclear stability and radioactive decay, radioactivity calculations. Interaction of Neutrons with Matter: Compound nucleus formation, elastic and inelastic scattering, cross sections, energy loss in scattering collisions, polyenergetic neutrons, critical energy of fission, fission cross sections, fission products, fission neutrons, energy released in fission, γ-ray interaction with matter and energy deposition, fission fragments. The Fission Reactor: The fission chain reaction, reactor fuels, conversion and breeding, the nuclear power resources, nuclear power plant & its components, power reactors and current status. Reactor Theory: Neutron flux, Fick's law, continuity equation, diffusion equation, boundary conditions, solutions of the DE, group diffusion method, Neutron moderation (two group calculation), one group reactor equation and the slab reactor. Health Hazards: radiation protection & shielding. Nuclear Fusion: Fusion reactions, reaction cross-sections, reaction rates, fusion power density, radiation losses, ideal fusion ignition, Ideal plasma confinement & Lawson criterion. Plasma Concepts: Saha equation, Coulomb scattering, radiation from plasma, transport phenomena. Plasma Confinement Schemes: Magnetic and inertial confinement, current status.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	1
2	Q of nuclear reaction, mass energy equivalence, conservation laws	1

3	Nuclear stability and radioactive decay, radioactivity calculations, nuclear reactions, binding energy	2
4	Compound nucleus formation, elastic and inelastic scattering, cross sections, energy loss in scattering collisions	3
5	Polyenergetic neutrons, critical energy of fission, fission cross sections	2
6	Fission products, fission neutrons, energy released in fission	2
7	γ-ray interaction with matter and energy deposition, fission fragments	1
8	Fission chain reaction, reactor fuels	1
9	Conversion and breeding	2
10	Nuclear power resources, power plants & its components, power reactors	2
11	Neutron flux and Fick's law, continuity equation	1
12	Diffusion equation (DE), boundary conditions, solutions of the DE, diffusion length	3
13	Group diffusion method, Neutron moderation (two group calculation)	2
14	One group reactor equation and the slab reactor	1
15	Radiation protection and shielding	2
16	Fusion reactions, reaction cross sections, reaction rates	2
17	Fusion power density, radiation losses, ideal fusion ignition	2
18	Lawson criterion & ideal plasma confinement	1
19	Saha equation, Coulomb scattering, radiation from plasma, transport phenomena	6
20	Magnetic and inertial confinement, current status	5
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------

Total Practical / Practice hours (14 times ‘P’)	-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1-5	Maxwell Energy Distribution, Gas Law
1-5	Basics of Atomic and Nuclear Physics [Fundamental particles, Atomic and Nuclear structure, Atomic and Molecular Weight, Mass and energy, Particle Wavelengths, Excited States and Radioactive decay]
10	Different types of Nuclear Reactors (Current status, Environmental impact, Health hazards)
16-20	Basics of Plasma Physics. Single particle motion in a tempo-spatially uniform electric and magnetic fields
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. J.R.Lamarsh, Introduction to Nuclear Engineering, Addison Wesley Publishing Co. Inc. 1975.
2. R.A.Gross, Fusion Energy, John Wiley & Sons Inc., 2008.
3. F.F.Chen, Introduction to Plasma Physics & Controlled Fusion, Plenum Press, 2004.
4. W. M. Stacey, Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, Wiley- VCH Publication.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	LCD Projector, OHP and Black Board Facilities
20.7	Site visits	----

20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies		
2.	**Course Title**	Plasma Based Materials Processing		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL737		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	ESL 870 (Very minor overlap)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	PHL 680 (Very minor overlap)
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. A Ganguli, Dr. R. Narayanan.

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** In the last few decades, plasma based materials processing has pervaded almost all areas, from semiconductors and plasma based coatings to plasma nitriding and plasma immersed ion implantation to plasma pyrolysis. Thus a comprehensive knowledge of how plasmas are utilized for different types of materials processing would be immensely useful for the future engineers from all fields.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Introduction: Plasma based processing of materials. Plasma Concepts: Plasma fluid equations, single particle motions, unmagnetized plasma dynamics, diffusion and resistivity, the DC sheath and probe diagnostics. Basics of Plasma Chemistry: Chemical reactions and equilibrium, chemical kinetics, particle and energy balance in discharges. Low Pressure Plasma Discharges: DC discharges, RF discharges - Capacitively and inductively coupled, microwave, ECR and helicon discharges. Low Pressure Materials Processing Applications: Etching for VLSI, film deposition, surface modification and other applications (plasma nitriding, plasma ion implantation, biomedical and tribological applications). High Pressure Plasmas: High pressure non-equilibrium plasmas, thermal plasmas – the plasma arc, the plasma as a heat source, the plasma as chemical catalyst. Applications of High Pressure Plasmas: Air pollution control, plasma pyrolysis and waste removal, plasma based metallurgy – ore enrichment, applications in ceramics, plasma assisted recycling

