MINUTES OF THE FORTIETH MEETING OF THE ACADEMIC COUNCIL HELD ON 05 JULY, 2017 AT 10.30 A.M.

PRESENT

The following members of the Academic Council attended the meeting:

Members		**Invitees**
Dr Leena Srivastava	Chairperson	Dr Montu Bose
Dr Rajiv Seth		Mr Sapan Thapar
Dr Prateek Sharma		Dr Sukanya Das
Dr Arun Kansal		Dr Swarup Dutta
Dr Malathi Lakshmikumaran		Dr LN Venkataraman
Dr Anubha Kaushik		Dr Shaleen Singhal
Dr Suresh Jain		Dr Prodipto Ghosh
Dr Sapna A Narula		Mr Atul Tripathi
Dr Nandan Nawn		Mr Shri Prakash
Dr Sudipta Chatterjee		Dr Bhawna Bali
Dr Chaithanya Madhurantakam		Dr Abhijit Datey
Dr MV Shiju		Dr Deepty jain
Dr Naqui Anwer		Dr Udit Soni
Dr Anandita Singh		Dr Priyanka Kaushal
Dr Anu Rani Sharma		Dr Ritika Mahajan
Ms Fawzia Tarannum		
Capt. Pradeep Kumar Padhy (Retd.)	Secretary	

Prof S Sundar, Dr Rakesh Khosa, Dr Kanchan Chopra, Prof TC Kandpal and Dr Vivek Suneja could not attend the meeting.

The Vice Chancellor welcomed all the members of the Academic Council and the special invitees.

ITEM NO. 1 To confirm the minutes of the thirty ninth meeting of the Academic Council held on 23 Dec 2016. The minutes of the thirty ninth meeting of the Academic Council held on 23 Dec 2016, was circulated to the members and no comments have been received.

TU/AC 40.1.1 The Council resolved that the minutes of the meeting of the Academic Council held on 23 Dec 2016 be confirmed.

ITEM NO. 2 To confirm the draft programme structure of PGDRE/APGDRE. The Registrar intimated that as resolved in the 39th meeting of the Academic Council vide resolution no TU/AC/39.4.1 dated 23 Dec 16, the revised programme structure of PGDRE/APGDRE courses was circulated for consideration of the Council on 27 Jan 2017. No comments have been received; the Council may, therefore, consider confirming the draft programme structure presented.

TU/AC 40.2.1 The Council resolved that the programme structure of PGDRE/APGDRE be confirmed (Annexure 1).

ITEM NO.3(a) To consider and approve the programme structure of third semester for MBA (Infrastructure). The recommendations of the meeting of the Board of Studies of Department of Business & Sustainability held on 12 June 17 w.r.t. MBA(Infra) programme were placed before the Council.

TU/AC 40.3(a).1 The Council resolved that programme structure of the third semester of MBA (infrastructure) programme as given below be accepted as amended and approved.

Semester 3: (Min-16 Credits)

Ser.	Course name	Type	Cr
1	Statistical Methods for Management	Core	3
2	Sustainable Urban Transport	Elective	2
3	Urban Water supply and Waste Management	Elective	2
4	IT and System Infrastructure	Elective	2
5	Advanced Logistics and SCM	Elective	2
6	Corporate Governance- evolution, challenges, and future direction	Core	2
7	Financial Intermediaries, Institutions and Markets	Elective	2
8	Entrepreneurship Development and Management	Elective	2
9	Business 2 Business marketing	Elective	2
10	Accounting and finance for sustainability	Core	3

ITEM NO.3(b) To consider and approve the outlines of courses for MBA(Infrastructure/BS). The recommendations of the meeting of the Board of Studies of Department of Business & Sustainability held on 12 June 17 were placed before the Council. A detailed discussion was held on the course outlines. The Council recommended the following: -

-Instead of having a specific course on statistics for infra there should be a common course which could be extended to other disciplines.

-The tutorials and assignments could be used to handle programme specific examples.

-Other types of sampling designs and distributions are to be included.

-Confidence interval should be part of estimation and both one & two-way techniques of analysis of variance(ANOVA) could be added.

TU/AC 40.3(b).1 The Council resolved that Course outlines of the following two courses for MBA (BS) & MBA(infrastructure) programmes be accepted as amended (vide Annexure 2) and approved:-

Ser	Course	Course	Type	Cr
1	Accounting and finance for sustainability	MBA(BS)/ MBA(Infra)	Core	3
2	Statistical methods for Management	MBA(Infra)	Core	3

ITEM NO. 4. To consider and approve inclusion of electives for MBA (BS) programme. The recommendations of the meeting of the Board of Studies of Department of Business & Sustainability held on 12 June 17 w.r.t. MBA(BS) programmes were placed before the Council. Dr Nandan stated that as per the existing practice students could choose any approved course as an optional course, hence academic council approval might not be required for finalisation of such electives. Dr Seth stated that the University had moved towards a system where electives across the University would be available to all students of any programmes, hence proposals on electives for programmes which were already approved need not be brought to the Council. He suggested that the issue could be discussed in the MPEC and the list of electives for a particular programme could be finalized. Dr Kaushik suggested that, as practiced in other Universities, the electives offered could be programme specific or open types.

TU/AC 40.4.1. The Council resolved that courses under any approved programme could be offered as electives for other programme.

ITEM NO. 5(a). To consider and approve the revised programme structure of the third semester of M.Tech (UDM). The recommendations of the meeting of the Board of Studies of Department of Energy and environment held on 08 June 17 w.r.t. MTech(UDM) were placed before the Council.

TU/AC 40.5(a).1 The Council resolved that following programme structure of the MTech (UDM) be accepted as amended and approved: -

Semester 3: 18 Credits (12 credits from Major Project Part 1; 2 credits from 1 Core Course; and 4 credits from 2 Elective Courses)

Ser	Course	Type	No of credits
1	Major project part 1	Core	12
2	Urban systems modelling	Core	2
3	Urban housing policy and practice	Elective	2
4	Energy efficient buildings	Elective	2
5	Sustainable urban transport	Elective	2
6	Urban disaster management and climate resilient cities	Elective	2

ITEM NO. 5(b) To consider and approve outline of courses for M.Tech (UDM). The recommendations of the meeting of the Board of Studies of Department of Energy and Environment held on 08 June 17 w.r.t. MTech (UDM) were placed before the Council. A detailed discussion was held on the course outlines. The following suggestions were provided: -

-Learning outcome of the course 'Urban housing policy & practice' could be rephrased.

-Modelling base (module 2) of the course 'Urban system modelling' be enhanced and module 3 of the course be developed as a separate OR course.

TU/AC 40.5(b).1 The Council resolved that course outlines of the following three courses of MTech(UDM) programme be accepted as amended (vide Annexure 3) and approved: -

Ser	Course	Type	Cr
1	Sustainable urban transport	Elective	2
2	Urban housing policy & practice	Elective	2
3	Urban system modelling	Elective	2

ITEM NO. 6 To consider and approve the outline of a course for MSc (Plant Biotechnology) /PhD programmes. The recommendations of the meeting of the Board of Studies of Dept of Plant Biotechnology held on 09 Jun 2017 were placed before the Council. A detailed discussion was held on the course outlines Dr Malati recommended that cosmetic application of nanomaterials might be included. Dr Kamna suggested that the theoretical component could be covered separately in a different course and the contents of the proposed course reduced. The Council recommended that practical components be incorporated and modules be rearranged for purpose of linearity.

TU/AC 40.6.1 The Council resolved that the course outlines of the following course of MSc (Plant Biotechnology)/PhD programmes be accepted as amended (Annexure 4) and approved: -

Ser	Course	Type	Cr
1	Nanomaterials: Introduction and applications	Elective	2

ITEM NO. 7(a). To consider and approve the programme structure of MTech (REEM). The recommendations of the meeting of the Board of Studies of Department of Energy & Environment w.r.t. MTech (REEM) programme held on 12 June 2017 were placed before the Council.

TU/AC 40.7(a).1 The Council resolved that following programme structure of **MTech (REEM)** be accepted as amended and approved.

Semester 1(22 Credits)

- **Nine Core courses**

Ser	Course	Type	Cr
1	Fundamentals of thermal and electrical engineering	Core	2
2	Renewable energy resource characteristics	Core	4

3	Power system engineering	Core	3
4	Heat transfer	Core	4
5	Conventional energy and environmental implications	Core	2
6	Technical Writing (Communication skills and technical writing)	Core	2
7	Energy conservation and management	Core	2
8	Introduction to management techniques – I	Core	1
9	Energy Lab – I (Power system lab and Heat transfer lab)	Core	2

Semester 2 (22 Credits)

- **Eight core courses**
- **Two optional courses**

Ser	Course Name	Type	Cr
1	Field visits / exposure to RE plants	Core	1
2	Solar technologies	Core	4
3	Wind, small hydro and RE hybrid systems	Core	2
4	Biomass and other renewable technologies	Core	3
5	Renewable energy policy and regulations	Core	3
6	Optimization techniques for energy management and planning	Core	3
7	Renewable energy project and management	Core	3
8	Energy lab – II	Core	3
9	Fluid mechanics and wind turbine models*	Elective	3
10	Applied numerical methods*	Elective	3

***** Optional courses

Semester 3

- **Two core courses + Summer internship/minor project (2 credits)**
- **Total required credits = 15 [6 Core + 9 elective]**

Ser	Course Name	Type	Cr
1	Energy Economics	Core	3
2	Energy simulation lab	Core	3
3	Introduction to management techniques – II	Elective	2
4	Solar photovoltaic power generation	Elective	3
5	Solar thermal power generation	Elective	3
6	Wind power generation	Elective	3
7	Biofuels and decentralized Energy Systems	Elective	3
8	Building energy and green building	Elective	3
9	Grid integration of renewable energy	Elective	3
10	Energy audit	Elective	3
11	Waste to energy	Elective	2
12	Independent study	Elective	3

Note:

1. Students need to acquire 9 credits through electives.
2. Elective courses having less than seven students will not be offered.

Semester 4 (15 Credits)

- **One core course**

Ser	Course Name	Type	Cr
1	Major project	Core	15

ITEM NO. 7(b). To consider and approve the outlines of courses for MTech (REEM). The recommendations of the meeting of the Board of Studies of Department of Energy & Environment w.r.t. MTech (REEM) programme held on 12 June 2017 were placed before the Council. A detailed discussion was held on the course outlines and the following were recommended: -

- Learning outcomes of the Course IMT-I be changed and more reading material added.
- Experiments of energy lab I need to be rephrased.
- MHD being an older method of power generation and not in use hence might be removed from the course 'Biomass and other renewable technologies'.
- In the course, 'Renewable energy policy and regulations' topics on energy trading and energy exchange to be included.
- In the Optimization techniques for energy management and planning course, 'Queuing theory' is not directly related to optimization of renewable energy systems, rather more applicable to supply chain related courses hence not to be included.
- Integer programming to be included in the course 'Optimization techniques for energy management and planning'.
- The course 'wind small hydro and RE hybrid systems' be renamed as Wind, small hydro and hybrid technologies.
- The credits for optional courses should be over and above the total credits required to obtain the degree.
- Energy pricing to be included 'Energy economics' and the course renamed as "Energy economics and pricing".

TU/AC 40.7(b).1. The Council resolved that outline of following courses of **MTech (REEM)** (vide Annexure 5) be accepted as amended and approved.

Ser.	Semester 1	Cr
1	Fundamentals of thermal and electrical engineering	2
2	Renewable energy resource characteristics	4
3	Power system engineering	3
4	Heat transfer	4
5	Conventional energy and environmental implications	2
6	Technical writing	2
7	Energy conservation and management	2
8	Introduction to management techniques - I	1

9	Energy lab – I (Power system lab and Heat transfer lab)	2

Ser.	Semester 2	Cr
1	Solar technologies	4
2	Wind, small hydro and RE hybrid technologies	2
3	Biomass and other renewable technologies	3
4	Renewable energy policy and regulations	3
5	Optimization techniques for energy management and planning	3
6	Renewable energy project management	3
7	Energy lab – II	3
8	Fluid mechanics and wind turbine models	3
9	Applied numerical methods	3

ITEM NO. 8(a). To consider and approve the programme structure of MSc (CSP). The recommendations of the meeting of the Board of Studies of Department of Energy & Environment w.r.t. MSc (CSP) programme held on 15 June 2017 were placed before the Council.

TU/AC 40.8(a).1 The Council resolved that following programme structure of **MSc(CSP)** be accepted as amended and approved.

Semester 1 (21 credits):

Ser	Course	Cr
1	Earth System Sciences	3
2	Basics of Climate Science	3
3	Environmental Law and Policy	3
4	Energy: Science, Technology and Policy	2
5	Impact of Climate Change	2
6	Environmental Statistics	3
7	Concept & Theories of Development	3
8	Climate Lab	2
9	Technical Writing/Academic Writing	Compulsory audit

Semester 2 (17 credits):

Ser	Core Courses	Cr
1	Research Methodology	2
2	Basic Principles of Geo-informatics	3
3	Climate Change Vulnerability and Adaptation	3
4	Climate Change Mitigation	3
	Electives (can choose any two)	
5	Introduction to Uncertainty and Risk Analysis	3
6	Multivariate Data Analysis	3

7	Climate Change and Water	3
8	Introduction to Climate Modelling	3
9	Economics of Climate Change	3

Minor Project – 2 credits

Semester 3(15 credits)

Core Course: Seminar Course [3]

Electives: [Choose any 4 courses. All the courses are 3 credits each.]

Climate Science and Technology	***Climate Policy and Development***
GHG Accounting	*Institutions and Governance*
Ecological Climatology	Adaptation and Mitigation Policy
Energy Modeling and Scenario Analysis	Climate Finance
Renewable Energy Technologies	Scenario Modeling
Atmospheric Dynamics	Climate Change and Public Health
Satellite Meteorology	Food Security and Agriculture
Advanced Geo-Informatics	Independent study
Climate Change and Disaster Risk Reduction	
Advanced Climate Modelling	

Semester 4: Major Project [15 credits]

ITEM NO. 8(b) To consider and approve the outlines of courses for MSc (CSP). The recommendations of the meeting of the Board of Studies of Department of Energy & Environment w.r.t. MS(CSP) programme held on 15 June 2017 were placed before the Council. A detailed discussion was held on the course outlines. Dr Prateek recommended that the revised course 'Earth system science' should be introduced to MSc(ESRM) students instead of the earlier course 'Geo sciences'. With regard to the bridge courses, Dr Jain stated that these courses would be conducted in the beginning of the session as audit courses for students not having prior knowledge of subjects such as basic mathematics/ programming/eEconomics post-secondary school level. Members recommended that the name of the 'Development theories and climate change' course be changed to 'Concept and theories of development' to make it more relevant.

TU/AC 40.8(b).1 The Council resolved that outline of following courses of **MSC(CSP)** (vide Annexure 6) be accepted as amended and approved.

Ser	**Course**	**Cr**
1	Applied Mathematics(Bridge)	1
2	Basic Computer Programming(Bridge)	1
3	Basic course in Economics(Bridge)	1

4	Earth system Sciences	3
5	Basics of climate Science	3
6	Environmental law and policy	3
7	Energy: Science, Technology and Policy	2
8	Impacts of Climate Change	2
9	Environmental Statistics	3
10	Concept & Theories of Development	3
11	Climate Lab	2
12	Technical Writing	2

ITEM NO. 9. To consider and approve the outlines of courses for MTech/MSc (WSG). The recommendations of the meeting of the Board of Studies of Department of Regional Water Studies w.r.t. MTech/MSc (WSG) programme held on 23 June 2017 were placed before the Council. A detailed discussion was held on the course outline. Dr Jain stated that the nomenclature contained an acronym, therefore recommended that the title be rephrased. Dr Seth recommended that this being an open elective a pre-requisite for the course might be mentioned. The Chair recommended that a proper balance between the duration and the content be maintained.

TU/AC 40.9.1 The Council resolved that outline of following course of **MSc/MTech(WSG)** (vide Annexure 7) be accepted as amended and approved.

Ser	Course	Type	Cr
1.	Social, economic and health dimensions of water, sanitation and hygiene	Elective	3

ITEM NO. 10(a). To consider and approve the programme structure of MA(PP&SD). The recommendations of the meeting of the Board of Studies of Department of Energy & Environment w.r.t. MA(PP&SD) programme held on 22 June 2017 were placed before the Council.

TU/AC 40.10(a).1 The Council resolved that following programme structure of **MA(PP&SD)** be accepted as amended and approved.

Semester-I: (17 credits)

Ser	Course	Cr
1.	Introduction to sustainable development	1
2.	Society and development policy	2
3.	Sustainable consumption and production	2
4.	India and the world	2
5.	Industrial development and sustainability	2
6.	Energy policy and sustainable development	2
7.	Governance and law	2
8.	Challenges of a digital economy	2
9.	Policy lab-I	2

NGO Attachment — 2 Credits

Semester-II: (18 credits)

Ser	Course	Cr
1.	Public policy processes & institutions	2

2.	Assessing public policy: methods and measurements	2
3.	Water science and policy	2
4.	Innovations in public management	2
5.	Sustainable urbanization	2
6.	Agriculture and rural development	2
7.	Ecosystem services and communities	2
8.	India: major policy issues	2
9.	Policy lab-II	2

International Visit – 2 Credits
Major Project – 27 Credits

ITEM NO. 10(b) To consider and approve the outlines of courses for MA (PP & SD). The recommendations of the meeting of the Board of Studies of Department of Policy Studies w.r.t. MA(PP&SD) programme held on 22 June 2017 were placed before the Council. A detailed discussion was held on the course outlines. As the programme catered to the needs of the serving mid-career officers, the discussion allowed the newer ways of evaluation in terms of active classroom participation; article and book reviews exercises; individual and group presentations; and other course-works like critiques and discussions. As regards the course on 'India and the world'**,** the council members suggested the reshuffling of the modules with a logical flow; In addition, the council discussed about the practicalities of policy lab course. The Chair suggested that greater level of objectivity should be followed in the method to be adopted in the proposed evaluation scheme.

TU/AC 40.10(b).1 The Council resolved that outline of following courses of **MA (PP &SD)** (vide Annexure 8) be accepted as amended and approved.

Ser	**Course**	**Cr**
1.	Society and development policy	2
2.	Sustainable consumption and production	2
3.	India and the world	2
4.	Industrial development and sustainability	2
5.	Energy policy and sustainable development	2
6.	Governance and law	2
7.	Challenges of a digital economy	2
8.	Policy lab-I	2

ITEM NO. 11. **To consider and approve TERI University PhD Regulations 2017**. The Registrar informed that the PhD regulations of the University had been revised on the basis of UGC (Minimum Standards and Procedure for awards of M Phil/PhD Degree) Regulation -2016 and required to be approved by the council for promulgation.

TU/AC 40.11.1 The Council resolved that draft of the regulation (vide Annexure 9) be circulated amongst the members for consideration.

ITEM NO. 12. Extension of maximum period for submission of Thesis. The Registrar informed the council that a doctoral candidate is expected to submit his/her thesis within five years from the date of registration and the period might be extended by Academic Council as a special case. He stated that Mr. Nehru Machineni (1032RPB) who had registered for PhD programme in Department of Natural Sciences completed his five-year period in March-2017 and on the recommendation of the supervisor, approval was sought for an extension of one year for the submission of the thesis.

TU/AC 40.12.1 The Council resolved that one-year extension be accorded to Mr. Nehru Machineni (1032RPB).

There being no other items for discussion, the meeting was adjourned with a vote of thanks to the Chair.

Sd/
Capt Pradeep Kumar Padhy (retd.)
Registrar

Enclosures:-
Annexure 1
Annexure 2
Annexure 3
Annexure 4
Annexure 5
Annexure 6
Annexure 7
Annexure 8
Annexure 9

Distribution:-
Electronic Copy
1. Vice-Chancellor, TERI University
2. All members of the Academic Council
3. Website

Printed Copy
4. Registrar, TERI University

Annexure 1

Program Outline for 'Advance PG Diploma in Renewable Energy (APGDRE)' in Open and Distance Learning (ODL)

Introduction: This is a two years course offered in ODL mode. It is designed to provide students comprehensive knowledge of different aspects of renewable energies, in addition to energy efficiency and energy conservation. In the two years Advanced PG Diploma course, the following four semesters are offered to the students. The modules and associated credits are structured as follows:

Semester 1:		**Module :** ***Renewables Energy Resources and Policies***	
	Course code	*Course Name*	*No. of credits*
1	DRE 123	Introduction to renewable energy resources & technologies	10
2	DRE 111	Energy policies & planning	7
3	DRE 142	Environmental and health impact of energy use	3

Semester 2:		**Module :** ***Energy Infrastructure & Efficiencies***	
	Course code	*Course Name*	*No. of credits*
1	DRE 113	Energy infrastructure	6
2	DRE 115	Introduction to basic engineering principles	5
3	DRE 112	Introduction to engines	2
4	DRE 114	Energy conservation and management	7

Semester 3:		**Module :** ***Renewable Energy Technologies***	
	Course code	*Course Name*	*No. of credits*
1	DRE 133	Solar thermal technologies	4
2	DRE 191	Solar PV technologies	4
3	DRE 137	Passive solar architecture	3
4	DRE 192	Wind energy technologies	3
5	DRE 193	Hydro power technologies	1
6	DRE 118	Biomass to energy	3
7	DRE 194	Other renewable technologies	2

Semester 4:		**Module :** ***Software Tools for Energy Analysis***	
	Course code	*Course Name*	*No. of credits*
1	DRE 162	RETscreen	5
2	DRE 164	Homer	5
3	DRE 166	PVSyst	5
4	DRE 167	SAM	5

Program Outline for 'PG Diploma in Renewable Energy (PGDRE)' in Open and Distance Learning (ODL)

Introduction: This is a one year course, offered in ODL mode. First semester is mandatory to all the students. For the second semester the student has the choice to pick any other semester offered as elective. The modules and associated credits are structured as follows:

Semester 1:		**Module :** ***Renewables Energy Resources and Policies*** ***(Core)***	
	Course code	*Course Name*	*No. of credits*
1	DRE 123	Introduction to renewable energy resources & technologies	10
2	DRE 111	Energy policies & planning	7
3	DRE 142	Environmental and health impact of energy use	3

AND

Select any one of the following electives given below

Semester 2:		**Module :** ***Energy Infrastructure & Efficiencies*** ***(Elective)***	
	Course code	*Course Name*	*No. of credits*
1	DRE 113	Energy infrastructure	6
2	DRE 115	Introduction to basic engineering principles	5
3	DRE 112	Introduction to engines	2
4	DRE 114	Energy conservation and management	7

OR

Semester 3:		**Module :** ***Renewable Energy Technologies*** ***(Elective)***	
	Course code	*Course Name*	*No. of credits*
1	DRE 133	Solar thermal technologies	4
2	DRE 191	Solar PV technologies	4
3	DRE 137	Passive solar architecture	3
4	DRE 192	Wind energy technologies	3
5	DRE 193	Hydro power technologies	1
6	DRE 118	Biomass to energy	3
7	DRE 194	Other renewable technologies	2

OR

Semester 2: :		**Module :** ***Software Tools for Energy Analysis*** ***(Elective)***	
	Course code	*Course Name*	*No. of credits*
1	DRE 162	RETscreen	4
2	DRE 164	Homer	4
3	DRE 166	PVSyst	4
4	DRE 167	SAM	4
5	DRE 169	TRNSYS	4

Annexure 2

Introduction for new core course on Accounting and Finance for Sustainability (Core)

<table>
<tr><td colspan="5">Course title: Accounting and Finance for Sustainability</td></tr>
<tr><td>Course code:</td><td colspan="2">No. of credits: 3</td><td>L-T-P distribution: 33-9-0</td><td>Learning hours: 42</td></tr>
<tr><td colspan="5">Pre-requisite course code and title (if any):</td></tr>
<tr><td colspan="5">Department: Department of Business Sustainability</td></tr>
<tr><td colspan="3">Course coordinator (s): Manipadma Datta</td><td colspan="2">Course instructor (s):</td></tr>
<tr><td colspan="5">Contact details:</td></tr>
<tr><td>Course type</td><td colspan="2">Elective</td><td colspan="2">Course offered in: Semester III</td></tr>
<tr><td colspan="5">Course Description
The course intends to expose the learners to the emerging world of sustainability-centered accounting and finance. The field is emerging. There are many challenges to standardize the practices. Different experiments and research are on. So it’s a felt need of importance that the budding managers develop a clear perspective to actively contribute to the evolving process of newer paradigm.</td></tr>
<tr><td colspan="5">Course Objectives
In the context of the above course description, the objectives are to:
• Help the learners develop a right kind of attitude toward the emerging challenges;
• Expose them to the latest developments in the area;
• Make them learn the skill sets developed so far;
• Equip them with the requisite knowledge to act as conscious change agents.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">PART I</td></tr>
<tr><td>Module</td><td>Topic</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>1.</td><td>Introduction:
a. Changing paradigm of corporate finance and accounting;
b. Integrating sustainability into business;
c. Triple Bottom Line (TBL) and its relationship with Finance and Accounting;
d. Emerging Challenges and opportunities.
(Put the order more logically)</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td colspan="5">PART II</td></tr>
<tr><td>2.</td><td>Measuring sustainability: the macro level indicators:
a. Green national accounting;
b. Genuine savings;
c. System of Environmental- Economic Accounting</td><td>3</td><td>1</td><td>0</td></tr>
</table>

	(SEEA).			
3.	Measuring sustainability: the firm level indicators a. Green/Environmental Profit & Loss Account b. Green/Environmental Balance Sheet.	2	1	0
4.	Life Cycle Cost Analysis (LCA) and Full Cost Accounting(FCA) a. Acquisition costs versus Life Cycle costs b. Measurement techniques.	2	1	0
5.	Activity Based Cost Management(ABCM): a. Activity identification b. Cost Centres vs. Cost Drivers; c. Activity Based Cost Measurement (ABCM). (Order changed)	1	1	0
6.	Integrated Reporting a. Economic and environmental reporting; b. Integrating process; c. Sustainable Reporting Standards	3	0	0
7.	Firm level performance analysis: a. Financial vs. Non-Financial : Integration b. Challenges to developing appropriate benchmarks; c. Case studies.	1	2	
PART IV				
8.	Sustainability issues: Impact on Business and Economy a. Sizing climate economy b. Sustainability : Economic, Environmental and Social Factors (EES) c. Value creation and EES variables d. Sustainable value added (SVA) : Measurement & Estimation e. Environmental liabilities: Identification and Reduction	3	1	0

9.	Responsible Investments: a. Responsible Investment Principles as defined by the UN (UNPRI); b. Approaches and forms; c. Stockholders' value max vs. stakeholders' value max; d. Stakeholders' activism; e. Valuation approaches. f. Concept of shared value and value chain analysis; g. Behavioural aspects.	3	1	0
10.	Sustainability Risk Management a. Risks and return relationship: the changing scenario; b. Capital budgeting decisions and sustainability risks; c. Risk Management approaches d. Developing proper risk reporting mechanism	2	1	
11.	Hedging Sustainability risks a. Hedging sustainability risks through market instruments; b. Weather derivatives; c. Energy derivatives.	2	0	0
12	Investment market and sustainability factors: a. Sustainable portfolios; b. Role of fund managers; c. Investment bankers and sustainability issues.	2	**0**	**0**
13	Market Indices and Sustainability Issues d. Basis and Construction mechanisms of such indices; e. Major green market indices in the world; f. Indian position and a global comparison.	2	**0**	**0**
14	Financing sustainability	3	**0**	**0**

	g. Kyoto Protocol and CDM; h. Carbon Financing; i. Carbon credit and emission trading; j. Other market based instruments - green bonds, social impact bonds and the like. k. Historic Climate (Green) Deal (22.04.2016 at UN)			
PART IV				
15	Policy and Regulatory issues l. An overview of the policy issues in India and the globe; m. Role of an appropriate regulatory framework; n. G20 and global growth through Green Finance.	2	0	0

Evaluation criteria

▪	Assignment/Presentation	20%	
▪	Term paper	20%	40%
▪	Mid-Term	30%	
▪	End-term	30%	

Pedagogical approach

The course will be delivered through lectures and discussion of case studies, research papers and articles.

1. Unerman, J, Bebington, J and O'Dwyer, B, Sustainable Accounting and Accountability, Routledge, London and new York, 2010.
2. Wells, G, Sustainable Business: theory and practice of business under sustainability, E Elgar, Cheltenham, UK, 2013.
3. Cherneva, Iveta (ed.), The Business Case for Sustainable Finance, Routledge, London and New York, 2012.
4. Bhattacharya, R N (ed.), Environmental Economics- an Indian Perspective, OUP, New Delhi, 2001.
5. Occasional materials and hand-outs as delivered by the faculty member.

Additional information (if any):

Student responsibilities: This is more an open-ended course. The students are required to focus on research based learning.

Course Reviewer(s):

1. Prof. B. Banerjee, President, IAA Research Foundation and former Professor, Rutgers University, USA.
2. Prof. S.K. Chaudhuri, Sr. Professor, IMT Gaziabad and Director, IPE Global Ltd.

Course title: Statistical Methods for Management			
Course code:	**No. of credits:** 3	**L-T-P distribution:** 28-14-0	**Learning hours:** 42
Pre-requisite course code and title (if any): Knowledge of mathematical techniques is required to understand the subject.			
Department: Department of Business and Sustainability			
Course coordinator (s): Montu Bose		**Course instructor (s):**	
Contact details:			
Course type	**Core**	**Course offered in:**	

Course Description

This course gives students an exhaustive introduction to statistical methods important in business and infrastructure. For last few decades India's growth rate is impressive along with high competition in the economy. Economic growth, expansion of trade and business has forced to invest in infrastructure. Given this background, businessmen can no longer rely on the old system of hit-or-miss methods, or leave their future on chances. They have now to proceed on scientific principles, prepare themselves for competitive markets and plan their business accordingly. The managers have therefore to depend on a variety of factors (like present labour condition, prices of raw materials etc.). All these factors are statistically taken account of before fixing the price of new commodity or services, so that it may find a suitable place in the market.

This course would be offered to MBA Business Sustainability as well as MBA Infrastructure. The lectures of this course would be provided in joint class; however, tutorials classes would be separate for each programme.

Course Objectives

In the course the students would be exposed to relative example in economics of infrastructure and business applications. The primary objective of this course is to motivate the use of statistical analysis and at the same time encourage students to go beyond the mathematical applications of technique and to develop critical judgment through statistical analysis. The specific objectives of the course are enable student –

- to understand and use of statistical methods ranging from graphical presentation of data to descriptive statistical representation of data for infrastructure & business-related studies;
- to analyse data for understanding the characteristics of the business & infrastructure related factors, their association etc.
- apply statistical techniques to forecast the market situation and to take proper decisions.

Course content

Module	**Topic**	L	T	P
1	**Introduction: Data and Statistics** Data: Concept & types of data; importance of data in infrastructure & business; Data sources: introduction to infrastructure & business-related data & sources.	2		
2	**Descriptive Statistics** Summarizing data: how to handle data scientifically to make proper decisions; Exploration & representation of infrastructure related data: tabulation, cross tabulation, variability checking, measuring the distribution and location statistically, association among inputs and	4	3	

	outputs; Use of diagrams in business & infrastructure projects and reporting.			
3	**Probability Distribution** Introduction to set theory and probability; Discrete and continuous distributions; Random variables; Discrete & continuous probability distributions: theory and its applications in business & infrastructure management.	4	3	
4	**Sampling and Sampling Distributions** Statistical Inference: concepts & relevance in business & infrastructure; Methods of Sampling: purposive, random, stratified, systematic, multy-stage; Concepts and estimation of - Point Estimation, Sampling Distribution of Mean, Sampling distribution of p, differences of means, proportions, difference of proportions, variances, ratio of variances sample size determination; Standard normal, χ^2 , t and F distributions.	4	1	
5	**Problem of Estimation** Population mean; Population proportion; Point and interval estimation, confidence interval; Determining sample size.	2	1	
6	**Hypothesis Testing** Null and alternative hypothesis; Test of significance; Type I and Type II errors; Practical issues	2	2	
7	**Analysis of Variance** Introduction to analysis of variance; Assumptions and analysis of one-way classified data; Assumptions and analysis of two-way classified data; Comparison of equality of k-population means; Multiple comparisons.	3	1	
8	**Simple linear regression – Introduction** Simple regression model; Least square method; Coefficient of determination; Model assumptions; Testing of significance; Predictions; Residual analysis.	4	2	
9	**Index Numbers** Method of construction of index numbers; Consumer price index (CPI) & Wholesale price index; Time series of index numbers; Deflation of index number.	3	1	

Evaluation criteria

The break-up of the evaluation procedure is as follows –

Minor-I Exam - 20%
Minor-II Exam - 20%
Project Work - 20%
Major Exam - 40%

Pedagogical approach

The course will be delivered through lectures and application of statistical tools in infrastructure related problems would be discussed.

References:

Textbooks:

1. Anderson DR., Dennis J. Sweeney and Thomas A. Williams (2002): Statistics for Business and Economics, Cengage Learning (10th Eds.), India.

2. David R. Anderson, Dennis J. Sweeney, and Thomas A. Williams (2014): Statistics for Business and Economics, Thomson South-Western College Publishing, 12th Ed.

Additional Readings:

3. Kohler, H. (2010): Statistics for Business & Economics, Harper Collins.
4. Levin, R. and Rubin, D. (2012): Statistics for Management, Pearson.
5. McClave, J. and Benson, P.G. (2013): Statistics for Business and Economics, Pearson.
6. Richard I.L. and David S.R. (2011): Statistics for Management, Pearson (7th Eds.).

7. Stine R. and D. Foster (2014): Decision making and Analysis, Pearson New International Edition.
8. Thukral J.K. (2015): Business Mathematics & Statistics, Mayur Paperback.
9. Triola, M.F. and Franklin, L.A. (2015): Business Statistics.
10. Watsnam, T. J. and Keith, P. (2014): Quantitative Methods in Finance, International Thompson Business Press.

Additional information (if any):

Course Reviewer(s):

1. Dr. Nilanjan Sen, Assistant Professor, St. Xavier's College, Kolkata.
2. Dr. Yamini Gupt, Associate Professor, University of Delhi, Delhi.
3. Dr. Tamal K. Kayal, Assistant Professor, Rabindra Bharati University, Kolkata

Annexure 3

Course title: Sustainable Urban Transport			
Course code: MEU144	**No. of credits:** 2	**LTP distribution:** 22-6-0	**Learning hours:** 28
Pre-requisite course code and title (if any): Basic knowledge of statistics			
Department:			
Course coordinator: Deepty Jain		Course instructor: Deepty Jain	
Contact details: deepty.jain@teriuniversity.ac.in			
Course type: Elective		Course offered in: Semester 3	

Course description:

Urban Transport is in a state of crisis today. Availability of mobility options or the lack of it has direct implications on the economic efficiency of our cities and overall well-being. Rising levels of air pollution and emissions, high dependency on fossil fuels, rising number of road accidents, high congestion levels, rising noise levels and health concerns are all negative impacts arising from the urban transport sector. Promoting sustainability in the transport sector is considered to be of vital importance in order to ensure that it meets the travel needs of all individuals, provide basic access to all services, and is energy efficient and environment friendly.

This course aims to provide an advanced understanding of the concept of sustainable transportation introduced as a theme in the first semester core course on Sustainable Provision and Management of Urban Services. It will discuss in detail the need to promote sustainability in transport, elements and principles of sustainable transportation and various strategies to achieve sustainable transportation. To ensure a better understanding among the students, case studies from around the world will be discussed under the different topics.

Students will be familiarized with the key aspects of transportation planning and policy making.

Course Objectives:

1. To provide understanding of sustainable transport and relevant policies and programs
2. To introduce to the concepts and aspects of transport planning and differentiate between short-term and long-term strategies and impacts
3. To provide understanding of travel demand models and demand management techniques
4. To enable students to plan for integrated multi-modal transport systems

Course contents

Topic	**L**	**T**	**P**

Module 1: Introducing the concepts of Transportation, accessibility and mobility planning Conceptualizing key terminologies - transport, transport systems, travel behaviour, infrastructure and users/commuters Sustainable transport concepts – society, environment and economy, indicators based approach Policy initiatives and programs on sustainable transport - global perspectives (SUMP, KYOTO Protocol), national policies (NUTP, CMP and NAPCC) and local initiatives Transport system effectiveness and efficiency – service level benchmarks	5	1	
Module 2: Transport economics, externalities and pricing Demand – supply elasticity, factors that influence demand and Externalities of transport, quantification and value association 1. Energy consumption, emissions and air quality (Lifecycle assessment) 2. Safety and security 3. Land consumption and waste production 4. Equity and inclusiveness 5. Mobility and accessibility Transport pricing and user costs - internalizing externalities	5		
Module 3: Behaviour analysis and travel demand models Four-step travel demand model Data collection and travel surveys User and their choices – variables that influence travel behavior	6	3	
Module 4: Strategies and regulations for sustainable transport Integrated land use and transport planning and neighbourhood designs Planning and designing for pedestrians and bicycles Planning and design of a public transport systems Integrated multi-modal transport networks Regulations and Enforcements (Parking policy, Congestion pricing,	6	2	

Evaluation Criteria:

	Weightage (%)
Assignments*	20%
Project work**	40%
Final Examination	40%

*Assignments- This shall cover review of mobility patterns and mobility planning process in different regions of the world

** Project Work – This shall cover development of flow model and audit of transport facility

Learning outcomes

On successfully completing this course the students will be able to:

1. Understand the impact of alternate transport infrastructure improvement strategies on society and environment
2. Identify key variables that influence travel choices and behaviour
3. Assess infrastructure quality and define strategies to achieve sustainable transport/mobility

Pedagogical approach:
The course will be delivered through classroom teaching, research-based discussions, case-study discussions of both successful and unsuccessful practices. Site visits for assignments.