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	2
2	Fluid equations for plasma	3
3	Single particle motions, unmagnetized plasma dynamics	2
4	Diffusion & transport	3
5	DC sheaths – basic equations, Bohm sheath criterion, Child-Langmuir law, Matrix sheath, collisional sheath, Langmuir probe diagnostics	5
6	Energy and enthalpy, entropy and Gibbs free energy, chemical equilibrium	3
7	Elementary reactions, gas phase kinetics, surface processes and kinetics	5

8	Plasma equilibrium – electropositive and electronegative	2
9	DC discharges	2
10	RF Discharges – capacitively and inductively coupled	4
11	ECR and helicon discharges	2
12	Plasma etching, nitriding deposition and implantation	2
13	High pressure non-equilibrium plasmas, thermal plasmas – the plasma arc	2
14	The plasma as a heat source – plasma torch, the plasma as chemical catalyst	2
15	Air pollution control, plasma pyrolysis and waste removal, plasma based metallurgy – ore enrichment, applications in ceramics, plasma assisted recycling	3
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Overview of Plasma Applications and Plasma as the Fourth State of Matter.
1	Plasma & Sheath Formation; Practical Plasma Sources.
2	Thermal Equilibrium.
3	Diffusion Across a Magnetic Field.

9	Analysis of the Cathode Region
11	Characteristics and Configurations
12	Plasma Processing in Microelectronics
12	Etch Requirements and Processes
12	Nitriding deposition and implantation
13	Atmospheric Pressure Glow Discharges and the Plasma Arc
14	Plasma Torch and Plasma as a Catalyst
15	Cleaning the Air, Plasma Pyrolysis
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. M.A. Lieberman and A.J. Lichtenberg, Principles of Plasma Discharges and Materials Processing, John-Wiley, 2005.
2. P.I. John, Plasma Sciences and the Creation of Wealth, Tata McGraw-Hill Book Co. Ltd., 2005.
3. S.M. Rossnagel, J.J. Cuomo, and WD Westwood, Handbook of Plasma Processing Technology, Noyes Publications, 1990.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----

21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Hydrogen Energy			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3		**Non-graded Units**	---
5.	**Course number**	ESL746			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. L. M. Das, Dr. K. A. Subramanian

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To teach fundamentals of hydrogen energy as energy systems, production processes, storage, utilization, and safety that is necessary for taking some important elective subjects as well as to increase the potential for job opportunities in automotive industries and hydrogen production & its infrastructure development related sectors as about 40% energy is being consumed by automotive sectors.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Introduction of Hydrogen Energy Systems: Hydrogen pathways introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and Hydrogen production power plants. Hydrogen Production Processes: Thermal-Steam Reformation – Thermo chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods. Electrochemical – Electrolysis – Photo electro chemical. Biological – Photo Biological – Anaerobic Digestion – Fermentative Micro-organisms. Hydrogen Storage: Physical and chemical properties – General storage methods, compressed storage – Composite cylinders – Glass micro sphere storage - Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Hydrogen Utilization: Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications. Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change. Hydrogen Safety: Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management, and simulation of crash tests.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to Hydrogen Energy Systems	4
2	Hydrogen Production Processes	10
3	Hydrogen Storage	7
4	Hydrogen Utilization	14
5	Hydrogen Safety	7

	Course Total	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Atomic structure of hydrogen, Resources for hydrogen, Hydrogen cycle, physiochemical properties of hydrogen
2-3	Suitable materials for hydrogen energy system, hydrogen energy storage technologies
4-5	Modification of necessary infrastructure change for hydrogen energy implementation from conventional system, National and international policy on hydrogen, Hydrogen safety codes
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. M. Ball and M. Wietschel, The Hydrogen Economy Opportunities and Challenges, Cambridge University Press, 2009
2. JOM Bockris, Energy options: Real Economics and the Solar Hydrogen System, Halsted Press

and London publisher, 1980.
3. M.K.G. Babu, K.A. Subramanian, Alternative Transportation Fuels: Utilization in Combustion Engines, CRC Press, 2013.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Power point projector, OHP and Black Board Facilities
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	40%
21.2	Open-ended problems	30%
21.3	Project-type activity	30%
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Solar Photovoltaic Devices and Systems			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL755			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	ESL730/ESL770

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	Faculty who will teach the course
	Prof. V. Dutta, Dr. Vamsi Krishna