Essential Reading Material - Books

1. Hensher, David A, Kenneth Button, Handbook of Transport Modelling, Pergamon Press, 2000.
2. Button, K., 2010. Transport economics. Edward Elgar Publishing. (chapter 5, 6, 7 and 11)
3. Ortuzar, J.D. and Willhumsen, L.G. Modelling Transport, 4th edition John Wiley, 2011.
4. TERI (2013); Pro-poor mobility - Policy guidelines and case studies Available at: http://www.teriin.org/div/pro-poormobility_policy-guidelines-case-studies.pdf
5. Fundamentals of Transportation System Analysis, Volume -1: Basic Concepts by Manheim Marvin
6. National Urban Transport Policy (2012)

Preferred Reading Material – Papers

1. Ahmad, S. & Puppim de Oliveira, J.A. 2016. Determinants of urban mobility in India: Lessons for promoting sustainable and inclusive urban transportation in developing countries. Transport Policy, 50, 106-114
2. Appleton, B., Davies, M., Tansey, J., Atwal, P., Dore, G. P., & Muzyka, D. 2008, GreenApple Canada 2008: SMART Transportation Ranking Report, Appleton Charitable Foundation.
3. Boussauw, K., Neutens, T., & Witlox, F. 2012. Relationship between spatial proximity and travel-to-work distance: the effect of the compact city. Regional Studies, 46, (6) 687-706
4. Cervero, R. 2003. Road expansion, urban growth, and induced travel: A path analysis., 69, (2) 145-164
5. Cheng, L., Bi, X., Chen, X., & Li, L. 2013. Travel Behavior of the Urban Low-income in China: Case Study of Huzhou City. Procedia - Social and Behavioral Sciences, 96, 231-242
6. Commission of the European Communities 2009, Action Plan on Urban Mobility Brussels, COM(2009) 490 final.
7. Dablanc, L. 2009, Urban Freight: Freight Transport, a Key for the New Urban Economy, Department for Internation Development (DFID).
8. Demirel, H., Sertel, E., Kaya, S., & Seker, Z.D. 2008. Exploring impacts of road transportation on environment: a spatial approach. Desalination, 226, (1-3) 279-288
9. May, A.D., Kelly, C., Shepherd, S., & Jopson, A. 2012. An option generation tool for potential urban transport policy packages. Transport Policy, 20, 162-173
10. Sanches, S.d.P. & Serra de Arruda, F. 2002. Incorporating Nonmotorized Modes in a Mode Choice Model. Transportation Research Record: Journal of the Transportation Research Board, 1818, 89-93
11. Schmucki, B. 2012. If I Walked on my Own at Night I Stuck to Well Lit Areas - Gendered spaces and urban transport in 20th century Britain. Research in Transportation Economics, 34, (1) 74-85
12. Tiwari, G., Jain, D., & Ramachandra Rao, K. 2016. Impact of public transport and non-motorized transport infrastructure on travel mode shares, energy, emissions and safety: Case of Indian cities. Transportation Research Part D: Transport and

Environment, 44, 277-291
13. Woodcock, J., Edwards, P., Tonne, C., Armstrong, B.G., Ashiru, O., Banister, D., Beevers, S., Chalabi, Z., Chowdhury, Z., Cohen, A., Franco, O.H., Haines, A., Hickman, R., Lindsay, G., Mittal, I., Mohan, D., Tiwari, G., Woodward, A., & Roberts, I. 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. The Lancet, 374, (9705)

Course Reviewers:
Dr. Geetam Tiwari, Indian Institute of Technology Delhi
Dr. Mukti Advani, Central Road Research Institute, Delhi

Course title: Urban Housing Policy and Practice			
Course code:	**No. of credits:** 2	**L-T-P:** 24-0-8	**Learning hours:** 28
Pre-requisite course code and title (if any) : NA			
Department: Department of Energy and Environment			
Course coordinator: Abhijit Datey		**Course instructor:** Abhijit Datey	
Contact details: abhijit.datey@teriuniversity.ac.in			
Course type: Elective		**Course offered in:** Semester 3	

Course description:

Urban India is facing a great housing crisis and therefore effective urban housing policies and programmes have become the need of the hour. The housing shortage is estimated to be 18.78 million by a technical group on housing shortage (2012-17) under the Ministry of Housing and Urban Poverty Alleviation, Government of India. This shortage largely exists for households belonging to Low Income Group (LIG) and Economically Weaker Section (EWS). These groups are largely excluded from the housing markets and are therefore forced to live in slums and squatter settlements scattered across all major urban areas. Housing is intrinsically linked to various other necessities of healthy urban life such as access to services like water supply, sewerage, health, education and livelihoods and therefore, housing problems are as complex as the variety of solutions for solving them. The discipline of housing studies is therefore multi-disciplinary, and requires a multi-pronged methodology and perspective.

This course aims to provide an understanding of the importance of housing in urban settlements, and outlines key theories and concepts of housing studies, housing problems and solutions. It would discuss the housing scenario in India and the linkages of housing with access to welfare, basic services and livelihoods. The course would also focus on the issues of slums and squatter settlements, various kinds of housing programmes targeting them and the effectiveness of these programmes. Case studies from India and abroad would be introduced to impart an understanding of variety of interventions and ways and methods to achieve them.

Course objectives:

1. To acquire knowledge of housing studies as a discipline, and interdisciplinary nature of its theoretical frameworks.
2. To understand housing issues in the context of developing countries and multiplicity of approaches to tackle them.
3. To impart an understanding of housing programmes for the low-income groups in

India and the developing world.				
Course contents:				
Module	Topic	L	T	P
1.	**Housing: Theory and Concepts** - The basics: - housing and home, quality and access, history, future and ideology. - The concepts: - social Justice, need, choice, rights and responsibility - Tenure: - Owner occupation, Property Rights, Social Housing and Private Housing - Welfare:- Welfare, Poverty, Homelessness - Money: - Sources of Finance, Markets, Rent , Affordability - Control: - Government, Accountability and Reform - Building: - Development, Planning and Architecture	6		
2.	**Housing Policy and Need for Government Intervention** - Housing: Process, Heterogeneity and Incrementality - Concepts of Provision, Support and Enablement - Housing Demand, Supply and Distortions in Housing market - Housing Affordability and Finance - Housing in India: Plans, Policies and Institutions - Cooperative Housing, Retrofitting and Redevelopment - International Conventions on Housing: UN-Habitat Agenda	8		4
3.	**Slums, Informal Settlements and Policy Options** - Understanding Slums and their linkages - Slum evictions and its impacts - Approaches to Slum Redevelopment - Tenure Regularisation (Rights Approach and Titles Approach), Incremental Approach to tenure - Basic Services Improvement/ Slum Networking - Mass Housing (Public and Private) - Direct Subsidy Transfers - Rental Housing - PPP Models of Slum Redevelopment (R&R, SRA)	8		4
4.	**Innovative Approaches to Housing Redevelopment: Cases from India and Asia**	2		
Field visit to a slum/ housing redevelopment site would be undertaken. Redevelopment exercise on the basis of settlement data would be given to students.				
Evaluation criteria (Continuous Assessment) Assignment-1 = 20% : (Review of research paper-Written Assignment) Assignment-2 = 20% : (Site Visit, Individual/Group Presentation) Assignment-3 = 20% : (Housing Redevelopment Exercise, Individual/Group Presentation) Final Exam = 40% : (Written Exam)				
Learning Outcomes:				

On completion of this course, the students would:

1. Identify key concepts of housing studies and frameworks behind housing policy formation.
2. Acquire thorough knowledge of variety of housing interventions and multiplicity of possible approaches for solving the housing question.
3. Learn essentials of managing a slum/housing redevelopment exercise.

Pedagogical approach: Lectures, Review of Policy and Research Papers, Learning through Cases, Site Visits

Readings:

Books

King, Peter (2015), "The Principles of Housing", Routledge

Turner, John F.C. (1976), "Housing by People", Marion Boyars

Hamdi, Nabeel (1995), "Housing without Houses: Participation, Flexibility, Enablement", ITDG Publishing

Clapham, David F., Clark William A.V. and Gibb, Kenneth (2012) "SAGE Handbook of Housing Studies", SAGE

Neuwirth, Robert (2006), "Shadow Cities: A Billion Squatters, A New Urban World", Routledge

Urban, Florian (2011), "Tower and Slab: Histories of Global Mass Housing", Routeledge

Sharma, Kalpana (2000), "Rediscovering Dharavi", Penguin India

Books and Reports available online

UN-HABITAT (2012) "Sustainable Housing for Sustainable Cities", UN-HABITAT

UN-HABITAT (2012) "Going Green, A Handbook of Sustainable Housing Practices in Developing Countries", UN-HABITAT

McKinsey Global Institute (2010), :India's Urban Awakening: Building Inclusive Cities, Sustaining Economic Growth", McKinsey Global Institute

MoHUPA and NBO, (2011), "Report of the Technical Group of Urban Housing Shortage (TG-12)

Papers:

Burgess, Rod (1985), "The Limits of State Self Help Housing Programmes", Development and Change, 16(2), pp. 271-312

Pugh, Cedric (2001), "The theory and practice of Housing Sector Development for Developing Countries 1950#99", Housing Studies, 16:4, 399-423.

Patel, Sheela (2013), "Upgrade, Rehouse or Resettle? An Assessment of the Indian Government's Basic Services for the Urban Poor (BSUP) Programme, Environment and Urbanisation, 25:1, 177-188

Desai, Renu (2012), " Governing the Urban Poor: Riverfront Development, Slum Resettlement and the Politics of Inclusion in Ahmedabad, 47(2), Economic and Political Weekly

Tiwari, Piyush and Rao, Jyoti (2016), "Housing Markets and Housing Policies in India", ADBI Working Paper Series No. 565, Asian Development Bank Institute

Mahadevia, Darshini, (2011), "Branded and Renewed? Policies, Politics and Processes of Urban Development in the Reform Era", 46(31), Economic and Political Weekly

Articles on Web

https://nextcity.org/informalcity/entry/when-tokyo-was-a-slum http://www.costford.com/Are%20Slum%20Inevitable.pdf https://www.theguardian.com/cities/2016/apr/14/slum-women-ahmedabad-india-housing-revolution

Course reviewers:
Prof. P.S.N. Rao, Professor, School of Planning and Architecture (SPA) New Delhi
Prof. Darshini Mahadevia, Professor, CEPT University, Ahmedabad

Course title: Urban systems Modelling			
Course code:	**No. of credits:** 2	**LTP distribution:** 21-0-14	**Learning hours:** 35
Pre-requisite course code and title (if any): Basic knowledge of statistics and GIS			
Department: Department of Energy and Environment			
Course coordinator: Deepty Jain		Course instructor: Deepty Jain	
Contact details: deepty.jain@teriuniversity.ac.in			
Course type: Compulsory		Course offered in: Semester 3	

Course description:
Urban areas or cities are dynamic and complex systems that also exhibit a self-organizing behaviour. The complex urban system has various inter-related subsystems like population, housing, transport, water and climate. It is difficult to envisage the changing development patterns of a city, as it is an outcome of these interacting sub-systems and externalities (policies, climate change and disasters). Therefore, the impact of these development patterns on economy, society and environment is uncertain.
In semester 1 and semester 2, UDM curriculum expands the knowledge of observing, measuring, analysing, describing and visualizing important processes taking place in urban regions, using statistical and spatial-analytical methods and techniques. The students have also gained an exposure on various aspects of urban development and management like theories of urbanization, services, ecology, city competitiveness, urban finance and policies.
This course will develop an understanding of methods, models and simulations applied for problem solving, better decision making and simulating urban changes. The students through the course will have an edge on understanding urban complexities, interactions between systems and therefore envisage development in lieu of certain policy changes.

Course Objectives:

5. To equip students with the concept of system theories and dynamic system approaches
6. To enable students to study interactions between urban sub-systems
7. To provide hands on experience on urban system models and simulations

Course contents

Topic	L	T	P
Module 1: Urban systems, complexities and inter-linkages between subsystems	10		2
a) Complexity, system theory and system dynamic approach for urban systems			

b) System quantification to study interactions for urban areas like infrastructure supply, accessibility, affordability (ArcGIS)				
c) Discrete choice models and quantification of interactions between systems like relocation models, choice models (SPSS/Stata/ArcGIS)				
Module 2: Urban models and simulations	9		12	
a) Concept of modelling, simulation and flavours of models – static and dynamic models, aggregated vs disaggregated models, simulations				
b) Conventional and New generation models like cellular automata, agent based models and flow dynamics				
c) Land use and Urban Development model and simulations (hands on exercise on METRONAMICA/SLEUTH/ CLUE-S)				
Module 3: Managing uncertainty and data limitations	2			
a) Uncertainty in urban systems and its impact on models, scenarios and solution findings				
b) Methods to manage uncertainty and data limitations				

Evaluation Criteria:

	Weightage (%)
Assignments*	30%
Project work**	30%
Final Examination	40%

*Assignments- This shall cover review of urban models, quantification of factors and development of residential choice models

** Project Work – This shall include development of an urban simulation, scenarios and estimating impacts on simulation results

Learning outcomes

On successfully completing this course the students will be able to:

4. Quantify interactions between drivers and sub-systems of urban system
5. Anticipate impact of alternate development strategies on futures
6. Develop models and simulations for urban systems

Pedagogical approach:

The course will be delivered through class-room teaching, research-based discussions, case-study of applied methodologies and hands-on-experience on statistical tools (Stata), GIS applications (Arc Map) and urban simulations like METRONAMICA/SLEUTH/CLUE-S.

Essential Reading Material - Books

7. Batty, Michael. Cities and complexity: understanding cities with cellular automata, agent-based models, and fractals. 2007. The MIT press. (Chapter 1 to chapter 6)
8. Train, K.E., 2009. Discrete choice methods with simulation. Cambridge university press. (Chapter 3 – Logit)
9. Field, A., 2013. *Discovering statistics using IBM SPSS statistics*. Sage. (Chapter 8 - Logistic regression)

Essential Reading Material - Papers

1. Michael Wegener, New spatial planning models, International Journal of Applied Earth Observation and Geoinformation, Volume 3, Issue 3, 2001, Pages 224-237, ISSN 0303-2434, http://dx.doi.org/10.1016/S0303-2434(01)85030-3.

Preferred Reading Material – Papers

1. Aguayo, Mauricio, et al. "Revealing the driving forces of mid-cities urban growth patterns using spatial modelling: a case study of Los Ángeles, Chile." Ecology and Society 12.1 (2007).
2. Barredo, J.I., Kasanko, M., McCormick, N. and Lavalle, C., 2003. Modelling dynamic spatial processes: simulation of urban future scenarios through cellular automata. Landscape and urban planning, 64(3), pp.145-160.
3. Benguigui, L., Czamanski, D. and Marinov, M., 2001. The dynamics of urban morphology: the case of Petah Tikvah. Environment and planning B: Planning and design, 28(3), pp.447-460.
4. Castle, C.J. and Crooks, A.T., 2006. Principles and concepts of agent-based modelling for developing geospatial simulations.
5. Chengxiang Zhuge, Chunfu Shao, Jian Gao, Chunjiao Dong, Hui Zhang, Agent-based joint model of residential location choice and real estate price for land use and transport model, Computers, Environment and Urban Systems, Volume 57, May 2016, Pages 93-105.
6. Meimei Wang, Yongchun Yang, Shuting Jin, Lei Gu, Heng Zhang, Social and cultural factors that influence residential location choice of urban senior citizens in China – The case of Chengdu city, Habitat International, Volume 53, April 2016, Pages 55-65.
7. Mohamed R. Ibrahim, How do people select their residential locations in Egypt? The case of Alexandria, Cities, Volume 62, February 2017, Pages 96-106.

Course Reviewers:
Dr. Talat Munshi, Technical University of Denmark, København
Dr. Jay Mittal, Department of Political Science, Auburn University

Annexure 4

Course title: Nanomaterials: Introduction and Applications			
Course code:	**No. of credits: 2**	**L-T-P:** 19-06-06	**Learning hours: 31**
Pre-requisite course code and title (if any):			
Faculty: Dr Udit Soni	**Department:** Department of Biotechnology		
Course coordinator: Dr Udit Soni	**Course instructor:** Dr Udit Soni		
Contact details: udit.soni@teriuniversity.ac.in			
Course type: Elective	**Course offered in:** Semester 2		

Course description:

Nanotechnology is an interdisciplinary field and attracts students from various disciplines. This course is provides basic overview of nanomaterials and their applications. This course begins with a review of various types of nanomaterials and an introduction to general terminologies. Subsequently the course covers synthesis methodologies, physical and chemical characterization of nanomaterials. Finally, case studies illustrating application of nanomaterials in diverse fields will be discussed.

Course objectives:

1. To understand the nature and properties of nanomaterials.
2. To provide scientific understanding of nanomaterials for utilization for various applications.

Course contents

S.No	**Topic**	**L**	**T**	**P**
1.	**Nanomaterials;** Introduction to nanomaterials: Three-, two-, one- and zero-dimensional nanomaterials (carbon nanotubes, carbon dots, quantum dots, graphene, metal and metal oxide based nanomaterials, semiconductor nanomaterials, hybrid and core shell nanomaterials, bio and polymer nanomaterials)	**4**	**0**	**0**
2.	**Properties of nanomaterials;** Crystal geometry and structure, chemical properties and surface functionalization, physical properties including photocatalytic, dielectric, magnetic, optical, mechanical, and structural.	**4**	**0**	**0**
3.	**Synthetic methodologies;** Top down and bottom up approaches for nanomaterial synthesis. Synthesis of nanoparticles by physical, chemical and biological methods.	**3**	**0**	**2**
4.	**Characterization of nanomaterials;** by various analytical methods, optical characterization, spectroscopy, structural characterization and imaging techniques.	**4**	**2**	**4**
5.	**Applications of nanomaterials**; health and disease diagnostics, biomedical, delivery vehicles, sensors and biosensors, cosmetics,	**4**	**4**	**0**

	agriculture, environment, food, energy and defence.			

Evaluation criteria:

1. 2 minor tests : 20% each
2. 1 major test (end semester) : 50%
3. Assignment: 10%

Learning outcomes:

1. Familiarity with working principles, tools and techniques in the field of nanomaterials.
2. Understanding of the strengths, limitations and potential uses of nanomaterials.

Pedagogical approach

The course will be delivered through classroom lectures and experiments. Case studies related to application of nanomaterials.

Materials:

Suggested readings:(*1–7*)

1. A. L. Rogach, *Semiconductor nanocrystal quantum dots synthesis, assembly, spectroscopy and applications* (Springer, Wien; London, 2008).
2. E. Gazit, *Plenty of room for biology at the bottom: an introduction to bionanotechnology* (Imperial College Press ; Distributed by World Scientific Pub. in the USA, London : Hackensack, NJ, 2007).
3. G. E. J. Poinern, *A laboratory course in nanoscience and nanotechnology* (CRC Press, Taylor & Francis Group, Boca Raton, 2015).
4. C. A. Mirkin, C. M. Niemeyer, Eds., *More concepts and applications* (Wiley-VCH, Weinheim, 2007), *Nanobiotechnology*.
5. A. K. Mishra, Ed., *Application of nanotechnology in water research* (Wiley, Scrivener Publishing, Hoboken, New Jersey, 2014).
6. K. R. Nill, *Glossary of biotechnology and nanobiotechnology terms* (Taylor & Francis, Boca Raton, 4th ed., 2006).
7. J. Kim, Ed., *Advances in nanotechnology and the environment* (Pan Stanford, Singapore, 2012).

Websites

Journals

Other readings

Additional information (if any): Basic knowledge of science and engineering require.

Student responsibilities:

1. Study of course materials as specified by the instructor
2. Timely submission of given class assignment

Course reviewed by:

1. Dr.Amit K Dinda, MD, Ph.D
   Professor
   Department of Pathology
   All India Institute of Medical Sciences, New Delhi
   President, Indian Society of Renal & Transplant Pathology (ISRTP)
   Secretary, Indian Society of Nanomedicine (ISNM)
   Fellow, Electron Microscopy Society of India (EMSI)
   dindaaiims@gmail.com

2. Dr R. P. Singh, Ph.D
   Professor
   Department of Biotechnology
   Indian Institute of Technology Roorkee
   rpsbsfbs@iitr.ac.in

3. Dr Indrajit Roy, Ph.D
   Associate Professor
   Department of Chemistry,
   University of Delhi,
   Delhi-110007.
   indrajitroy11@gmail.com

4. Dr Naveen Kumar Navani, Ph.D
   Associate Professor
   Department of Biotechnology
   Indian Institute of Technology Roorkee
   navnifbs@iitr.ac.in

Annexure 5

M.Tech Renewable Energy Engineering and Management

Semester I

Course title: Fundamentals of Thermal and Electrical Engineering			
Course code:	**No. of credits:** 2	**L-T-P:** 28-0-0	**Learning hours:** 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator(s): Dr. Naqui Anwer		**Course instructor(s):** Dr. Naqui Anwer	
contact details: naqui.anwer@teriuniversity.ac.in			
Course type: Core		**Course offered in :** Semester 1	

Course Description

The course is designed to provide basic knowledge of thermal and electrical engineering. It incorporates the fundamentals of thermodynamic principles and their applications. This course provides the required level of knowledge of thermal engineering to understand the mechanical engineering and related courses to the students not having background of mechanical Engineering. It also incorporates the fundamentals of electrical circuit components, electrical and magnetic circuits, DC and AC sources. This course provides the required level of knowledge of electrical engineering to understand power system and related courses to the students not having background of electrical engineering

Course objectives

- Providing basic knowledge of thermodynamic principles.
- Providing knowledge related to thermodynamic processes.
- Providing knowledge about use of steam tables.
- Provide basic knowledge of electrical circuit components.
- Providing knowledge related to characteristics and behaviour of electrical circuits on AC and DC sources and their applications.
- Providing knowledge of magnetic circuits.

Course content

Module	Topic	L	T	P
	Fundamentals of thermal engineering (1 credit)			
1	**Zeroth law of thermodynamics** System, surroundings and properties. Energy and Processes. Work and heat. Zeroth law of thermodynamics.	3	0	0
2	**First law of thermodynamics** First law of thermodynamics. Constant pressure process. Adiabatic and Polytropic Process. Steady state flow process. Limitations.	4	0	0
3	**Second law of thermodynamics**	4	0	0

	Kelvin-Plank statement and Clausius statement. Reversibility, irreversibility and carnot cycle. Entropy. Temperature entropy diagram.			
4	**Power and refrigeration cycles** Reheat, regeneration and binary vapour cycle. Gas power cycle. Refrigeration cycle. Thermodynamics of ideal gas mixture.	3	0	0
	Fundamentals of electrical engineering (1 credit)			
5	**Circuit components** Resistance (R), Inductance (L) and Capacitance (C). Ohm's law. DC and AC sources – voltage and current, ideal and practical, dependent and independent	2	0	0
6	**DC circuits** KCL & KVL, loop or mesh analysis, nodal analysis, star↔delta transformation, Thevenin's and Norton's theorem, superposition theorem, maximum power transfer theorem.	4	0	0
7	**AC circuits** Representation of sinusoidal quantities, steady state analysis of R-L-C series and parallel circuits, resonance in electrical circuits, energy and power, complex power – apparent, active and reactive power, three phase ac circuits – phase & line voltages and currents	4	0	0
8	**Magnetic circuits** Magnetic flux and mmf, analogy between electrical and magnetic circuits, magnetic materials, eddy current & hysteresis losses.	4	0	0
		28	**0**	**0**

Evaluation criteria

- Assignment: 10%
- Two Minor tests: 20% (each)
- Major exam: 50%

Learning outcomes

- Understanding the basics of characteristics and behaviour of laws of thermodynamics.
- Solving the problems related to thermodynamic applications.
- Solving the problems related power and refrigeration cycles.
- Understanding the use of steam tables and apply them to real problems.
- Understanding the basics of DC and AC sources along with their applications on electrical circuits.
- Solving the problems related to applications of network theorems and solving complex DC circuits.
- Solving the problems related to R-L-C circuits connected to single phase and three phase AC.
- Solving the problems related to magnetic circuits.

Pedagogical approach

A combination of class-room interactions, tutorials, assignments and projects.
Materials RE Sonntag, C Borgnakke, GJ Van Wylen: Fundamentals of Thermodynamics, Sixth Edition, (Wiley-India, 2007). PK Nag: Engineering Thermodynamics, Third Edition (Tata McGraw-Hill, 2005) YA Cengel and MA Boles: Thermodynamics: An Engineering Approach, Sixth Edition (Tata McGraw-Hill, 2008) SR Turns: An Introduction to Combustion: Concepts and Applications, Second Edition (McGraw Hill, 2000) B.L.Theraja, A.K.Theraja, "A text book of Electrical Technology", S.Chand Publication, 2012 D.P.Kothari, I.J.Nagrath, "Fundamentals of electrical engineering", Tata Mc Graw-Hill Publication, 2016
Additional information (if any):
Student responsibilities Attendance, feedback, discipline: as per university rules

Course reviewers

1. Dr. Sanjay Agrawal, Associate Professor, Department of Electrical Engineering, SOET, IGNOU, New Delhi
2. Dr. M. Rizwan, Assistant Professor, Department of Electrical Engineering, Delhi Technological University, New Delhi

Course title: Renewable Energy Resource Characteristics			
Course code: ENR 122	**No. of credits:** 4	**L-T-P:** 46-10-0	**Learning hours:** 56
Pre-requisite course code and title (if any): Not required			
Department: Energy and Environment			
Course coordinator: Dr. Priyanka Kaushal		**Course instructor(s):** Dr. Som Mondal/ Dr. Jami Hossain/Dr. Priyanka Kaushal	
Contact details: priyanka.kaushal@teriuniversity.ac.in			
Course type: Core		**Course offered in:** Semester 1	
Course description The course is designed to familiarize and train the student with the tools and techniques used to assess the various renewable energy resources and its potential at any location across the globe, so that a student is able analyse a case quantitatively at the end of the term.			
Course objectives The objective of the courses is to develop in-depth knowledge for the following: ▪ Various renewable energy resources available at a location and assessments of its potential, using tools and techniques.			

- Solar energy radiation, its interactions, measurement and estimation
- Site selection for wind turbines, wind systems, measurements and instruments
- Develop and read hydrographs, estimate flow, head, and power
- Geothermal, wave, tidal and OTEC resources, site selection
- Properties critical for Bio-energy resource assessment, pathway selection, biomass supply

Course contents

Module	Topic	L	T	P
	SOLAR			
1	**Introduction** Introduction to renewable energy sources – solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem	1		
	Solar Energy Resources Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extra-terrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectral distribution	2		
	Sun-earth movement in different seasons, solar geometry, solar radiation on tilted surface, local apparent time, irradiance, insolation	2	1	
	Attenuation of solar radiation by the atmosphere, albedo, beam and diffuse components of hourly and daily radiation, GHI and DNI, clearness index, Radiation augmentation	2		
	Different climatic zones and their impact on site selection	1		
2	**Measurement of solar radiation** Instruments: sunshine recorder, Pyranometer, Pyrheliometer, Albedometer. Radiation measurement stations in India (NIWE, IMD etc.), solar radiation data, graphs, Meteonorm and NASA-SSE databases Hands-on measurement of beam, diffuse and total radiation	2	1	
3	**Prediction of available solar radiation** Solar mapping using satellite data, Typical Meteorological Year Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components	2	2	
	WIND			
4	**Introduction** Introduction to Atmospheric Boundary Layer Theory	2		
5	**Physics of Wind**	5		

	Wind Systems in India as Case			
6	**Basic Introduction to Wind Energy** Worldwide Developments	2	1	
7	**Wind Measurements/Instrument etc.**	4	2	
	BIOMASS			
8	**Basics** Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. **Biomass resource assessment** Estimation of woody biomass, non woody biomass and wastes, ASTM standards.	2 2		
9	**Bulk chemical properties** Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids.	2	1	
10	**Chemical composition of biomass** Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractable, COD.	2	1	
11	**Structural properties** Physical structure, particle size and size distribution, permeability. Physical properties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry).Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.	5	1	
	SMALL HYDRO RESOURCES, GEOTHERMAL AND OCEAN RESOURCES			
12	**Basics** Indian resource potential and exploitation, power potential estimation, hydrographs. **Resource Assessment** Methods for determining head and flow, head and flow measurements, site evaluation, cartography, geotechnical studies.	2 2		
	GEOTHERMAL AND OCEAN ENERGY			
13	Heat mining, potential sites, Darcy's law, volcano related heat resources, sedimentary basins, hot dry rocks, estimation of wave	4		

	power, tidal power sites, scatter diagram of wave heights, OTEC resource map.			
	Total	**46**	**10**	**0**

Evaluation criteria

- Quizzes/Assignments: 30%
- Minor tests: 30%
- Final Examination: 40%

Learning outcomes

At the end of the course the student will be able to:

- Identify a Renewable Energy Resource at a given location
- Assess/quantify the potential of the renewable-energy resource/s at a given location
- Develop understanding for case studies

Pedagogical approach

A combination of class-room interactions, group discussion and presentations, tutorials and assignments

Materials

Text Books

Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).

Reference Books

Donald Klass, "Biomass for Renewable Energy, Fuels, and Chemicals", Entech International Inc., USA
JA Duffie and WA Beckman, "Solar Engineering of Thermal Processes", Third Edition (John Wiley & Sons)
S Sukhatme and J Nayak, "Solar Energy: Principles of Thermal Collection and Storage", Third Edition (Tata McGraw Hill, 2008)
TERI Energy Data Directory (TEDDY) 2016 (TERI Press, 2016)

Websites

Ministry of new and renewable energy
Planning commission

Additional information (if any)

There will be test before and after the completion of the course

Student responsibilities

Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharing within the class

Course reviewers

1. Prof. R N Singh, Professor, School of Energy and Environmental Studies, Devi Ahilya Vishwavidyalaya, Indore

Course title: Power System Engineering

Course code: ENR 135	**No. of credits:** 3	**L-T-P:** 35-07-0	**Learning hours:** 42

Pre-requisite course code and title (if any): None

Department: Energy and Environment

~~**Academic Council – 40 /05.07.2017**~~

Course coordinator: Dr. Naqui Anwer	**Course instructor(s):** Dr. Naqui Anwer

contact details: naqui.anwer@teriuniversity.ac.in

Course type: Core	**Course offered in :** Semester 1

Course description

It is very important to understand the characteristics, technologies and operation of conventional power system for generation, transmission and distribution of electrical energy. The programme is focused on renewable energy and therefore, it becomes more important to understand the functioning of conventional power system infrastructure first, so that the effects of increasing share of renewable energy can be understood. The course is designed to impart the knowledge of conventional power system equipments to the students. To work in a power industry, it is very important to understand the basic concepts of power systems and the related issues. Restructuring of power industry has increased the challenges even more. Hence, it is important for the renewable energy engineer to understand the basic concepts of power system operation, planning and analysis.

Course objectives

This course is designed to bring students of different disciplines to a certain level and to equip them with necessary knowledge of power systems. The objectives of the course are:

- To impart knowledge about the methods of power generation,
- Understanding the transmission and distribution of electric power and related issues,
- Understanding the behaviour of power systems on variable load, and
- Determination of load flow analysis and economic load dispatch.

Course content

Module	Topic	L	T	P
1	**Methods of power generation** Thermal power plants Hydro-electric power plants Nuclear power plant Diesel power plant Combined cycle power plant Pumped storage plants Introduction to renewable energy sources	8		
2	**Synchronous machines and transformer** ***Transformer:*** construction, working, equivalent circuit, losses ***Synchronous machines:*** construction, principle of operation (generator/motor action), equivalent circuits, phasor diagram, operation of synchronous generator on infinite bus bar/grid, excitation control	9	2	
3	**Transmission & distribution** Classification of transmission lines – short, medium and long transmission line, transmission line parameters, modelling of lines and transmission line performance: Voltage regulation and efficiency; Loadability of lines, Basic concepts of HVDC	8	2	
4	**Variable load on power stations** Load and load duration curves, important terms and factors Important points in selecting generating units, interconnected grid system	2		
5	**Power system analysis** 40 Load flow analysis: Gauss Seidel, Newton Raphson, Economic load Dispatch and unit commitment	8	3	
		35	**7**	**0**

Evaluation criteria

Course reviewers

1. Prof. J S Saini, Professor Emeritus, Department of Mechanical and Industrial Engineering, IIT *Roorkee*
2. Dr. R.L. Sawhney, Former Professor, TERI Unievrsity, Delhi; School of Energy and Environmental Studies, Devi Ahilya Vishwavidyalaya, Indore
3. Dr. Sanjay Agrawal, Associate Professor, Department of Electrical Engineering, SOET, IGNOU, New Delhi
4. Dr. M. Rizwan, Assistant Professor, Department of Electrical Engineering, Delhi Technological University, New Delhi

Course title: Heat Transfer			
Course code: ENR 137	**No. of credits**: 4	**L-T-P**: 46-10-0	**Learning hours**: 56
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator(s): Dr. Som Mondal		**Course instructor(s)**: Prof. S C Mullick/ Dr. Som Mondal	
Contact details: **som.mondal@teriuniversity.ac.in**			
Course type: Core		**Course offered in**: Semester 1	

Course description

The course is designed to familiarize the students with the basic principles of heat transfer mechanisms and applications. Students will learn in detail about the concepts of conduction, forced convection, natural convection and radiation, how their combinations contribute in any heat transfer process, how a heat transfer process can be made more efficient and how to reduce heat losses. The students would also learn about types of heat exchangers, their analysis, selection, sizing. The course also covers basics of condensation on different surfaces and different boiling regimes in pool and flow boiling.

Course objectives

- To impart knowledge of conduction, convection and radiation, their fundamental equations and correlations
- To apply the principles of heat transfer into engineering applications such as heat exchanger, heat pipe, insulation wall etc.
- To develop understanding on boiling and condensation process

Course contents

Module	**Topic**	**L**	**T**	**P**
1	**Fundamentals of Heat Transfer** Relevance and application of heat transfer in renewable energy technologies Introduction to different heat transfer mechanisms: conduction, convection and radiation	2		

2	**Conduction** Steady state heat conduction in uniform solids and composite systems of rectangular, cylindrical and spherical geometries, electrical analogy, thermal contact resistance Critical thickness of insulation Heat transfer from extended surfaces Transient heat conduction, lumped system analysis, time constant	10	2	
3	**Convection** Physical mechanisms of convection Thermal boundary layer, external and internal forced convection under laminar and turbulent flow conditions Laminar and turbulent natural convection over surfaces, natural convection inside enclosures	14	2	
4	**Heat Exchangers** Different types of heat exchangers: plate heat exchanger, shell-and-tube heat exchangers: parallel flow and counter-flow, overall heat transfer coefficient, fouling factors Analysis of heat exchangers: logarithmic mean temperature difference (LMTD) method, effectiveness-NTU method Selection and sizing of heat exchangers	8	2	
5	**Radiation** Thermal radiation, emission characteristics of black and grey surface Emissivity and absorptivity, Reflectivity and transmissivity, Planck's law, Stefan-Boltzmann Law, Directional intensity of radiation, Kirchhoff's Law Radiative heat transfer between surfaces, Shape factor: reciprocity relation, summation rule, superposition rule and symmetry rule Radiative heat transfer within an enclosure, radiation shield	6	2	
6	**Boiling and Condensation** Film-wise and drop-wise condensation, estimation of heat transfer coefficients for condensation on surfaces, condensation on tube and on tube banks Pool boiling curve, nucleate and film boiling, flow boiling, estimation of heat transfer coefficients in nucleate boiling Principle and construction of heat pipe	6	2	
	Total	**46**	**10**	**0**

Evaluation criteria

- Assignments: 20%
- Two Minor Tests: 15% (each)
- Final Examination: 50%

Learning outcomes

After studying this course students will be able to:

- Develop fundamental understanding of different heat transfer processes and relate them to practical problems in renewable energy technologies
- Model heat transfer problems and solve it
- Develop the skill to analyse heat exchangers, their sizing and selection
- Understand heat exchange process through boiling and condensation

Pedagogical approach:

A combination of class-room interactions, tutorials, assignments and group projects.

Reading materials

Text Books

1. S. P. Sukhatme, "A Textbook on Heat Transfer", Fourth Edition (University Press India Ltd., 2005)
2. YA Cengel. "Heat and Mass Transfer: A practical approach", Third Edition (Tata McGraw Hill, 2005)

Reference Books

1. JP Holman, "Heat Transfer", Ninth Edition (Tata McGraw-Hill, 2007)
2. PK Nag, "Heat Transfer", First Edition (Tata McGraw-Hill, 2002)
3. FP Incropera and DP DeWitt, "Fundamentals of Heat and Mass Transfer", Fifth Edition (*Wiley-India, 2007*)

Additional information (if any)

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Dr. Maddali Ramgopal, Professor, Mechanical Engineering, Indian Institute of Technology Kharagpur
2. Dr. Arvind Pattamatta, Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology Madras

Course title: Conventional Energy and Environmental Implications			
Course code:	**No. of credits:** 2	**L-T-P**: 28-0-0	**Learning hours**: 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Dr. Priyanka Kaushal		**Course instructor(s)**: Dr. Priyanka Kaushal	
Contact details: priyanka.kaushal@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 1	

Course description

The course discusses and analyse the role of energy in the development of India. The focus of the course is on the conventional energy sources & their conversion technologies as well as the environmental impacts including global climate change.

Course objectives

The objective of the courses is to develop understanding for the following:
Utilization of conventional energy sources like- coal, oil & natural gas, nuclear and hydro.
Environmental implications due to energy generation and use.

Course contents

Module	Topic	L	T	P
1	Overview of Energy Sector	2		
	COAL			
2	Coal Basics Formation of coal World and domestic reserves Coal types, coal characteristics and properties Quality of Indian coals	2		
3	Coal Utilization Technologies Uses of coal Coal utilization technologies	2		
4	Environmental Aspects and Clean Use of Coal Environmental impacts of coal mining and combustion and control measures Clean coal technologies Coal washing, pyrolysis, gasification, liquefaction, Coal bed methane, ash utilization Carbon capture and storage	6		
	OIL & NATURAL GAS			
5	Basics Origin and mode of occurrences of petroleum Reserves of oil and natural gas world and India Natural gas fields	2		
6	Uses, Production, Demand, Imports, Environmental Aspects Use of petroleum products as fuels and feedstock Uses of natural gas, LNG, CNG, LPG Oil Refining Environmental aspects of oil and natural gas	2		
	NUCLEAR			
7	Basics			

	Basic concepts (radioactivity, nuclear reactions, fission, fusion), uranium and thorium reserves	2		
8	Fuel Processing and Safety Nuclear fuel cycle Nuclear fuel reprocessing, safety & nuclear waste management	1		
	HYDRO			
9	Basic & Technology Basic concepts Components of hydroelectric power plant, hydro potential and exploitation in India Major hydroelectric power plants in India	2		
10	Environmental Issues, Myths Environmental issues, myths, constraints and problems Importance of hydropower, private sector participation	4		
11	Energy and Climate Change Linkages Energy and the climate change dimension, energy access, climate change and equity, international response to climate change, India's responses to climate change	3		
	Total	**28**	**0**	**0**

Evaluation criteria

- Assignments/Tutorials: 20%
- Two Minor Test: 15% (each)
- Final Examination: 50%

Learning outcomes

At the end of the course the student will be able to

- To understand the energy systems.
- Quantify the scale of pollution from a conventional Energy source.
- Identify strength and weak-linkages in the energy systems.

Pedagogical approach

A combination of class-room interactions, tutorials, assignments and projects.