12.	Will the course require any visiting faculty?	Yes

13.	Course objectives
	The Course will be introducing the students to all the aspects of PV technology. This will enable them to understand the requirements for PV materials and PV systems for different applications. The role of PV in autonomous, hybrid and distributed generation will be emphasized.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Photovoltaic materials will be discussed in details. This will include materials in bulk and thin film forms. The role of microstructure (single crystal, multi crystalline, polycrystalline, amorphous and nano-crystalline) in electrical and optical properties of the materials will be emphasized. The need for different cell design will be identified and the technology route for making solar cells will be discussed. Different methods of characterization of materials and devices will be discussed. Applications of Photovoltaic for power generation from few watts to Megawatts will be introduced.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Review of Photovoltaic Conversion	02
2	Thermodynamics of Photovoltaic Conversion	03
3	First, Second and Third Generation PV Devices: Design and Fabrication	12
4	PV device characterization	03
5	PV system for standalone applications (Lighting, Water Pumping etc.)	06
6	PV system for grid interactive applications	06
7	PV based hybrid system	02
8	Very Large Scale Photovoltaic (VLSPV)	02
9	PV Instrumentation	04
10	Environmental effects of Photovoltaic	02

	Course Total	42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component
(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Energy Bands and energy Gap, Carrier concentration at Thermal Equilibrium, Carrier-Transport Phenomena.
1	Junction depletion region, Current-Voltage Characteristics of junctions in reverse and forward directions
2,3	Silicon manufacturing and properties, low cost industrial technologies
4,5	Module design- series and parallel considerations of solar cell, Hot spot generation
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. K.L.Chopra and S.R. Das, Thin Film Solar Cells, Plenum Press, 1981.
2. A.L. Fahrenbuch and RH Bube, Fundamentals of solar cells, Academic Press, 1983.
3. G.A.Martin. High Efficiency Silicon Solar Cells, Trans Tech. Publications, 1987.
4. R.Brendel and A.Goetzberger, Thin Film Crystalline Si Solar cells, Wiley VCH, 2003.
5. Bhattacharya, Tapan, Terrestrial solar photovoltaic, Narosa Publishing House, 1998.
6. L.France and T.G.Ang, Photovoltaic Engineering Handbook, Adam Hilger, 1990.
7. A.M.Roger and J.Ventre, Photovoltaic Systems Engineering, CRC Press, 2000.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Photovoltaic System Design Software (TRANSYS)
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Wind and Small Hydro Energy Systems			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL768			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course** Prof. T. S. Bhatti, Dr. A. Verma	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** The subject will enhance the understanding of the students on basic concepts of aerodynamics, horizontal and vertical axis wind turbines, small hydro system components and design, hybrid systems and controls

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Introduction, General theories of wind machines, Basic laws and concepts of aerodynamics, Micro-siting, Description and performance of the horizontal–axis wind machines, Blade design, Description and performance of the vertical–axis wind machines, The generation of electricity by wind machines, case studies, Overview of micro mini and small hydro, Site selection and civil works, Penstocks and turbines, Speed and voltage regulation, Investment issues, load management and tariff collection, Distribution and marketing issues, case studies, Wind and hydro based stand-alone / hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	General theories of wind machines, Basic laws and concepts of aerodynamics	6
2	Description and performance of the horizontal–axis wind machines, Blade design	6
3	Description and performance of the vertical–axis wind machines,	5
4	Micro-siting, The generation of electricity by wind machines, case study	5
5	Overview of micro mini and small hydro, Site selection and civil works	6
6	Penstocks and turbines	6
7	Speed and voltage regulation, Investment issues, load management and tariff collection, Distribution and marketing issues, case studies,	4
8	Wind and hydro based stand-alone / hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems	4
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Wind energy basics
1	Measurement of wind speed and direction
4	Methods of estimation of wind energy
5	Basics of hydro energy, Relevance of small hydro power plants in the present world scenario.
5	Components of small hydro power plants
5	Measurement of head and flow rate of water streams
2,3,4	Present world scenario of wind energy
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. J.F.Manwell, J.G.McGowan and A.L.Rogers, Wind Energy Explained – Theory, Design and Application John Wiley & Sons, Ltd., 2002.
2. M.O.L.Hansen, Aerodynamics of Wind turbines, Earthscan, 2008.
3. F.D.Bianchi, H.D.Battista and R.J.Mantz, Wind Turbine Control Systems- Principles, Modelling and Gain Scheduling Design, Springer, 2007.
4. A.Harvey, A.Brown and P.Hettiarachi, Micro-Hydro Design Manual: A Guide to Small-Scale

Water Power Schemes, ITDG, 1993.
5. M.Laguna, Guide on How to Develop a Small Hydropower Plant, ESHA, 2004.
6. R.Ritter, Good & Bad of Mini Hydro Power, GTZ, 2009.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Power point presentation, OHP and black board Facilities
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	15 %
21.2	Open-ended problems	05 %
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**	Centre for Energy Studies		
2.	**Course Title**	Solar Energy Utilization		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL 770		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. G. N. Tiwari, Prof. T. C. Kandpal, Prof. S. C. Kaushik, Dr. Dibakar Rakshit