Materials

Recommended readings

1. Rao. S and Parulekar B.B., "Energy Technology", Khanna Publishers
2. Bernard R Cooper and William A Ellingson, "The Science & Technology of Coal and coal utilization" Edited, ISBN0-306-41436.8, Plennwell
3. Pradip Kumar Das & Hrishikesh, "Petroleum and Coal" ,ISBN 81-7533-042-2, MD
4. Deshpande, B G, "The World Of Petroleum"

5. Yadav, M S, "Nuclear Energy and Power" SBS Publishers & Distributors Pvt. Ltd.
6. Jack J Fritz, "Small and Mini Hydropwer system", ISBN 0-07-022470-6, MC Graw Hill

Reference Books

1. Bruce G Miller, "Coal Energy System", ISBN 0-12-497451-1, Elsevier Academic Press
2. William L Leffler, Petroleum Refining, ISBN 0-87814-776-4, Pennwell
3. Dr. Duncan Seddon, "Gas Usage and Value", ISBN 1-59370-073-3, Pennwell Raymond L Murray, Nuclear Energy, Pergamon Press
4. Small Hydropower Initiative and Private Sector Participartion, Alternate Hydro Energy Centre, IIT Roorkee
5. Charles Simeons, "Hydropwer-The use of water as an alternate source of energy", ISBN 0 08 023269 8 Pergamon press
6. Douglas M Considine, Energy Handbook, Mc Graw Hill
7. Editor in Chief- Cutler J Cleveland, "Encyclopedia of Energy", Elsever Academic Press
8. Wiley Encyclopedia Series, Energy, Technology & Environment

Websites

coal.nic.in,
worldcoal.org,
petroleum.nic.in,
dae.gov.in
npcil.nic.in,
powermin.nic.in
nhpcindia.com

Additional information (if any)

Student responsibilities
Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Mr. Surender Pratap, Director R & D, Petroleum Conservation and Research Association (PCRA), New Delhi
2. Dr. Ajay Kumar Singh, Central Institute of Mining and Fuel Research, Dhanbad
3. Dr. Sunil Singal, Senior Scientific Officer, Alternate Hydro Energy Centre, IIT Roorkee

Course title: Technical Writing			
Course code: NRE 101	**No. of credits**: 2	**L-T-P**: 16-12-0	**Learning hours**: 28
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator(s):		**Course instructor(s):** Ms Namrata Yadav	
Contact details:			

Course type: Core	**Course offered in**: Semester 2

Course description

Students in the technology professions are proficient in their particular disciplines, but often unable to communicate effectively through reports or even scientific publications. Given that many students taking this course will not have a strong background in English, we propose to tackle this course in two ways.

One, by exposing the student to the requirements of technical writing as opposed to other kinds of formal writing and two, by providing a large number of exercises aimed at improving basic grammar, which will be assessed.

The student should be able to organize information for a report, a scientific paper and a proposal. He should be able to proofread his work, write concise emails and make technical presentations in PowerPoint. The use of graphs, tables and illustrations will also be taught.

Course objectives

Upon satisfactory completion of the course, students will be able to:

- Understand and use structures of argument appropriate to technical documents
- Understand and use a range of current web platforms and technologies

Course content

Module	**Topic**	**L**	**T**	**P**
	Critical thinking, reading and writing Why critical thinking is important in reading and writing? Ideating and developing an argument Understanding our audience and who we are writing for?	2		
	Academic writing: An interdisciplinary approach Understanding different styles in the science and social science space: Thesis, dissertation (Understanding the difference in science and social science writing) Publications, reports Op eds, critiques Blogs, journals On writing, well - positioning yourself as an author Audience, purpose and strategy Style, flow and formality Developing a discussion, argument and analysis Types of abstract and its development Words and its usage - looking at various writing styles and guidelines Use of infographics (tables, graphs, charts and visuals) Paragraph development: unity, lead and ending Reference styles Proof reading & editing Understanding the peer review process Presentation and form	6	6	
	Business Writing How to develop a good research proposal	6	4	

	How to develop a project proposal Report writing Developing a good power point presentation Thinking about communication Communication skills			
	Professional Writing Email Writing CV and cover letters Letters & Memos	2	2	
	Total	**16**	**12**	**0**

Evaluation criteria

- Assignments: 35%
- Presentations: 15%
- Major Test: 50%

Learning outcomes

Pedagogical approach

Materials

Required text

1. Beer D. (1991) ***Writing and Speaking in the Technology Professions: A Practical Guide,*** Wiley-IEEE Press.
2. Markel M. (2009) *Technical Communications*, 9th Edition, Bedford/St Martin's.
3. Markel M. (1994) ***Writing in the Technical Fields: A Step-by-Step Guide for Engineers,* Scientists and Technicians**, publisher.

Suggested readings

http://courses.washington.edu/hcde231/Readings.html
http://www.writing.engr.psu.edu/
http://owl.english.purdue.edu/owl/resource/629/01/
http://www.writing.engr.psu.edu/exercises/

Case studies
Websites

Journals
Journal of Technical Writing and Communications

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course title: Energy Conservation and Management			
Course code:	**No. of credits:** 2	**L-T-P:** 20-06-04	**Learning hours**: 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Mr. Sapan Thapar		**Course instructor(s)**: Mr. Sapan Thapar	
Contact details: sapan.thapar@teri.res.in			
Course type: Core		**Course offered in**: Semester 1	

Course description

Energy Management has been identified as a key instrument to reduce greenhouse gas emissions, besides increasing the cost competitiveness of the entity/ facility while enhancing the energy security of the nation. Policy makers and technology providers have been working towards the cause of energy efficiency and its overall management. This course is designed to educate students on the various dimensions of energy management across the entire value chain.

Course objectives

- To impart knowledge in the domain of energy conservation
- To bring out Energy Conservation Potential and Business opportunities across different user segments under innovative business models
- To inculcate knowledge and skills about assessing the energy efficiency of an entity/ establishment

Course contents

Module	Topic	L	T	P
1	Introduction to Energy Conservation Need for Energy Conservation Energy Sources, Supply & Demand Overview of Electrical and Thermal Energy	4		
2	Policy & Regulations for Energy Conservation Institutional Structure Energy Conservation Policies & Legislations National and International Programmes	4		
3	Energy Conservation Opportunities – Electrical Buildings & Lighting Systems Motors, Pumps, Transformers Power Transmission & Distribution System	3		
4	Energy Conservation Opportunities – Thermal Boilers, Furnaces & Waste Heat Recovery Systems Cogeneration Systems HVAC, Cooling Towers & DG Systems	3		
5	Energy Data Analysis			

	IT Tools and Applications Smart Energy Systems	2		
6	Business Approaches Market Opportunities EE Financing & ESCO Business Models Case studies on Innovations and Best Practices	4	6	
7	Site Visit Power Distribution Utility Industry/ Building			4
	Total	**20**	**6**	**4**

Evaluation criteria

- Assignments: 20%
- Two Minor Test: 20% (each)
- Final Examination: 40%

Learning outcomes

- Obtain knowledge about energy conservation policy, regulations and business practices
- Analyse energy systems from a supply and demand perspective
- Recognize opportunities for enabling rational use of energy
- Apply knowledge of Energy Conservation Opportunities in a range of contexts
- Develop innovative energy efficiency solutions and demand management strategies

Pedagogical approach

A combination of class-room interactions, group discussions, tutorials, assignments and site visits

Materials

Text Books

1. LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998)

Reference Books

1. WC Turner and Steve Doty: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)
2. Sumper Andreas and Baggini Angelo: Electrical Energy Efficiency: Technologies and Applications (John Wiley 2012)
3. Frank Kreith: Handbook on Energy Efficiency and Renewable Energy (CRC Press, 2007)
4. George Polimeros: Energy Cogeneration Handbook (Industrial Press, Inc., New York, 1981)

Websites

National Productivity Council (http://www.npcindia.gov.in) Bureau of Energy Efficiency (https://www.beeindia.gov.in) Petroleum Conservation Research Association (http://www.pcra.org)
Additional information (if any):
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Mr RP Gokul, Head (Energy Efficiency Division), ICF International
2. Mr Amit Kumar, Sr. Director, TERI

Course Title: Introduction To Management Techniques - I			
Course code: ENR 185	**No. of credits**: 1	**L-T-P**: 14-0-0	**Learning hours**: 14
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Dr. Ritika Mahajan		**Course instructor(s)**: Dr. Ritika Mahajan	
Contact details: ritika.mahajan@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 2	

Course description

The course is divided into two parts, one with management and organization principles, and, the other with basic business finance. Since one of the main challenges remains as how to develop the marketability of renewable energy which is needed to ensure its meaningful acceptance, a set of business ideas is necessary for the students to be aware of. This course would help them to adopt a systematic approach to solve the organizational problems.

Course objectives

- To make the students learn basic organization and management principles.
- To help the students develop a systematic approach to address problems.
- To ensure that the students get aware of the organization-environment interface.

Course contents

Module	Topic	L	T	P
1	Introduction Types of organization structures Basic concepts in management; management functions, skills and roles	2		
2	Basic elements of planning and decision making Approaches to organizational planning	2		

	Strategic and operational plans Goal setting with responsibility Decision making process and tools SWOT analysis and decision trees			
3	Basic elements of organizing Organization design and its nature Designing of jobs (or roles) and reporting relations Forms of organization design Delegation of authority Responsibility and authority relationship Centralized vs. decentralized organizations	2		
4	Managerial Control Basic control processes: feedback and feed forward Real-time information and control Mandatory and non-mandatory control	2	0	0
5	Managing Changes Issues involved Manager's role as change agent Resistance to changes Models of change management	2		
6	Management environment Technological environment Social environment Economic environment Political environment Legal environment Global environment	2		
7	Management and society Ethics in management Corporate social responsibility (CSR) Strategic CSR and Creating Shared Value	2		
	Total	**14**	**0**	**0**

Evaluation criteria

- Minor exam: 30%
- Assignment/Presentation: 30%
- Major exam: 40%

Learning outcomes

- To understand the basics of management.
- To understand the optimization of resource allocation and its use.
- To understand the business perspective of the emerging section of renewable energy.

Pedagogical approach

A combination of class-room interactions and assignment.
Materials Hand-outs distribution by faculty.
Additional information (if any) **Books Recommended:** Koontz, H and Weihrich, H, Essentials of Management, Tata McGraw Hill Robbins, SP and Coulter, M, Management, Prentice Hall Koontz, H, Principles of Management, Tata McGraw-Hill Stoner, James AF, Freeman, RE and Gilbert (Jr.) DR, Management, Prentice Hall Luthans, F, Introduction to Management: A Contingency Approach, Tata McGraw Hill Ghuman, K and Aswathappa, K, Management: Concept, Practice and Cases, Tata McGraw Hill In addition to books, participants are encouraged to read journals/magazines like Harvard Business Review California Management Review Vikalp IIMB Management Review Forbes etc.
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Vinay Sharma, IIT Roorkee
2. Kumkum Bharti, IIM Kashipur

Course title: Energy Lab – I (Power system lab and Heat transfer lab)			
Course code:	**No. of credits**: 2	**L-T-P**: 0-0-56	**Learning hours**: 56
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator: Dr. Naqui Anwer		**Course instructor(s)**: Dr. Naqui Anwer/ Dr. Som Mondal	
Contact details: naqui.anwer@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 1	
Course description To work in power industry, it is very important to develop an expertise to handle various power system equipments like synchronous machine, DC machine, Induction machine, transformers and transmission lines. This laboratory is designed to give students a hands-on experience on different equipment of electrical power system. Heat Transfer is one of the important subjects which is commonly applied in renewable energy, industrial, commercial and domestic systems. The experiments are designed to provide exposure of			

practical aspects of the various theoretical concepts developed under the various courses. The laboratory consists of experiments on various conductive, convective, radiative, boiling and condensing mechanisms of heat transfer.

Course objectives

- To provide hand-on experience on experimental set ups/prototypes related to power system and heat transfer.
- To provide practical learning about construction and operation of power system equipments and heat transfer equipments.

Course contents

Module	Topic	L	T	P
1	Transmission & Distribution ABCD parameters of short, medium and long transmission lines To determine the performance of transmission line under different loading condition.			3 2
2	Induction Machine To vary the speed of an induction motor by varying voltage and to change the direction of rotation. To perform the no load test and block rotor test on an induction motor. To perform the load test on an induction motor.			2 3 2
3	Transformer To operate two transformers in parallel and study the load sharing between them. To perform the OC and SC test and Polarity test. Sumpner's back to back test on a transformer and determine the circuit model parameters. To calculate regulation at full and unity power factor of a single phase transformer.			3 2 2 2
4	DC Machines To study speed control of DC motor above the normal range by field control and to plot speed vs field current characteristics. To obtain load characteristics of DC shunt motor.			3 3
5	Power System Analysis To understand reactive power and power factor in single-phase and three- phase circuits. To find the OCC and SCC of an alternator. To simulate the different types of faults in a power system.			3 3 3
6	Conduction Measurement of thermal conductivity of an insulating slab.			3
7	Natural Convection			

	Measurement of heat transfer coefficient in natural convection on vertical cylinder.			3
8	Radiation Measurement of emissivity of a gray surface.			3
9	Heat Exchanger Estimation of overall heat transfer coefficient for tube in tube type heat exchanger in counter flow mode. Estimation of overall heat transfer coefficient for shell and tube heat exchanger with water on both sides. Estimation of overall heat transfer coefficient for shell and tube heat exchanger with thermic fluid on one and water on the other side.			2 3 3
10	Forced Convection Measurement of convective heat transfer coefficient in a pipe by forced convection.			3
	Total	**0**	**0**	**56**

- **Evaluation criteria**
- Practical Records: 20%
- Viva voce: 30%
- Continuous evaluation: 50%

Learning outcomes

- Students shall be able to understand the characteristics and behaviour of various power system equipments and heat transfer systems through experimental verification.
- Students are expected to learn the integrated operation and mathematical modelling of the power system equipments.

Pedagogical approach

Students complete a procedure given in the laboratory manual to determine the behaviour of the equipments/prototypes/experimental set ups and produce the expected characteristics.

Materials

Recommended readings

1. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Tata McGraw-Hill, 3rd edition, 2014
2. D.P. Kothari and I.J. Nagrath, "Electrical Machines", Tata McGraw-Hill, 4th edition, 2010
3. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Inc., 1994
4. YA Cengel and AJ Ghajar, "Heat and Mass Transfer: Fundamentals and Applications", Tata McGraw-Hill, 4th edition, 2011
5. Robert Alan Granger, "Experiments in Heat Transfer and Thermodynamics", Cambridge University Press, 1994

Additional information (if any):

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Dr. M. Rizwan, Assistant Professor (Electrical Engineering), Delhi Technological University, New Delhi
2. Prof. S. Maji, Department of Mechanical Engineering, SOET, IGNOU, New Delhi

Course title: Conventional Energy and Environmental Implications			
Course code:	**No. of credits:** 2	**L-T-P**: 28-0-0	**Learning hours**: 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Dr. Priyanka Kaushal		**Course instructor(s)**: Dr. Priyanka Kaushal	
Contact details: priyanka.kaushal@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 1	

Course description

The course discusses and analyse the role of energy in the development of India. The focus of the course is on the conventional energy sources & their conversion technologies as well as the environmental impacts including global climate change.

Course objectives

- The objective of the courses is to develop understanding for the following:
- Utilization of conventional energy sources like- coal, oil & natural gas, nuclear and hydro.
- Environmental implications due to energy generation and use.

Course contents

Module	**Topic**	**L**	**T**	**P**
1	Overview of Energy Sector	2		
	COAL			
2	Coal Basics Formation of coal World and domestic reserves Coal types, coal characteristics and properties Quality of Indian coals	2		
3	Coal Utilization Technologies Uses of coal Coal utilization technologies	2		
4	Environmental Aspects and Clean Use of Coal Environmental impacts of coal mining and combustion and control measures Clean coal technologies Coal washing, pyrolysis, gasification, liquefaction, Coal bed methane,	6		

	ash utilization Carbon capture and storage			
	OIL & NATURAL GAS			
5	Basics Origin and mode of occurrences of petroleum Reserves of oil and natural gas world and India Natural gas fields	2		
6	Uses, Production, Demand, Imports, Environmental Aspects Use of petroleum products as fuels and feedstock Uses of natural gas, LNG, CNG, LPG Oil Refining Environmental aspects of oil and natural gas	2		
	NUCLEAR			
7	Basics Basic concepts (radioactivity, nuclear reactions, fission, fusion), uranium and thorium reserves	2		
8	Fuel Processing and Safety Nuclear fuel cycle Nuclear fuel reprocessing, safety & nuclear waste management	1		
	HYDRO			
9	Basic & Technology Basic concepts Components of hydroelectric power plant, hydro potential and exploitation in India Major hydroelectric power plants in India	2		
10	Environmental Issues, Myths Environmental issues, myths, constraints and problems Importance of hydropower, private sector participation	4		
11	Energy and Climate Change Linkages Energy and the climate change dimension, energy access, climate change and equity, international response to climate change, India's responses to climate change	3	0	0
	Total	**28**	**0**	**0**

Evaluation criteria

- Assignments/Tutorials: 20%
- Two Minor Test: 15% (each)
- Final Examination: 50%

Learning outcomes

At the end of the course the student will be able to

- To understand the energy systems.
- Quantify the scale of pollution from a conventional Energy source.
- Identify strength and weak-linkages in the energy systems.

Pedagogical approach

A combination of class-room interactions, tutorials, assignments and projects.

Materials

Recommended readings

1. Rao. S and Parulekar B.B., "Energy Technology", Khanna Publishers
2. Bernard R Cooper and William A Ellingson, "The Science & Technology of Coal and coal utilization" Edited, ISBN0-306-41436.8, Plennwell
3. Pradip Kumar Das & Hrishikesh, "Petroleum and Coal" ,ISBN 81-7533-042-2, MD
4. Deshpande, B G, "The World Of Petroleum"
5. Yadav, M S, "Nuclear Energy and Power" SBS Publishers & Distributors Pvt. Ltd.
6. Jack J Fritz, "Small and Mini Hydropwer system", ISBN 0-07-022470-6, MC Graw Hill

Reference Books

1. Bruce G Miller, "Coal Energy System", ISBN 0-12-497451-1, Elsevier Academic Press
2. William L Leffler, Petroleum Refining, ISBN 0-87814-776-4, Pennwell
3. Dr. Duncan Seddon, "Gas Usage and Value", ISBN 1-59370-073-3, Pennwell Raymond L Murray, Nuclear Energy, Pergamon Press
4. Small Hydropower Initiative and Private Sector Participartion, Alternate Hydro Energy Centre, IIT Roorkee
5. Charles Simeons, "Hydropwer-The use of water as an alternate source of energy", ISBN 0 08 023269 8 Pergamon press
6. Douglas M Considine, Energy Handbook, Mc Graw Hill
7. Editor in Chief- Cutler J Cleveland, "Encyclopedia of Energy", Elsever Academic Press
8. Wiley Encyclopedia Series, Energy, Technology & Environment

Websites

coal.nic.in,
worldcoal.org,
petroleum.nic.in,
dae.gov.in
npcil.nic.in,
powermin.nic.in
nhpcindia.com

Additional information (if any)

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Mr. Surender Pratap, Director R & D, Petroleum Conservation and Research Association (PCRA), New Delhi
2. Dr. Ajay Kumar Singh, Central Institute of Mining and Fuel Research, Dhanbad
3. Dr. Sunil Singal, Senior Scientific Officer, Alternate Hydro Energy Centre, IIT Roorkee

Course title: Technical Writing			
Course code: NRE 101	**No. of credits**: 2	**L-T-P**: 16-12-0	**Learning hours**: 28
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator(s):	**Course instructor(s):** Ms Namrata Yadav		
Contact details:			
Course type: Core	**Course offered in**: Semester 2		

Course description

Students in the technology professions are proficient in their particular disciplines, but often unable to communicate effectively through reports or even scientific publications. Given that many students taking this course will not have a strong background in English, we propose to tackle this course in two ways.

One, by exposing the student to the requirements of technical writing as opposed to other kinds of formal writing and two, by providing a large number of exercises aimed at improving basic grammar, which will be assessed.