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** In these days of energy crisis and environmental deterioration, solar energy finds an important place as a solution. It is being used globally to generate electricity and provide industrial and domestic applications. Through photovoltaic and thermal routes, power is being made available to distant and isolated places where grid access is almost impossible. Solar water heating, solar space heating and solar heat in the form of industrial process heat, is being used.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Solar radiation and modeling, solar collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentrators, Selective coatings, Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration, Active and passive heating and cooling of buildings, Solar thermal power generation, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options, Industrial process heat systems, Solar thermal power generation and sterling engine, Solar economics.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction	1
2	Solar radiation and modeling	6
3	Solar collectors and types: flat plate, concentrating solar collectors,	5
4	Advanced collectors and Selective coatings	4
5	Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration	7
6	Active and passive heating and cooling of buildings	5
7	Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options	5
8	Industrial process heat systems	3
9	Solar thermal power generation and sterling engine	4
10	Solar economics	2

	Course Total	42

16. **Brief description of tutorial activities:**

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. **Brief description of Practical / Practice activities**

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. **Brief description of module-wise activities pertaining to self-learning component** (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Basic heat transfer (conduction, convection, radiation and respective heat transfer coefficient)
1	Physical properties of basic materials (air, water, metal, insulating materials etc.)
1	Surface properties
1	Greenhouse effects
10	Basics of mass transfer and economics (conversion factors)
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. **Suggested texts and reference materials**

1. J.A.Duffie and W.A.Beckman, Solar Energy of Thermal Processes, John Wiley & Sons Inc., 1991.
2. G.N.Tiwari, Solar Energy, Narosa Publishing House, 2002.
3. D.Y.Goswami, F.Krieth, and J.F.Krieder, Principals of Solar Engineering, Taylor and Francis

Inc., 2000.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Blackboard, LCD projector, OHP
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Operation & Control of Electrical Energy Systems		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL796		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	----

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. T. S. Bhatti, Dr. A. Verma

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** To introduce the real time monitoring and control systems in a modern computerized load dispatch centre including the market operation in restructured power systems

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Real Time Monitoring of Power Systems: State Estimation, Topological observability Analysis, Security Analysis of Power Systems, Economic Dispatch & Unit Commitment. Control of Power & Frequency: Turbine -Governor Control Loops, Single Area and Multi-Area Systems Control, Effect of high penetration of Wind & Other Renewable/Distributed Generation on P-F Control. Control of Voltage & Reactive Power: Generator Excitation Systems, & Automatic Voltage Regulators, Transformer Tap Changes Controls, Voltage Control in Distribution Networks using New Power Electronic Devices. Introduction to Market operations in Electric Power Systems: Restructured Power Systems, Short Term Load Forecasting, Power Trading through Bilateral, Multilateral Contracts and Power Exchanges, Role of Distributed Generators in market Operations.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Real Time Monitoring of Power Systems	14
2	Control of Power and Frequency	14
3	Control of voltage and reactive power	10
4	Introduction of Market operations in electric power systems	4
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1,2	Basics of power system component steady state modelling for transmission networks (generator modelling, transformer model, transmission line and load models)
1,3	Network modelling and short circuit analysis: Y bus and Z bus matrices formulation, Mutually coupled branches Z bus, Fault calculations using Z bus, Algorithm for various power flow calculations.
1,3	AC load flow formulations, Gauss-siedel method, Newton Raphson method, Decoupled power flow method
1,2,3,4	New Advancements/techniques in Power System Operation and Control
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. A.J.Wood and B.F Wollenberg, Power Generation Operation and Control, Wiley - Interscience Publication, 2003.
2. O.I.Elgerd, Electric Energy Systems Theory: An Introductuion, Tata McGraw Hill Publication, 1982.
3. M.Shahidepour et al., Market Operationhs in Electric Power Systems, Wiley Inderscience & IEEE Publication, 2002.
4. Bhattacharya et al., Operation of Restructured Power Systems, Kluwer Academic Publicshers, 2001.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	PSCAD/ ETAP software

20.2	Hardware	Nil
20.3	Teaching aids (videos, etc.)	Nil
20.4	Laboratory	PC LAB for running the software
20.5	Equipment	Nil
20.6	Classroom infrastructure	Blackboard, LCD projector, OHP
20.7	Site visits	Visit to the Northern Regional Load dispatch centre in Delhi
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	50%
21.2	Open-ended problems	25%
21.3	Project-type activity	25%
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	MHD Power Generation		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL810		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	----

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course**
	Prof. R. P. Sharma, Dr. R. Uma.

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	After doing this course the students are expected to have the basic ideas of MHD systems in general and apply them for designing the MHD generators. Problems related to the operations like instabilities, plasma sheath etc should be resolved.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Principle of MHD power generation, Properties of working fluids, MHD equation and types of MHD duct, Losses in MHD generators, Diagnostics of parameters, MHD cycles, MHD components (air heater, combustion chamber, heat exchanger, diffuser, insulating materials and electrode walls, magnetic field etc.), Economics and applications of MHD, Liquid metal MHD generators.

15. Lecture Outline (with topics and number of lectures)

Module no.	**Topic**	**No. of hours**
1	Principle of MHD power generation	4
2	Properties of working fluids	12
3	MHD equation and types of MHD duct,	11
4	Losses in MHD generators, Diagnostics of parameters, MHD cycles, MHD components , Economics and applications of MHD	9
5	Liquid metal MHD generators	6
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	**Description**	**No. of hours**
	-------	-------
Total Tutorial hours (14 times ‘T’)		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	MHD approximations and their applications in MHD systems. (T.J.M. Boyd & J.J.Sanderson)
2	Instability (Ionisation) in spatial and temporal and effect of this instability in the performance of MHD generator. (J. Rosa)
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. R.J.Rosa, Magneto hydrodynamic Energy Conversion, McGraw-Hill, 1968.
2. G.J.Womack, MHD Power Generation, Chapman and Hall Ltd., 1968.
3. S.Sutton, Direct Energy Conversion, McGraw-Hill, 1966.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----

20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Solar Architecture			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL840			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	Partly with ESL770 Solar Energy Utilization
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	----

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course**
	Prof. G. N. Tiwari, Prof. S. C. Kaushik, Dr. Dibakar Rakshit

12.	**Will the course require any visiting faculty?**	Yes

13.	**Course objectives**
	This course has objectives to elaborate PG students regarding current trends in solar architecture and following key concepts: Solar Radiation, Sun Angles, and Importance of Sun Angles for Building Fenestration/day lighting, Solar Passive Architecture, heat transfer in buildings, Natural Heating/Cooling concepts for Building, Earth to Air Heat Exchanger, Thermal Comfort Requirements, Energy Conservation, and Concept of Zero Energy Buildings.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Thermal comfort, sun motion, Building orientation and design, passive heating and cooling concepts, thumb rules, heat transfer in buildings: Thermal modeling of passive concepts, Evaporative cooling, Energy efficient windows and day lighting, Earth air tunnel and heat exchanger, Zero energy building concept and rating systems, Energy conservation building codes, Software for Building Simulation, Automation and Energy Management of Buildings.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Solar Radiation Concept	2
2	Sun Angles	1
3	Building Orientation and Design	2
4	Passive Heating	4
5	Passive Cooling	4
6	Basics of Heat Transfer in Buildings	6
7	Thermal Modeling of Passive Concepts	6
8	Evaporative Cooling	4
9	Day lighting through Windows	5

10	Earth air tunnel and heat exchanger	2
11	ZEBC, Building rating system, Simulation Tools, Codes	6
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
2	Sun-earth angle and motion
2	Fourier analysis
1,6	Transient heat conduction analysis
3	Building materials and their energy density and greenhouse effect
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. G.N.Tiwari, Solar Energy, CRC Press, 2002.
2. M.S. Sodha, N.K. Bansal, P.K. Bansal, A. Kumar, and M.A.S.Malik, Solar Passive Building,

Science and Design, Pergamon Press, 1986.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	No
20.2	Hardware	No
20.3	Teaching aids (videos, etc.)	Yes
20.4	Laboratory	No
20.5	Equipment	No
20.6	Classroom infrastructure	LCD Projector, OHP and Black Board Facilities
20.7	Site visits	No
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	50
21.2	Open-ended problems	25
21.3	Project-type activity	0
21.4	Open-ended laboratory work	0
21.5	Others (please specify)	25 Assignment/Tutorials/Presentation of one concept

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Solar Refrigeration and Air Conditioning		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL850		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course**
	Prof. S. C. Kaushik