The student should be able to organize information for a report, a scientific paper and a proposal. He should be able to proofread his work, write concise emails and make technical presentations in PowerPoint. The use of graphs, tables and illustrations will also be taught.

Course objectives

Upon satisfactory completion of the course, students will be able to:

- Understand and use structures of argument appropriate to technical
- documents
- Understand and use a range of current web platforms and technologies

Course content

Module	Topic	L	T	P
	Critical thinking, reading and writing Why critical thinking is important in reading and writing? Ideating and developing an argument Understanding our audience and who we are writing for?	2		
	Academic writing: An interdisciplinary approach Understanding different styles in the science and social science space: Thesis, dissertation (Understanding the difference in science and social science writing) Publications, reports	6	6	

	Op eds, critiques Blogs, journals On writing, well - positioning yourself as an author Audience, purpose and strategy Style, flow and formality Developing a discussion, argument and analysis Types of abstract and its development Words and its usage - looking at various writing styles and guidelines Use of infographics (tables, graphs, charts and visuals) Paragraph development: unity, lead and ending Reference styles Proof reading & editing Understanding the peer review process Presentation and form			
	Business Writing How to develop a good research proposal How to develop a project proposal Report writing Developing a good power point presentation Thinking about communication Communication skills	6	4	
	Professional Writing Email Writing CV and cover letters Letters & Memos	2	2	
	Total	**16**	**12**	**0**

Evaluation criteria

- Assignments: 35%
- Presentations: 15%
- Major Test: 50%

Learning outcomes

Pedagogical approach

Materials

Required text

Beer D. (1991) Writing and Speaking in the Technology Professions: A Practical Guide, Wiley-IEEE Press.

Markel M. (2009) Technical Communications, 9th Edition, Bedford/St Martin's.

Markel M. (1994) Writing in the Technical Fields: A Step-by-Step Guide for Engineers, Scientists and Technicians, publisher.

Suggested readings

http://courses.washington.edu/hcde231/Readings.html http://www.writing.engr.psu.edu/ http://owl.english.purdue.edu/owl/resource/629/01/ http://www.writing.engr.psu.edu/exercises/ Case studies Websites **Journals** Journal of Technical Writing and Communications
Additional information (if any)
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course title: Energy Conservation and Management			
Course code:	**No. of credits:** 2	**L-T-P**: 20-06-04	**Learning hours**: 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Mr. Sapan Thapar		**Course instructor(s)**: Mr. Sapan Thapar	
Contact details: sapan.thapar@teri.res.in			
Course type: Core		**Course offered in**: Semester 1	

Course description

Energy Management has been identified as a key instrument to reduce greenhouse gas emissions, besides increasing the cost competitiveness of the entity/ facility while enhancing the energy security of the nation. Policy makers and technology providers have been working towards the cause of energy efficiency and its overall management. This course is designed to educate students on the various dimensions of energy management across the entire value chain.

Course objectives

- To impart knowledge in the domain of energy conservation
- To bring out Energy Conservation Potential and Business opportunities across different user segments under innovative business models
- To inculcate knowledge and skills about assessing the energy efficiency of an entity/ establishment

Course contents

Module	Topic	L	T	P
1	Introduction to Energy Conservation Need for Energy Conservation Energy Sources, Supply & Demand Overview of Electrical and Thermal Energy	4		

2	Policy & Regulations for Energy Conservation Institutional Structure Energy Conservation Policies & Legislations National and International Programmes	4		
3	Energy Conservation Opportunities – Electrical Buildings & Lighting Systems Motors, Pumps, Transformers Power Transmission & Distribution System	3		
4	Energy Conservation Opportunities – Thermal Boilers, Furnaces & Waste Heat Recovery Systems Cogeneration Systems HVAC, Cooling Towers & DG Systems	3		
5	Energy Data Analysis IT Tools and Applications Smart Energy Systems	2		
6	Business Approaches Market Opportunities EE Financing & ESCO Business Models Case studies on Innovations and Best Practices	4	6	
7	Site Visit Power Distribution Utility Industry/ Building			4
	Total	**20**	**6**	**4**

Evaluation criteria

- Assignments: 20%
- Two Minor Test: 20% (each)
- Final Examination: 40%

Learning outcomes

- Obtain knowledge about energy conservation policy, regulations and business practices
- Analyse energy systems from a supply and demand perspective
- Recognize opportunities for enabling rational use of energy
- Apply knowledge of Energy Conservation Opportunities in a range of contexts

- Develop innovative energy efficiency solutions and demand management strategies

Pedagogical approach
A combination of class-room interactions, group discussions, tutorials, assignments and site visits

Materials

Text Books

1. LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998)

Reference Books

1. WC Turner and Steve Doty: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)
2. Sumper Andreas and Baggini Angelo: Electrical Energy Efficiency: Technologies and Applications (John Wiley 2012)
3. Frank Kreith: Handbook on Energy Efficiency and Renewable Energy (CRC Press, 2007)
4. George Polimeros: Energy Cogeneration Handbook (Industrial Press, Inc., New York, 1981)

Websites

National Productivity Council (http://www.npcindia.gov.in)
Bureau of Energy Efficiency (https://www.beeindia.gov.in)
Petroleum Conservation Research Association (http://www.pcra.org)

Additional information (if any):

Student responsibilities
Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Mr RP Gokul, Head (Energy Efficiency Division), ICF International
2. Mr Amit Kumar, Sr. Director, TERI

Course title: Introduction to management techniques - I			
Course code: ENR 185	**No. of credits:** 1	**L-T-P:** 14-0-0	**Learning hours:** 14
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr. Ritika Mahajan	**Course instructor(s):** Dr. Ritika Mahajan		
Contact details: ritika.mahajan@teriuniversity.ac.in			

Course type: Core	**Course offered in:** Semester 2

Course description

The course is divided into two parts, one with management and organization principles, and, the other with basic business finance. Since one of the main challenges remains as how to develop the marketability of renewable energy which is needed to ensure its meaningful acceptance, a set of business ideas is necessary for the students to be aware of. This course would help them to adopt a systematic approach to solve the organizational problems.

Course objective

- To make the students learn basic organization and management principles.
- To help the students develop a systematic approach to address problems.
- To ensure that the students get aware of the organization-environment interface**.**

Course contents

Module	**Topic**	**L**	**T**	**P**
1	**Introduction** Types of organization structures Basic concepts in management; management functions, skills and roles	2	0	0
2	**Basic elements of planning and decision making** Approaches to organizational planning Strategic and operational plans Goal setting with responsibility Decision making process and tools SWOT analysis and decision trees	2	0	0
3	**Basic elements of organizing** Organization design and its nature Designing of jobs (or roles) and reporting relations Forms of organization design Delegation of authority Responsibility and authority relationship Centralized vs. decentralized organizations	2	0	0
4	**Managerial Control** Basic control processes: feedback and feed forward Real-time information and control Mandatory and non-mandatory control	2	0	0
5	**Managing Changes** Issues involved Manager's role as change agent Resistance to changes	2	0	0

	Models of change management			
6	**Management environment** Technological environment Social environment Economic environment Political environment Legal environment Global environment	2	0	0
7	**Management and society** Ethics in management Corporate social responsibility (CSR) Strategic CSR and Creating Shared Value	2	0	0
	Total	**14**	**0**	**0**

Evaluation criteria

- Minor exam: 30%
- Assignment/Presentation: 30%
- Major exam: 40%

Learning outcomes

- An understanding of fundamentals of management.
- An ability to optimize resource allocation and its use
- Familiarity with business perspective of the emerging section of renewable energy

Pedagogical approach

A combination of class-room interactions and assignment.

Materials

Hand-outs to be distributed by faculty.

Books Recommended:
Koontz, H and Weihrich, H, Essentials of Management, Tata McGraw Hill
Robbins, SP and Coulter, M, Management, Prentice Hall
Koontz, H, Principles of Management, Tata McGraw-Hill
Stoner, James AF, Freeman, RE and Gilbert (Jr.) DR, Management, Prentice Hall
Luthans, F, Introduction to Management: A Contingency Approach, Tata McGraw Hill
Ghuman, K and Aswathappa, K, Management: Concept, Practice and Cases, Tata McGraw Hill

Additional information (if any)
In addition to books, participants are encouraged to read journals/magazines like

Harvard Business Review California Management Review Vikalp IIMB Management Review Forbes etc.
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Vinay Sharma, IIT Roorkee
2. Kumkum Bharti, IIM Kashipur

Course title: Energy Lab – I (Power system lab and Heat transfer lab)			
Course code:	**No. of credits**: 2	**L-T-P**: 0-0-56	**Learning hours**: 56
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator: Dr. Naqui Anwer		**Course instructor(s)**: Dr. Naqui Anwer/ Dr. Som Mondal	
Contact details: naqui.anwer@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 1	

Course description

To work in power industry, it is very important to develop an expertise to handle various power system equipments like synchronous machine, DC machine, Induction machine, transformers and transmission lines. This laboratory is designed to give students a hands-on experience on different equipment of electrical power system.

Heat Transfer is one of the important subjects which is commonly applied in renewable energy, industrial, commercial and domestic systems. The experiments are designed to provide exposure of practical aspects of the various theoretical concepts developed under the various courses. The laboratory consists of experiments on various conductive, convective, radiative, boiling and condensing mechanisms of heat transfer.

Course objectives

- To provide hand-on experience on experimental set ups/prototypes related to power system and heat transfer.
- To provide practical learning about construction and operation of power system equipments and heat transfer equipments.

Course contents

Module	Topic	L	T	P
1	Transmission & Distribution ABCD parameters of short, medium and long transmission lines To determine the performance of transmission line under different	 0 0	 0 0	 3 2

	loading condition.			
2	Induction Machine To vary the speed of an induction motor by varying voltage and to change the direction of rotation. To perform the no load test and block rotor test on an induction motor. To perform the load test on an induction motor.	0 0 0	0 0 0	2 3 2
3	Transformer To operate two transformers in parallel and study the load sharing between them. To perform the OC and SC test and Polarity test. Sumpner's back to back test on a transformer and determine the circuit model parameters. To calculate regulation at full and unity power factor of a single phase transformer.	0 0 0 0	0 0 0 0	3 2 2 2
4	DC Machines To study speed control of DC motor above the normal range by field control and to plot speed vs field current characteristics. To obtain load characteristics of DC shunt motor.	0 0	0 0	3 3
5	Power System Analysis To understand reactive power and power factor in single-phase and three- phase circuits. To find the OCC and SCC of an alternator. To simulate the different types of faults in a power system.	0 0 0	0 0 0	3 3 3
6	Conduction Measurement of thermal conductivity of an insulating slab.	0	0	3
7	Natural Convection Measurement of heat transfer coefficient in natural convection on vertical cylinder.	0	0	3
8	Radiation Measurement of emissivity of a gray surface.	0	0	3
9	Heat Exchanger Estimation of overall heat transfer coefficient for tube in tube type heat exchanger in counter flow mode. Estimation of overall heat transfer coefficient for shell and tube heat exchanger with water on both sides. Estimation of overall heat transfer coefficient for shell and tube heat exchanger with thermic fluid on one and water on the other side.	0 0 0	0 0 0	2 3 3
10	Forced Convection			

	Measurement of convective heat transfer coefficient in a pipe by forced convection.	0	0	3
	Total	**0**	**0**	**56**

Evaluation criteria

- Practical Records: 20%
- Viva voce: 30%
- Continuous evaluation: 50%

Learning outcomes

Students shall be able to understand the characteristics and behaviour of various power system equipments and heat transfer systems through experimental verification.
Students are expected to learn the integrated operation and mathematical modelling of the power system equipments.

Pedagogical approach

Students complete a procedure given in the laboratory manual to determine the behaviour of the equipments/prototypes/experimental set ups and produce the expected characteristics.

Materials

Recommended readings

1. D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Tata McGraw-Hill, 3rd edition, 2014
2. D.P. Kothari and I.J. Nagrath, "Electrical Machines", Tata McGraw-Hill, 4th edition, 2010
3. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Inc., 1994
4. YA Cengel and AJ Ghajar, "Heat and Mass Transfer: Fundamentals and Applications", Tata McGraw-Hill, 4th edition, 2011
5. Robert Alan Granger, "Experiments in Heat Transfer and Thermodynamics", Cambridge University Press, 1994

Additional information (if any):

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Dr. M. Rizwan, Assistant Professor (Electrical Engineering), Delhi Technological University, New Delhi
2. Prof. S. Maji, Department of Mechanical Engineering, SOET, IGNOU, New Delhi

Semester II

Course title: Solar Technologies			
Course code: ENR 124	**No. of credits**: 4	**L-T-P**: 51-2-6	**Learning hours**: 56
Pre-requisite course code and title (if any): None			

Department: Energy and Environment				
Course coordinator: Dr. Som Mondal		**Course instructor(s)**: Dr. Som Mondal		
Contact details: som.mondal@teriuniversity.ac.in				
Course type: Core		**Course offered in**: Semester 2		
Course description Solar energy, most abundant and freely available natural energy resources, is used for various applications including space heating, cooling, lighting, process heat for industrial purposes and also electricity generation through PV system and steam power plant. This course covers the basics of conversion technologies, system designing techniques and the methods of direct use of solar energy in daily life. The course has three parts. Part A deals with physics and technology of PV materials, devices, systems design and applications. Part B deals with Solar Thermal collector technologies, storage and applications. Finally, under Part C, the method for harnessing solar energy through passive architecture is covered.				
Course objectives The objective of the course is to develop in-depth understanding of various technologies and applications to harness solar energy through active conversion methods such as photovoltaic & thermal and integration of passive architectures in building.				
Course contents				
Module	**Topic**	**L**	**T**	**P**
	Part-A: Solar Photovoltaic Technology (1.5 Credit)			
1	Physics of solar cells Crystal structure, band theory, energy band diagrams, Fermi level, intrinsic and extrinsic semiconductor, doping, n-type and p-type silicon, p-n junctions, drift and diffusion current, absorption of radiation and excess minority carriers, generation, recombination and carrier separation Standard solar cell structure, I-V characteristics, FF, Voc, Isc, Pmax, conversion efficiency, losses in solar cell, Rs, Rsh, impact of radiation and temperature, PC1D simulation of industrial solar cell structure Concepts of heterojunctions, multi junction and concentrated solar cell, Introduction to advanced softwares used in solar cell simulation	5	2	
2	Solar PV module technologies *First generation: Silicon wafer based technology:* Materials and process requirements for solar cell fabrication, process flow, process control measures, quality control techniques Single and poly crystalline silicon solar cells, Materials and process requirements for module assembly, routine and type tests, qualification test standards, types of degradation. *Second generation: Thin film technologies:* Merits and demerits of thin film technologies, amorphous-Si, CdTe and CIGS solar cell module, manufacturing steps *Third generation/emerging PV technologies:*Organic PV, Dye sensitized PV, Quantum-dot, Hot-carrier, Up conversion and down conversion Latest benchmark efficiencies – laboratory and manufacturing	5		2
3	Solar PV systems	4		4

	Balance of System (BoS) components: battery, PCU (charge controller, inverter, data logger), transformer, cables and connectors, switches/circuit breakers, energy meters, bypass and blocking diodes Types of PV systems: Standalone, grid-connected, hybrid, rooftop business models – CAPEX and RESCO, canal top, floating PV system System design: SPV system design guideline and methodologies, introduction to PVSyst, designing of standalone/grid-connected PV systems for domestic/commercial use			
4	Solar PV applications Lighting, agriculture, refrigeration, telecommunications, space, BIPV, fencing, water purification, navigation, defence, offshore, etc.	2		
	Part –B: Solar Thermal Technology (1.5 Credit)			
5	Solar Radiation review Solar radiation on the collector, Liu & Jordan relation	2		
6	Solar Thermal collectors Non concentrating collectors Flat plate collectors: general design features and characteristics, materials. Unglazed, Single and double glazed solar collectors, Optical losses and thermal losses, thermal analysis and performance characteristics. Design of water and air heating collectors: their specific features. Short term and long term performance (utilizability) Evacuated tube collectors: general design features, characteristics, materials, thermal analysis Thermo siphon system and forced convection system, Concentrating solar collectors: General description; concentrators, receivers, Orienting/tracking requirements, Materials General characteristics Optical features of solar concentrators: II Law of thermodynamics for solar concentrators. Optical and thermal losses, Thermal performance characteristics parabolic trough collectors (PTC), Parabolloid dish collectors, Scheffler dish, Linear Fresnel Reflector Collector	12		
7	Application Solar hot water/steam systems, Solar cookers: box type, dish type and others; dryers; desalination systems; absorption cooling; furnace, Process heating systems, community cooking system Power generation: Concentrator based system, Fresnel system, central tower, distributed line focus and point focus systems, Hybrid solar thermal	4		
8	Energy Storage	3		

	Sensible heat storage, latent heat storage (PCM), thermo-chemical storage Organic & inorganic PCMs, properties, characterization Applications in power generation, green building, cooking, cold storage, transportation, district heating & cooling, salinity gradient solar pond			
	Part –C: Passive Architecture (1 Credit)			
9	Climate and human thermal comfort Factors affecting climate; climatic zones and their characteristics; urban climate; microclimate; implications of climate on building design; principles of energy conscious design, Building materials, embodied energy of building materials, alternative building materials	5		
10	Thermal performance of buildings Heat Transfer Conduction, convection, radiation; evaporation; solar radiation; radiation on tilted surfaces; unshaded surface; shaded surface; simplified method for performance estimation	3		
11	Passive concepts for heating and cooling *Passive heating:* direct gain, indirect gain, thermal storage wall, roof top collectors, isolated gain, solarium *Passive cooling*: nocturnal cooling, evaporative cooling, roof surface evaporative cooling (RSEC), direct evaporative cooling using drip-type (desert) coolers, nocturnal radiation cooling, earth coupling, *Daylighting:* basic principles and systems	4		
12	Rating systems of energy efficient buildings LEED, GRIHA for existing and new building	2		
	Total	**51**	**2**	**6**

Evaluation criteria

- Quizzes/Assignments: 30%
- Two Minor tests: 15% (each)
- Final Examination: 40%

Learning outcomes

After completing this course students will be able to:

Understand the physics and technology of solar PV, solar thermal and passive architecture
Apply system design approaches for various application of solar PV and thermal technologies
Design and integrate the concepts of passive architecture in existing and new buildings

Pedagogical approach

A combination of class-room interactions, practicals/simulation, assignments

Materials

Recommended readings

Text Books

1. Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).
2. CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, Third Ed (PHI Learning, 2015)

Reference Books

1. SM Sze, Kwok K Ng: Physics of semiconductor devices, third edition (John Wiley & Sons, 2007)
2. MA Green: Solar Cells Operating Principles, Technology, and System Applications (Prentice-Hall, 1981)
3. MA Green:High Efficiency Silicon Solar Cells (Trans Tech Publications, 1987)
4. SJ Fonash: Solar Cell Device Physics (Academic Press, 1982)
5. Handbook of photovoltaic science and engineering, ed. Antonio Luque and Steven Hegedus (John Wiley and Sons, 2011)
6. Anna Mani, S Rangarajan: Handbook of Solar Radiation Data for India, (Allied Publishers, 1980)
7. Richard C Neville, RC Neville, Bas Van Der Hoek: Solar Energy Conversion: The Solar Cell (Elsevier Science & Technology, 1995)
8. Peter Würfel : Physics of Solar Cells: From Basic Principles to Advanced Concepts (Wiley-VCH, 2009)
9. JF Kreider and F Kreith: Solar Heating and Cooling: Active and Passive Design (Hemisphere Publishing Corporation, 1982)
10. Low Temperature Engineering Application of Solar Energy, ed. RC Jordan (ASHRAE, 2004)
11. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications (Tata McGraw Hill, 1997)
12. AB Meinel & MP Meinel: Applied Solar Energy: An Introduction (Addison)1976
13. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition (John Wiley & Sons, 2013)
14. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)

Additional information (if any)

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Dr. O S Sastry, Consultant, ISA, NISE Campus, Gurgaon
2. Dr. A K Saxena, Addl. GM & Head, BHEL Gwalpahari
3. Prof. J K Nayak, IIT Bombay
4. Mr. S K Singh, DG-NISE, Gurgaon

Course title: Wind, Small Hydro and RE Hybrid Systems			
Course code:	**No. of credits**: 2	**L-T-P**: 22-6-0	**Learning hours**: 28
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Dr. Jami Hossain		**Course instructor**: Dr. Jami Hossain	
Contact details: jami.hossain@teriuniversity.ac.in			
Course type: Core		**Course offered in**: Semester 2	

Course description

This course on wind, small hydro and RE hybrid systems introduces technologies and related engineering associated with implementation of onshore and offshore wind farms with modern wind turbines from an applied industry and project implementation perspective. Small hydro, micro-hydro RE hybrid projects are also discussed. The course intends to provide the students with a high level of practical understanding of these technologies and projects.

Course objective

- To impart practical knowledge and insights on implementation of wind projects with modern wind turbines
- To understand the functioning of small hydro projects
- To impart knowledge on design, system integration and planning of RE hybrid systems.

Course contents

Module	Topic	L	T	P
1	Wind technologies Modern wind turbine, is working, trends in evolution and worldwide development Different types of wind turbines Transport, logistics, assembly and installation of wind turbines Offshore wind turbines Considerations in offshore Wind turbine manufacturing Grid connection	10	2	0
2	RE hybrid systems Wind and Solar hybrids, considerations on design and optimization. Different types of hybrids. Design of Wind-Solar Parks Repowering	5	2	0
3	Small hydro & micro hydro General description classification of schemes, siting and economic considerations, system components: weir/intake, channel, desilting, forebay, spillway, penstock, turbine, generator, governor, control. Different types of small hydro projects	7	2	0
	Total	**22**	**6**	**0**

Evaluation criteria	
Assignments:	20%
Two Minor tests:	15% (each)
Major exam:	50%

Learning outcomes
On successful completion of this course the students will be able to:
Calculate renewable energy potentials
Translate theories into practice
Do financial analysis of renewable energy projects.

Pedagogical approach
A combination of class-room interactions, tutorials, field visits, assignments and projects.

Materials

Recommended readings

Text Books

1. VVN Kishore, "Renewable Energy Engineering and Technology – A Knowledge Compendium" ed. (TERI Press, *2008)*

Reference Books

1. Paul Gipe, " Wind energy basics: A guide to small and micro wind)", Chelsea Green Publishing, 2008)
2. Adam Harvey, Andy Brown and Priyantha Hettiarachi: Micro-Hydro Design Mannual: A Guide to Small-scale water power schemes (ITDC Publishing, 1993)
3. Godfrey Boyle, "Renewable Energy" (Atlantic Publishing Company, 2008)
4. Hnologien, "GATE", 1988

Additional information (if any):

Student responsibilities
Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Sanjay Chaturvedi, COO, Sembcorp
2. Dr. V V N Kishore, Retired Professor from TERI, Pune

Course title: Biomass and Other Renewable Technologies			
Course code:	**No. of credits**: 3	**L-T-P**: 42-0-0	**Learning hours**: 42
Pre-requisite course code and title (if any): None			
Department Energy and Environment			
Course coordinator: Dr. Priyanka Kaushal		**Course instructor**: Dr. Priyanka Kaushal	
Contact details: priyanka.kaushal@teriuniversity.ac.in			

Course type: Core	**Course offered in**: Semester 2

Course description

This course is designed to make the students conversant mainly with various Biomasses to energy technologies. Other RE technologies, such as geothermal energy, tidal energy, wave energy and ocean thermal energy conversion will also be covered. The main topics covered are: biomass conversion technologies (both thermo-chemical and bio-chemical methods of conversion) and liquid bio fuels. Basic principles of the technologies, experience gained on the ground, levels of commercialization, challenges of integrating with conventional energy/power system are covered.

Course objectives

- To develop understanding the various route to generate energy from biomass and other renewable resources
- To calculate energy production potential; energy content in various resources.
- To identify challenges and strength of various energy convention technologies

Course contents

Module	**Topic**	**L**	**T**	**P**
1	Biomass Technology: Thermo-chemical conversion Thermo-chemical conversion of biomass, biomass processing, briquetting, pelletisation, biomass stoves, biomass carbonization, pyrolysis of biomass, biomass gasification, gasifiers: [updraft (forced draft & Natural draft), downdraft (Open core, throat type & modular)], Gasifier stoves, gasifier thermal applications, gasifier engine applications: dual fuel and 100% gas mode operation, power generation systems: (decentralized, grid interactive).	14	0	0
2	Biomass Technology: Bio-chemical conversion Aerobic and anaerobic processes, activated sludge process, plug flow reactors, anaerobic fixed film reactor, UASB reactor, anaerobic fluidized bed reactor, estimation of methane yield, anaerobic digestion system for MSW, Vermi-composting, different designs of biogas plants for animal waste, Biogas engine applications.	10	0	0
3	Liquid Bio Fuels Liquid biofuels, non-edible oilseeds, oil extraction, preprocessing, transesterification, biodiesel, characterization of liquid fuels, production of syngas from biomass, production of methanol from syngas, production of ethanol from ligno-cellulosic biomass, Liquid bio-fuel applications.	10	0	0
4	Other Renewable Energy Technologies Geothermal, wave energy, tidal energy, ocean thermal energy.	4	0	0
5	Case Study India specific and global context	4	0	0
	Total	**42**	**0**	**0**

Evaluation criteria

- Assignments: 20%
- Two minor tests: 15% (each)
- Major exam: 50%

Learning outcomes

On successful completion of this course the students will be able to:

Calculate Bioenergy and Other Renewable energy potentials
Identify the best solution
Quantify the amount of Energy produced
Translate theories into practice

Pedagogical approach

A combination of class-room interactions, tutorials, field visits, assignments and projects.

Materials

Recommended readings

Text Books

1. VVN Kishore, "Renewable Energy Engineering and Technology – A Knowledge Compendium", ed. (TERI Press, *2008*).

Reference Books

1. Donald Klass, "Biomass for Renewable Energy, Fuels, and Chemicals", (Entech International Inc., USA)
2. Godfrey Boyle, "Renewable Energy", (Atlantic Publishing Company, 2008)
3. Thomas Read & Agua das, "Handbook of biomass downdraft gasifier engine systems" (The Biomass Energy foundation Press, 1988)
4. Klaus von Mitzlaff, "Engines for Biogas – Theory, Modification, Economic Operation" (Deutsche Gesellschaft fur Entwicklungstechnologien GATE, 1988)

Additional information (if any):

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Prof. T S Bhatti, Professor, Centre for Energy Studies, IIT Delhi
2. Dr. P. Basu, Director & Professor, Dept. of Mechanical Engineering, Dalhousie University, Canada

Course title: Renewable Energy Policy and Regulations			
Course code: ENR 138	**No. of credits:** 3	**L-T-P:** 16-20-26	**Learning hours:** 42

Pre-requisite course code and title (if any): NA	
Department: Department of Energy and Environment	
Course coordinator: Prof. Jami Hossain	**Course instructor:** Prof Jami Hossain/Dr Naqui Anwer/Dr Atul Kumar
Contact details:	
Course type: Core	**Course offered in:** Semester 2

Course description:

The course is meant to comprehensively impart knowledge on the overall policy and regulatory environment governing renewable energy development in the country. The students will also be sensitized to emergent trends competitive bidding in Solar and Wind based capacity addition.

The course will cover national and state policies, regulatory and legislative frameworks on Renewable Energy. Some of these policies and guidelines emanate from an overarching Act such as the Electricity Act or another overarching policy such as the National Climate Change Policy. The policies, regulations and guidelines determine electricity off-take approaches, tariffs, control period and even technical requirements like maintenance of grid frequency in a certain band etc. It is also important to have an understanding of the institutional architecture that enables implementation of the policies and regulation as much as the policies in force.

The course will present a policy and regulatory framework for renewable energy as it is practiced in India. However, similar frameworks either exist in other developing countries or certain elements can be adopted in other countries as well.

Course objectives

1. To impart knowledge on the overall policy, regulatory and institutional framework on Renewable Energy
2. To provide understanding of the main drivers that influence Renewable Energy policy formulation
3. To provide insights on emergent policy trends with regard to procurement of renewable energy
4.

Course contents

Module	Topic	L	T	P
1	**Introduction to policy parameters, regulatory bodies** Introduction to overall policy environment on energy sector and the parameters that drive policy formulation such as – per capita electricity Consumption, % electrification, GDP, total installed capacity, generation mix and the overall power sector structure, Entities – Consumers and their tariffs, generator, DISCOM, Regulators- CERC & SERC, Statutory bodies, SLDC, RLDC, NLDC, CTU, STU, CEA Typical issues of Indian power sector – Cross Subsidization, Theft of electricity, Transmission losses etc.	4	2	0
2	**Indian energy Policy** An Introduction to Indian Energy Policy, Electricity Act, National	8	6	0

	Tariff Policy, National Action Plan on Climate Change , National RE Policy, National Solar Missions, Wind Power, Regulatory Commissions, Grid Code, Green Corridor, Solar Parks, Hybrid Parks, Repowering, Offshore, Scheduling and Forecasting, Electricity Trading, Offtake through Energy Exchange, Open Access, RPO Distributed Generation Regional Grid in the South Asian Region. Electrification and off grid status/scenario in India Scenario evolving with competitive bidding			
3	**National grid, small grid and off grid policies** Scope and challenges in implementing off grid solutions Policy & regulatory Framework for rural electrification Micro and Mini grids Relevant policies and frameworks in other countries Recent off grid programs started by Govt. of India for enhancing the rural electrification through off-grid solutions DDG scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) Remote Village Electrification Program Village Energy Security Programme (VESP) Off grid programme under JNNSM	4	2	0
4	**Seminar** For this part of the course the students can take up a case study and analyse its Policy framework, outcomes, advantages/disadvantages. Few of the case studies which students can take up are given in the reference list		10	0
5	**Simulation Lab/ Project** 1. In this, the students can familiarise themselves with methods of computing net tariff after accounting for Deviation settlement under forecasting and scheduling and working with open access charges in inter-state and intra-state 2. Tariff computation as per CERC guidelines			26
	Total	16	20	26

Evaluation criteria:

Assignment/Lab : 50%
Minor test : 20%
Major exam : 30%

Learning outcomes:

Enhanced understanding of renewable energy policy environment
Sound understanding of the institutional frameworks w.r.t. Renewable Energy
Sound understanding of policy frame work for grid connected and off grid renewable energy

Pedagogical approach:

A combination of class-room interactions, tutorials, assignments and projects.

Materials:

Recommended readings

Reading Material:

P R Krithika and Siddha Mahajan, Background paper: Governance of renewable energy in India: Issues and challenges

http://www.teriin.org/projects/nfa/pdf/working-paper-14-Governance-of-renewable-energy-in-India-Issues-challenges.pdf

ÇSE Presentation : Renewable Energy in India: Growth and Targets

http://cseindia.org/docs/photogallery/ifs/Renewable%20Energy%20in%20India%20Growth%20and%20Targets.pdf

Charles K Ebinger, India's Energy and Climate Policy Can India Meet the Challenge of Industrialization and Climate Change?

https://www.brookings.edu/wp-content/uploads/2016/07/india_energy_climate_policy_ebinger.pdf

Megha Kaladharan, Renewable Energy in India: An Analysis of the Regulatory Environment and Evolving Policy Trends. (www.cprindia.org)

CEA : Draft Natioanl Electricity Plan 2016

http://www.cea.nic.in/reports/committee/nep/nep_dec.pdf

Gisele Schmid, The development of renewable energy power in India: which policies have been effective?

https://unige.ch/gsem/iee/files/3313/9574/8551/11103_v2.pdf

References

1. Electricity Act 2003
2. CERC Regulation on Renewable Energy
3. Comparative Study on Rural Electrification Policies in Emerging Economies: Keys To Successful Policies; International Energy Agency

4. Best practices of the Alliance for Rural Electrification: what renewable energy can achieve in developing countries; Alliance for Rural Electrification
5. Gokak Committee Report on DDG & Report on the Working Group on Power for Eleventh Plan (2007-12)

Journals and Magazines

1. The Zambian ESCO project
2. Sunlight Power Maroc (Morocco)
3. Solar Energy Supplies in Zimbabwe
4. Off grid solutions applied in various parts of India (e.g. LaBL- SMU, NTPC DDG, VESP, DESI Power, Husk Power, etc)
5. Case study - Qualified Third Party Model of Philippines
6. SHP in Nepal and Sri Lanka
7. IDCOL/Grammen Shakti model in Bangladesh
8. Solar PV and SHP 'fee for service' model in Laos PDR
9. SHP/Pico hydro in China and Vietnam
10. Gansu Pilot project (China)

Additional information (if any): NA

Student responsibilities:
Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Mr. Chintan Shah, Suzlon
2. Mr. Dheeraj Jain, Regen
3. Dr. Jethani, MNRE

Course title: Optimization Techniques for Energy Management and Planning			
Course code ENR xxx	**No. of credits:** 3	**L-T-P:** 32-10-0	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Faculty: Dr Atul Kumar		**Department:** Energy and Environment	
Course coordinator (s): Dr Atul Kumar		**Course instructor (s):** Dr Atul Kumar	
Contact details			
Course type: Core			
Course offered in: Semester 2			
Course Description This Course imparts knowledge on optimization techniques and methods that are used in planning and operation of an energy system or a power system. Optimization techniques can be used not only for long-term planning but also for immediate operation. Given that power systems have embedded in them, diverse generation sources including renewable energy and also renewable energy fluctuates			

over different time horizons, in the operation of such a power system, it becomes important to arrive at an optimal configuration during real time operation.

Course objectives

- Use techniques to assess energy demand for various sectors
- Examine various optimization techniques used for satisfying energy demand to various sectors
- Provide exposure to numerous problems of energy sector where reliability and other technical criterial should be met and costs minimized.

Course content

Module	Topic	L	T	P
1	**Probability theory** The nature of random variables: populations and samples, parameters and statistics. Probability concepts; properties of random variables, probability distribution functions	4	1	0
2	**Demand analysis and forecasting** Drivers of energy demand, Sectoral energy demand: - domestic, commercial, industrial, agricultural. Projections for future demands.	4	1	0
3	**Introduction to optimization** Problem formulation: decision variables, objective function, maxima, minima, constraints. Analysis techniques: simulation, optimization, stochastic optimization, metaheuristics and intelligent techniques	4	0	0
4	**Linear programming and application** Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis. Example and case study	6	2	0
5	**Dynamic programming and application** Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming. Optimal energy resource, Power generation expansion planning, case study	6	2	0
6	Integer Programming, Nonlinear programming and their application Integer programming solution algorithm, Nonlinear Unit commitment and dispatch problem Optimal technology mix in micro and macro level energy planning. Nonlinear programming and its application	6	2	0
6	Multi objective optimization Introduction, non-inferior solutions, trade off analysis, weighted and constraints method	2	0	0
		32	**8**	**0**

Evaluation criteria

- **Minor test 1: 15%**
- **Minor test 2: 15%**

- **Assignment/Tutorials: 20%**
- **Major test: 50%**

Learning outcomes

After completing this course, students would be able to:

- Define and use optimization terminology and concepts
- Apply optimization methods for energy system planning, including developing a model, defining an optimization problem, applying optimization methods, exploring the solution, and interpreting results.
- Explain methods for power system planning and operation: Least-cost planning, integrated planning of resources

Pedagogical approach

The course will be delivered through class room lectures. Relevant case studies shall be discussed in class so that students are introduced to the latest stage of development in the subject. Endeavour shall be made to introduce software packages in the class through demonstrations. The students would be encouraged to utilise on open source software.

Materials

Textbooks

Taha, H. A. (2007). *Operations Research—An Introduction*. Prentice Hall of India. New Delhi.
Vohra, N. D. (2006). *Quantitative Techniques in Management, 3e*. Tata McGraw-Hill Education.
Rardin, R. L. (1998). *Optimization in operations research*. Upper Saddle River, NJ: Prentice Hall.
Dhillon, J. S., and Kothari, D. P. (2010). *Power system optimization*. Preintce Hall of India Private Limited.
Ayyub B.M. and McCuen R.H. (2011). *Probability, Statistics and Reliability for Engineers and Scientists*. CRC Press, Boca Raton.
Kottegoda N.T. and Rosso R. (2008). *Applied Statistics for Civil and Environmental Engineers*, McGraw-Hill, International Edition.

Suggested readings

Parikh, J. K. (1997). *Energy models for 2000 and beyond*. Tata McGraw-Hill.
ETSAP, IEA. "MARKAL home page." *URL: http://www. etsap. org/Tools/MARKAL. htm*.
Loulou, R., Goldstein, G., & Noble, K. (2004). *Documentation for the MARKAL Family of Models*, ETSAP.
Loulou, R., & Labriet, M. (2008). *ETSAP-TIAM: the TIMES integrated assessment model Part I: Model structure*. Computational Management Science, 5(1), 7-40.
Loulou, R., Remme, U., Kanudia, A., Lehtila, A., & Goldstein, G. (2005). *Documentation for the TIMES Model Part II*. Energy technology systems analysis programme (ETSAP).
Berthouex P.M. and Brown L.C. (1994). *Statistics for Environmental Engineers*, Lewis Publishers, CRC Press.
Bryman, A. (2008). *Social Research Methods.* Oxford University Press.

Journals

Applied Energy
Computational Management Science
Energy Policy
Energy Economics
Energy
IEEE transactions on power systems

International Journal of Electrical Power & Energy Systems
Additional information (if any)
Student responsibilities The course is highly technical and latest state of the art techniques shall be used, so attendance and class participation will be given utmost importance. All assignments should be submitted as per the timeline. Students will be expected to take up typical energy and power demand problems and use optimization techniques to solve such problems.

Course reviewers

1. Professor Amit Garg, Indian Institute of Management (IIM), Ahmadabad
2. Dr Ashu Verma, Centre for Energy Studies, Indian Institute of Technology (IIT Delhi)

Course title: Renewable Energy Project Management			
Course code:	**No. of credits**: 3	**L-T-P**: 34-08-00	**Learning hours**: 42
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator: Dr. Atul Kumar		**Course instructor(s)**: Dr. Atul Kumar	
Contact details: atulk@teri.res.in			
Course type: Core		**Course offered in**: Semester 2	
Course description The course is designed for the students to prepare them for the working in various renewable energy projects right from conceptualization to delivery of energy services/electricity. Students will discover the renewable energy project life cycle and learn how to build a successful project from pre-implementation to completion. It will introduce project management topics such as resources, costs, time constraints and project scopes.			
Course objectives Understand and articulate the importance of Project Management in any renewable energy project Develop a manageable project schedule Use tools and techniques to manage a project during execution			
Course content			

Module	Topic	L	T	P
1	Introduction Definition, need/benefits, projects versus routine production, project life cycle, investigative approach, process group.	2	0	0
2	Planning Project planning matrix, aim oriented project planning, generation and screening of project ideas, capital budgeting, criteria and models for resource allocation	6	2	0

3	Analysis Market and demand analysis, technical analysis, financial estimates and projections, investment appraisal criteria, cost benefit analysis, risk analysis	8	4	0
4	Financing Project financing, elements and parties of financing, multilateral and bilateral financing of renewable energy project, case studies	4	0	0
5	Contract Management Contract selection, tendering, negotiation, contract preparation, Power Purchase Agreements (PPAs) contract, Engineering, Procurement, Construction (EPC) contract.	4	0	0
6	Implementation Project management, network analysis for project management-PERT, CPM and CERT, Fuzzy logic, project material management, evaluation & analysis, implementation & monitoring, performance indices, supply chain management, customer relation management	8	2	0
7	Review Control of In-Progress projects, post completion audits, abandonment analysis	2	0	0
	Total	**34**	**8**	**0**

Evaluation criteria

- **Minor test 1: 15%**
- **Minor test 2: 15%**
- **Assignment/Tutorials: 20%**
- **Major test: 50%**

Learning outcomes

After completing this course, students would be able to:

Describe a renewable energy project life cycle, and can skillfully map each stage in the cycle
Identify the resources needed for each stage, including tools and supplementary materials
Describe the time needed to successfully complete a renewable energy project, considering factors such as task dependencies and task lengths
Demonstrate effective project execution and control techniques that result in successful projects.