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	This course will contain Basic Thermodynamic Modelling, Design Studies and Evaluation Methods for Solar Cooling Systems.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Potential and scope of solar cooling, Types of solar cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning, Solar operation of vapour absorption and vapour compression refrigeration cycles and their thermodynamic assessment, Rankine cycle, sterling cycle based solar cooling systems, Jet ejector solar cooling systems, Fuel assisted solar cooling systems, Solar desiccant cooling systems, Open cycle absorption / desorption solar cooling alternatives, Advanced solar cooling systems, Thermal modeling and computer simulation for continuous and intermittent solar refrigeration and air-conditioning systems, Refrigerant storage for solar absorption cooling systems, Solar thermoelectric refrigeration and air-conditioning, Solar thermo acoustic cooling and hybrid air-conditioning, Solar economics of cooling systems.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Scope of Solar Cooling	1
2	Solar Collection and Storage Options	3
3	Types of Solar Cooling	2
4	Vapour Compression Refrigeration	3
5	Photovoltaic Refrigeration	1
6	Rankine cycle solar cooling	3
7	Gas cycle solar cooling systems	1
8	Steam Jet Ejector Cooling	2
9	Thermo compression systems	2

10	Vapour Absorption Cooling	3
11	Types of Absorption cooling	2
12	Open cycle Absorption cooling cycle	2
13	Vapour Absorption cooling cycle	2
14	Solid and Liquid Desicant cooling	3
15	Hybrid Solar Air Conditioning cycle	2
16	Solar Thermoelectric cooling	3
17	Solar Thermo acoustic cooling	2
18	Corporative study of cooling systems	2
19	Solar economics of cooling systems	2
20	Advanced Solar Cooling Concepts	2
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	History of Refrigeration
1	Traditional cooling options

1	Unit of Refrigeration cooling (TR) and Compression work (Horse Power)
3	Heating/Cooling load calculations
4	Types of compression based Refrigeration system
4	Air compression based Refrigeration
4	Traditional Refrigerants
4	Problems with conventional Refrigerants
4	Ozone Depletion Potential and Global warming Potential of various Refrigerants
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. S.C.Kaushik, Solar Refrigeration and space conditioning, Divyajyoti Publications, 1989.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	---
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	20
21.2	Open-ended problems	20
21.3	Project-type activity	20

21.4	Open-ended laboratory work	-
21.5	Others (please specify)	40 (Lectures)

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Electrical Power System Analysis			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL860			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	10% with EEL791
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	**Faculty who will teach the course** Prof. T. S. Bhatti, Dr. A. Verma	

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives** The subject will enhance the understanding of the students on power system network modeling and short circuit analysis, power flow solutions, security analysis, state estimation and transient stability.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Network modeling and short circuit analysis: Primitive network, Y bus and Z bus matrices formulation, Power invariant transformations, Mutually coupled branches Z bus, Fault calculations using Z bus, Power flow solutions: AC load flow formulations, Gauss-siedel method, Newton Raphson method, Decoupled power flow method, Security analysis: Z bus methods in contingency analysis, Adding and removing multiple lines, Interconnected systems, Single contingency and multiple contingencies, Analysis by DC model, System reduction for contingency studies, State Estimation: Lone power flow state estimator, Method of least squares, Statistics error and estimates, Test for bad data, Monitoring the power system, Determination of variance, Improving state estimates by adding measurements, Hierarchical state estimation, Dynamic state estimation, Power system stability: transient and dynamic stability, Swing equation, Electric power relations, Concepts in transient stability, Method for stability assessment, Improving system stability.

15. **Lecture Outline** (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Network modeling and short circuit analysis	8
2	Power flow solutions	10
3	Security analysis	8
4	State Estimation	8
5	Power system stability	8
	Course Total	**42**

16. **Brief description of tutorial activities:**

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times ‘T’)		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times ‘P’)		-------

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1,2,3,4	Basics of power system component steady state modelling for transmission networks (generator modelling, transformer model, transmission line and load models)
5	Basics of Eigen Value Analysis, left and right eigen vectors, stability prediction
1,2	Algorithm Development for Y Bus, One Power Flow Method and Fault Analysis in MATLAB PLATFORM
1,2	Hands on Experience with ETAP. Perform Fault and load flow analysis using the same.
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. X.F.Wang, Y.Song and M.Irving, Modern Power Systems Analysis, Springer, 2009.
2. J.Machowski, J.W.Bialek and J.R.Bumby, Power System Dynamics - Stability and Control, John Wiley and Sons Ltd., 2008.
3. G.Kusic, Computer-Aided Power Systems Analysis, CRC Press, 2009.
4. A.R.Bergen and V.Vittal, Power Systems Analysis, Prentice-Hall, 2000.
5. H.Saadat, Power Systems Analysis, Mc Graw Hill, 2002.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	Power Point presentation, OHP and Black Board Facilities
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Nil
21.2	Open-ended problems	12%
21.3	Project-type activity	Nil
21.4	Open-ended laboratory work	Nil
21.5	Others (please specify)	Some typical examples

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Fusion Energy			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL870			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	----

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐ Every semester ☐ I sem ☐ II sem ☒ Either semester

11.	**Faculty who will teach the course**
	Prof. R. P. Sharma, Prof. A. Ganguli, Dr. R. Uma, Dr. R. Narayanan

12.	**Will the course require any visiting faculty?**	No

13.	**Course objectives**
	After doing this course the students are expected to have basic understanding of nuclear fusion process and the schemes to achieve this.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Fission and fusion, Need for plasma, Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement, Plasma concept, Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport, Important heating schemes, Tokamak and magnetic mirror, Reactor concepts, Current status.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Fission and fusion	4
2	Plasma concept, Need for plasma	4
3	Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement,	12
4	Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport,	10
5	Important heating schemes, Tokamak and magnetic mirror, Reactor concepts, Current status.	12
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Basic idea about nuclear forces, composition of nucleus, Binding energy and rest mass energy, mass defect of a nuclear reaction.
2,3	Cross- section & mean free path ; reactivity
4	Vectors and scalars, vector identities, dot and cross products, conservation laws, electromagnetic fluid equations and Fick's law.
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. F.F.Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum Press, 1983.
2. W.L.Kruer, The Physics of Laser Plasma Interaction, Addision-Weseley, 1988.
3. H. Hagler and M. Kristiansen, Introduction to Controlled Thermonuclear Fusion, Lexington, 1977.
4. W. M. Stacey, Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, 2nd edition, Wiley- VCH Publication.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----

20.5	Equipment	----
20.6	Classroom infrastructure	---
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies	
2.	**Course Title**	Advanced Fusion Energy		
3.	**L-T-P structure**	3-0-0		
4.	**Credits**	3	**Non-graded Units**	---
5.	**Course number**	ESL871		
6.	**Course Status** (Course Category for Program):			

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	---
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	Faculty who will teach the course
	Prof. R. P. Sharma, Prof. A. Ganguli, Dr. R. Uma, Dr. R. Narayanan

12.	Will the course require any visiting faculty?	No

13.	Course objectives
	After doing this course, the students are supposed to have the basic understanding of various kinds of instabilities and their effect on heating the plasma and transport in fusion devices

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Tokamak confinement Physics, Particle motions in a tokamak, Toroidal equilibrium, Toroidal stability, High-beta Tokamak, Experimental observations, Fusion Technology, Commercial Tokamak Fusion-power plant, Tandem- mirror fusion power plant, Other Fusion reactors concepts, Inertial confinement fusion reactors, Reactor cavity, Hybrid fusion/fission systems, Process heat and synthetic fuel production.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Tokamak confinement Physics, Particle motions in a tokamak, Toroidal equilibrium, Toroidal stability, beta effects	15
2	Experimental observations, Fusion Technology, Commercial Tokamak Fusion-power plant	5
3	Tandem- mirror fusion power plant, Other Fusion reactors concepts	5
4	Inertial confinement fusion reactors, Reactor cavity,	14
5	Hybrid fusion/fission systems, Process heat and synthetic fuel production	3
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	-------	-------
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
	------	-------
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1	Basic particle evolution in various electromagnetic configurations
1	Basic concepts of cross field transport; stability and instability
2,4	Current state of fusion programmes (websites and reference books to be provided in class)
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. A.Simon and W.B.Thompson, Advances in Plasma Physics, John Wiley and Sons, 1976.
2. T.H. Stix, The Theory of Plasma Waves, McGraw-Hill, 1962.
3. K. Miyamoto, Plasma Physics for Nuclear Fusion, MIT Press, 1980.
4. W. M. Stacey, Fusion: An Introduction to the physics and technology of magnetic Confinement Fusion, 2nd edition, Wiley- VCH Publication

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	----
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----

20.6	Classroom infrastructure	LCD Projector, OHP and Black Board Facilities
20.7	Site visits	----
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	----
21.2	Open-ended problems	----
21.3	Project-type activity	----
21.4	Open-ended laboratory work	----
21.5	Others (please specify)	----

Date: (Signature of the Head of the Department/ Centre / School)

COURSE TEMPLATE

1.	**Department/Centre/School proposing the course**		Centre for Energy Studies		
2.	**Course Title**	Solar Thermal Power Generation			
3.	**L-T-P structure**	3-0-0			
4.	**Credits**	3	**Non-graded Units**	---	
5.	**Course number**	ESL880			
6.	**Course Status** (Course Category for Program):				

Institute Core for all UG programs	---
Programme Linked Core for:	---
Departmental Core for:	---
Departmental Elective for:	---
Minor Area / Interdisciplinary Specialization Core for:	---
Minor Area / Interdisciplinary Specialization Elective for:	---
Programme Core for:	---
Programme Elective for:	JES
Open category Elective for all other programs (No if Institute Core)	Yes

7.	**Pre-requisite(s)**	---

8.	**Status vis-à-vis other courses**		
8.1	List of courses precluded by taking this course (significant overlap)		**---**
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	10% with ESL 340, 10% with ESL 740, 20% with ESL 770
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	---
8.2	Supersedes any existing course		---

9.	**Not allowed for**	---

10.	**Frequency of offering**	☐Every semester ☐I sem ☐II sem ☒Either semester

11.	Faculty who will teach the course
	Prof. S. C. Mullick, Prof. T. C. Kandpal, Prof. S. C. Kaushik, Prof. G. N. Tiwari

12.	Will the course require any visiting faculty?	No

13.	Course objectives
	To provide knowledge, understanding and application oriented skills on various solar thermal power generation technologies and their components/subsystems (solar concentrators, thermal storage and power conversion options) towards their effective utilization for meeting electricity demand with minimum environmental emissions.

14.	**Course contents** (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities):
	Relevance of solar thermal power generation; Design and performance characteristics of different solar concentrator types suitable for thermal power generation; Tracking of solar concentrators; performance characterization of solar concentrators ,Storage option for solar thermal power plants; Modes of power generation in solar thermal power plants; Sizing solar thermal power plants; Operation and maintenance issues; Emerging trends in solar thermal power generation; Economics of solar thermal power generation; Case studies.

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Electricity demand in the country, Challenges with conventional power generation option, Need and relevance of renewable energy based power generation, suitability of solar thermal power generation for India	2
2	Solar thermal power generation, Components of solar thermal power plant	2
3	Solar concentrators, Parameters characterizing solar concentrators, Solar radiation availability for solar concentrators and its dependence on tracking modes	3
4	Optical design and concentration characteristics of Parabolic Through, Parabolic Dish, Fresnel Lens, Linear Fresnel Reflector, Compound Parabolic Concentrator, and Central Tower Receive System, optical performance and durability characterization	7
5	Thermal performance of solar concentrators, Receiver designs, Thermal performance characterization	4
6	Tracking of solar concentrators	2
7	Power generation block of solar thermal power plants, Oil-Indirect steam generation, Organic Rankine cycle, Brayton cycle, Stirling	5

	engine, air and water cooling arrangements, Choice of heat transfer fluids	
8	Storage of heat in solar thermal power plants, Storage media and heat transfer fluids	3
9	Sizing solar thermal power plants for stand alone, with storage, with auxiliary, and with storage and auxiliary mode of operation, Field layout, Site selection	4
10	Issue in manufacture and use of (a) reflectors for use in solar thermal power plants (II) absorbers (III) support structures (IV) tracking systems and other components	3
11	Operation and maintenance of solar thermal power plants, water requirement etc.	2
12	Economics of solar thermal power generation	2
13	Case studies on existing solar thermal power plants	3
	Course Total	**42**

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		-------

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		-------

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not include assignments / term papers etc.)

Module no.	Description
1-3	Solar radiation, Sun-earth geometry, Basic optics of solar collection-reflection, refraction, and absorption from a glass, Equations of parabola, cylinder, sphere, circles etc. in Cartesian and polar coordinates
4-5	Basics of heat transfer, Materials aspects of solar thermal collection-glass, metals, selective coatings, Basics of power cycles, Carnot, Rankine, Bryton, Stirling cycles
6-10	Solar thermal power generation module of the software "System Advisor Model"
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

1. K. Lovegrove and W. Stein, Concentrating solar Power Technology: Principles Development and Applications, Woodhead Publishing Ltd., 2012.
2. J.A. Duffie and WA Beckman, Solar Engineering of Thermal Processes, John Wiley and Sons, 2006.
3. S.A. Kalogirous, Solar Energy Engineering, Academic Press, 2009.
4. J.F. Kreider, Medium and High Temperature Solar Processes, Academic Press, 1979.
5. S. S.Mathur and T.C.Kandpal, Solar Concentrators in “Reviews of Renewable Energy Resources”, Wiley Eastern Limited, New Delhi, 1984.
6. W.Vogel and H.Kolb, Large Scale Solar Thermal Power, Wiley-VCH Verlag GmbH&Co. KGaA Weinheim, 2010.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Sizing software for solar thermal power plants
20.2	Hardware	----
20.3	Teaching aids (videos, etc.)	----
20.4	Laboratory	----
20.5	Equipment	----
20.6	Classroom infrastructure	----
20.7	Site visits	Visit to system and facilities installed in and around Solar Energy Centre of Ministry of New and Renewable Energy
20.8	Others (please specify)	----

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	20%
21.2	Open-ended problems	20%
21.3	Project-type activity	10%
21.4	Open-ended laboratory work	-
21.5	Others (please specify)	50% Assignments on niche area identification, site selection and choice of CSP technology

Date: (Signature of the Head of the Department/ Centre / School)