Pedagogical approach

The course will be delivered through class room lectures. Relevant case studies shall be discussed in class so that students are introduced to the latest stage of development in the subject.

Materials

Textbooks

1. Prasanna, C. (2008). Projects, Planning, Analysis, Selection, Financing, Implementation and Review. Tata McGraw-Hill Publishing Company Limited.
2. Finnerty, J. D. (2013). Project financing: Asset-based financial engineering. John Wiley & Sons.
3. Frigenti, E., & Comninos, D. (2002). The Practice of Project Management: a guide to the business-focused approach. Kogan Page Publishers.
4. Lewis, J. P. (2002). Fundamentals of project management: developing core competencies to help outperform the competition. AMACOM Div American Mgmt Assn.
5. Scott, B. (2005). The Art of Project Management. *California USA. O'Relly Media Inc*.

Suggested readings

1. *Andrew S. and Jennifer G. (2005) Applied Software Project Management, Cambridge, MA, O'Reilly Media.*
2. *Gary H. (2001) Project Management (The Briefcase Book Series), McGraw-Hill.*
3. *Harold K. (2003) Project Management: A Systems Approach to Planning, Scheduling and Controlling, 8th Ed., Wiley.*
4. *Jack R.M. and Samuel J.M. (2002) Project Management: A Managerial Approach, 5th ed., Wiley.*
5. *James L. (2002) Fundamentals of Project Management, 2nd ed., American Management Association.*
6. *Project Management Institute (2003) A Guide To The Project Management Body of Knowledge, 3rd ed., Project Management Institute.*

Journals

Project Management Journal
International Journal of Project Management

Other

Flyvbjerg, B. (2006). From Nobel Prize to project management: getting risks right. *Project Management Journal*, 37(3): 5–15.

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course reviewers

1. Professor Jyotirmay Mathur, Centre for Energy & Environment Malaviya National Institute of Technology Jaipur
2. Professor Vijay Prakash Ojha, Institute of Management Technology (IMT), Ghaziabad

Course title: Energy Lab – II			
Course code:	**No. of credits**: 3	**L-T-P**: 11-0-62	**Learning hours**: 42
Pre-requisite course code and title (if any):			
Department: Energy and Environment			
Course coordinator: Dr. Atul Kumar	**Course instructor(s)**: Dr. Priyanka Kaushal/ Dr. Naqui Anwer/ Dr. Jami Hossain/ Dr. Som Mondal/ Dr. Atul Kumar		
Contact details: atulk@teri.res.in			
Course type: Core	**Course offered in**: Semester 2		

Course description

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.

Course objectives

The aim of Energy Laboratory II is to ground the analytical subject material in a practical problem, meaning that the skills and knowledge students learn throughout the programme will be applied in real renewable energy engineering work.

Module	**Topic**	**L**	**T**	**P**
1	Solar radiation measurement Measurement of total and diffuse solar radiation on a horizontal surface and comparison of computed values of total solar radiation on an inclined plane with experimental measured value	1	0	3
2	Box type solar cooker Thermal testing of a box type solar cooker: Determination of first and second figure of merit To determine the top heat loss factor of a box type solar cooker	1	0	6
3	Paraboloid concentrator solar cooker Cooling test on paraboloid concentrator solar cooker to determine its $F'U_L$ Heating test on paraboloid concentrator solar cooker to determine its $F'\eta 0$	1	0	6
4	Solar thermal collector and storage Determination of heat loss factor $F'U_L$ of linear solar absorber Estimation of energy storage by phase change material	1	0	6
5	Solar PV module characterization Dark and illuminated I-V characterization and spectral response of solar cells. I-V and P-V characteristics of PV modules under simulator and field	1	0	5

	radiation and temperature condition			
6	Power flow calculation for a stand-alone PV Power flow calculation for a stand-alone PV system with DC load and a battery Power flow calculation of stand- alone PV system with AC load and a battery Power flow calculation of stand-alone PV system with DC & AC load battery	1	0	4
7	Battery and Inverter performance analysis Charging and discharging characteristics of a battery Performance analysis of inverter	1	0	4
8	Biomass for energy (Combustion Lab) Estimation of volatile matter and fixed carbon in biomass Estimation of calorific value of solid fuels Energy and environment performance testing of cook stove: Water Boiling Test (WBT) and Kitchen Performance Test (KTP)	2	0	16
9	Wind energy convertor Determination of cut-in speed of wind turbine Determination of Tip Speed Ratio (TSR) at different wind speeds Determination of coefficient of performance of wind turbine Evaluation of power curves	1	0	6
10	Performance evaluation of Solar PV Wind Hybrid System with DC/AC micro-grid Study of system performance (a) with change in wind speed/pitch angle, and (b) with change in irradiance Study of integration of DC micro-grid to the main AC grid using 3-phase inverter Power flow control in DC micro-grid for various loading	1	0	6
	Total	**11**	**0**	**62**

Evaluation criteria

- Practical Records: 20%
- Viva voce: 30%
- Continuous evaluation: 50%

Learning outcomes

After completing this course, students would be able to:

Measure solar radiations and test the performance of different solar thermal applications
Characterize solar cells and analyse different parameters such as power flow, efficiency of different components such PV module, battery, inverter and PV system
Characterize the properties of solid biofuels along with performance testing of cook stove
Analyse the performance of wind energy converter and hybrid systems with DC and AC micro-

grids.
Pedagogical approach Students complete a procedure given in the laboratory manual to determine the behaviour of the equipments/prototypes/experimental set ups and produce the expected characteristics.
Materials 1. Garg, H. P., and Kandpal, T. C. (1999). *Laboratory manual on solar thermal experiments.* Narosa Publishing House, New Delhi. (self-study) 2. Doebelin, E.O. 2004. *Measurement Systems Application and Design*, 5th ed. McGraw-Hill, New York. (self-study) 3. D.P.Kothari and D.K.Sharma (2000), *Energy Engineering: Theory and Practice*. S. Chand Publisher, New Delhi. (self-study) 4. http://cleancookstoves.org/technology-and-fuels/testing/protocols.html
Additional information (if any)
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Professor S. K. Samdarshi, Centre for Energy Engineering, Central University of Jharkhand, Ranchi
2. Dr. S. K. Tyagi, Centre for Energy Studies, Indian Institute of Technology Delhi

Course title: Fluid Mechanics and Wind Turbine Models			
Course code:	**No. of credits**: 3	**L-T-P**: 28-14-0	**Learning hours**: 42
Pre-requisite course code and title (if any): None			
Department: Energy and Environment			
Course coordinator: Dr. Jami Hossain		**Course instructor**: Dr. Jami Hossain	
Contact details: jami.hossain@teriuniversity.ac.in			
Course type: Elective		**Course offered in**: Semester 2	
Course description The course is about fundamental concepts of fluid flow, fluid kinematics and fluid dynamics and its application to design aspects of wind turbines. The course also carries a description on system design and Wind Turbine Sub-systems			
Course objective ▪ The aim of this core course is to impart knowledge on the fundamentals of fluid flow to the			

student and to apply these concepts to design aspects of wind turbines ▪ To impart knowledge on different Engineering Systems associated with a wind turbine				
Course contents				
Module	**Topic**	**L**	**T**	**P**
1	Physics of Fluid Flow Shear stain and stress Classification of fluids on the basis of flow System and control volume Fluid properties, fluid statistics Fluids in rigid-body motion Fluid kinematics Reynolds transport theorem Mass, Bernoulli and energy equations Energy analysis of steady flows Conservation of momentum Linear momentum equation, angular momentum equation Differential analysis and modellilng Continuity equation, divergence theorem Stream function, Navier-stokes equation and its approximate solutions	8	4	0
2	Boundary Layer Theory Similarity theory Surface roughness Power law, modified power law, logarithmic laws	4	2	0
3	Fundamentals of Aerodynamics Drag and lift, friction and pressure drag Flow separation, parallel flow over flat plates, flow over cylinders and spheres Aerofoils and Aerofoil Terminology	4	2	0
4	Aerodynamics in Wind Turbines HAWT Momentum theory Blade element theory Coefficient of performance BETZ limit Axial flow Wake Rotor design/ blade design/ structure Loads / forces and mechanics, gyroscopic motion Thrust Power curve VAWT	6	3	0

5	Wind Turbine Sub – Systems *Mech Transmission:* Hub, Shafts, Bearings, Gear Box, Torque Converter *Generation Systems:* Induction, Synchronous, DFIG, Variable Speed, PMG, Ring Generators Power Regulation Power Electronics – IGBT, Thyristors etc. Controls & Instrumentation Grid Connection	6	3	0
	Total	**28**	**14**	**0**

Evaluation criteria

- Assignments 10%
- Two Minor tests 20% (each)
- Major exam 50%

Learning outcomes

- Understand and apply laws of fluid mechanics
- Application of these laws to wind turbine design
- Gain understanding of the environment in which WTG functions (Boundary Layer)
- Systems and Sub-systems of wind turbines

Pedagogical approach

A combination of class-room interactions, tutorials, assignments and projects.

Materials

Suggested readings

1. YA Cengel and JM Cimbala, "Fluid Mechanics: Fundamentals and Applications", Tata McGraw Hill
2. Manwell et. "Wind Energy Explained: Theory Design and Application" Al Wind Energy Handbook by Burton et. Al

Additional information (if any):

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Dr. Rajesh Katyal, DDG, NIWE
2. Prof. Tanay Uyar, Marmara University, Istanbul

Course title: Applied Numerical Methods			
Course code: ENR 172	**No. of credits**: 3	**L-T-P**: 22-10-20	**Learning hours**: 42
Pre-requisite course code and title (if any): None			

Department: Energy and Environment	
Course coordinator: Dr. Som Mondal	**Course instructor:** Dr. Som Mondal
Contact details: som.mondal@teriuniversity.ac.in	
Course type: Elective	**Course offered in**: Semester 2

Course description

This course is designed for application of numerical methods in solving problems related to renewable energy technologies. The course starts with introduction of numerical methods and its applicability in renewable technologies with an introduction to basic computation using MATLAB. It covers the concepts of solution techniques of linear and non-linear equations and systems of equations. In module 3, differentiation and integration using numerical methods are covered. Application of different initial value and boundary value problems in renewable energy using finite difference method is taught in module 4. An introduction to solution of partial differential equation and finite element method is also covered. Computational practical problem solving is an integral part of the course.

Course objective

The objective of the course is to prepare students with knowledge of numerical methods which may be applied to solve complex problems in renewable energy field.

Course contents

Module	Topic	L	T	P
1	**Introduction** Application of numerical methods in renewable energy Introduction to various softwares, their capabilities, limitation and tools, basic computation process	2	0	0
2	Linear equation and non-linear equations Linear algebraic equations and matrices Gauss elimination, LU-factorization, matrix inverse and condition, Eigen value problems, Iterative methods, Convergence and accuracy of iterative methods Solution of non-linear equations: Regula-Falsi method, Fixed-point Iteration, Newton-Raphson Method, Order of Convergence Solution of system of non-linear equations Case study	8	2	6
3	Numerical differentiation and integration Numerical differentiation: high-accuracy differentiation formulas, first order and second order differentiation, derivatives of unequally spaced data, derivatives for data with errors, partial derivatives Numerical integration: numerical integration formulas, numerical integration of functions, integrals for data with errors	4	2	4
4	Solution of ordinary differential equation (ODE) Implicit & explicit Finite-Difference Method (FDM), FDM for Initial Value ODE, Modified Euler Method; Runge-Kutta Method, Multi-point Methods	8	6	10

	Boundary Value-ODE, Dirichlet and Neuman boundary conditions Solution of second order partial differential equations: elliptic and parabolic equations Case studies			
	Total	**22**	**10**	**20**

Evaluation criteria

- Assignments: 20%
- Two Minor tests: 15% (each)
- Major exam: 50%

Learning outcomes

- To formulate engineering problems and develop algorithm for numerical solution.
- Understand and identify the right numerical methods for solution.
- Solve the problems using software like MATLAB, PYTHON etc.

Pedagogical approach

A combination of class-room interactions, practical, tutorials and assignments.

Materials

Recommended readings

1. Chapra, S.C., "Applied Numerical Methods with MATLAB", Tata McGraw Hill, New Delhi, 2007
2. Chapra, S.C. and Canale, R.P., "Numerical methods for Engineers", Tata McGraw Hill, New Delhi, 2007
3. Jain, M.K., Iyenger, S.R.K. and Jian, R.K., "Numerical Methods for Scientific and Engineering Computation, New Age International ltd", New Delhi, 2008
4. Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons Inc, India, 1999
5. Saumyen Guha and Rajesh Srivastava, "Numerical Methods for Engineering and Science", Oxford Higher Education, 2010
6. Joe D. Hoffman, "Numerical Methods for Engineers and Scientists", Second Edition, Taylor and Francis, USA, 2001

Additional information (if any):

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Dr. Sumit Basu, Professor, Mechanical Engineering, Indian Institute of Technology Kanpur
2. Dr. Suresh A. Kartha, Associate Professor, Civil Engineering, Indian Institute of Technology Guwahati

Annexure 6

M.Sc. Climate Science and Policy

Annexures I: Bridge Courses

1. Applied Mathematics

Course title: Applied mathematics			
Course code: NRC	**No. of credits:** 1[eq]	**L-T-P:** 8-6-0	**Learning hours:** 10
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s):		**Course instructor(s):**	
Contact details:			
Course type: Bridge course		**Course offered in:** Semester 1	

Course description

The course is designed to serve as a foundation course even for students with no prior mathematical experience in higher education in order to meet the requirement of mathematical knowledge in various subsequent courses offered in the master's degree program. The course will introduce the students to fundamentals of mathematics applicable to climate science.

Course objective

- Is to introduce basic Numeric method approach

Course contents

Module	**Topic**	L	T	P
1.	Differential calculus: Relations and functions, limits and continuity, derivatives and differentiation, applications of differential calculus. Differential equations: Ordinary differential equations, partial differential equations, applications	**2**	**3**	
2.	Integral calculus: Indefinite integrals, methods of integration– integration by substitution, by parts, decomposition into sums etc, applications. Definite integrals, theorems of definite integrals and evaluation of definite integrals, applications. Introduction of differential equations and its applications.	**2**	**3**	
		4	**6**	**0**

Evaluation criteria

- 2 minor test: 50% each

Learning outcomes

- Understanding of basic concepts of mathematics applicable to climate science

Pedagogical approach

Classroom teaching and assignments

Materials Mackenzie A. (2005) Mathematics and Statistics for Life Scientists, Taylor & Francis, New York. Parkhurst D.F. (2006) Introduction to Applied Mathematics for Environmental Science, Springer, New York. **Textbooks** **Journals** **Suggested readings** Prasad G. (2004) Differential Calculus, Pothishala Pvt. Ltd., Allahabad Prasad G. (2004) Integral Calculus, Pothishala Pvt. Ltd., Allahabad
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr. Phil Walker, Director of Student Education in Mathematics at the University of Leeds, United Kingdom.
2. Young-suk Jang, Maths Analyst, Seattle.

2. Basic Computer Programming

Course title: Basic computer programming			
Course code: NRC	**No. of credits:** 1^{eq}	**L-T-P:** 2-2-12	**Learning hours**: 10
Pre-requisite course code and title (if any): None			
Department: Department of Energy and Environment			
Course coordinator(s): Ms Pooja Chaudhary	**Course instructor(s):** Ms Pooja Chaudhary		
Contact details:			
Course type: Optional Audit	**Course offered in:** Semester 1 as bridge course		

Course description

The course aims to teach basic programming and computational concepts to students with little or no previous coding experience. It will introduces basic computer programming and problem solving in structured program logic environment. After the course, students will develop confidence in their ability to apply programming techniques to problems especially with respect to climate modelling.

Course objectives

- The main objective of the course to build foundation for Climate modelling course which will be offered in subsequent semester.

Course contents

Module	Topic	L	T	P

1	Course Outline I. Introduction to Computers and Programming a) Hardware and Software b) Number System, Programs and Data	1	1	
2	II. Input, Processing, and Output a) Designing a Program b) Input, Output, and Variables c) Variable Assignment and Calculations d) Variable Declarations and Data Types e) Named Constants f) Hand Tracing a Program g) Documenting a Program	1	1	
3	III. Modules a) Introduction to Modules b) Defining and Calling a Module c) Passing Arguments to Modules d) Local Variables, Global Variables and Global Constants			2
4	IV. Decision Structures and Boolean Logic a) Introduction to Decision Structures b) Dual Alternative Decision Structures c) Comparing Strings d) Nested Decision Structures e) The Case Structure f) Logical Operators g) Boolean Variables			2
5	V. Repetition Structures a) Introduction to Repetition Structures b) Condition-Controlled Loops: While, Do-While, and Do-Until c) Count-Controlled Loops and the For Statement f) Nested Loops			2
6	VI. Functions a) Introduction to Functions b) Writing Your Own Functions c) More Library Functions			2
7	VII. Arrays a) Array Basics b) Sequentially Searching an Array c) Processing the Contents of an Array e) Two-Dimensional Arrays			2
		2	**2**	**12**

Evaluation criteria

Course grades will be based on the following criteria:

- Assignments and final practical examination: 50% each

Learning outcomes

Upon completion of the course, students would be able to: ▪ Upon successful completion of this course, the student will be able to: ▪ Describe the major components in problem solving for a computer program. ▪ Apply top-down concepts in algorithm design. ▪ Create flowcharts to illustrate program algorithm or process. ▪ Analyze and write pseudocode to illustrate compact and informal high-level descriptions of computer programming algorithms. ▪ Define variables, Loops and arrays used in program methodology. ▪ Implement input and output to access and process files. ▪ Describe and apply object-oriented programming methodology.
Pedagogical approach Tutorial and practical
Materials **Suggested Readings** Gelernter D. and Jagannathan S. (1990) Programming Linguistics, The MIT Press. Goldschlager L. (1998) A Lister Computer Science - A Modern Introduction Prentice Hall. John C.M. (2002) Concepts in Programming Languages, Cambridge University Press.
Additional information (if any) This course has practical methodology to orient students towards learning basics of programming.
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Mr Jagdish Mutharia, IT Division, TERI, New Delhi.
2. Mr Sanjay Kumar IT consultancy, Gurgaon, Haryana.

3. Basic Course in Economics

Course title: Basic course in economics			
Course code:	**No. of credits:** 1^{eq}	**L-T-P:** 10-0-0	**Learning hours:** 10
Pre-requisite course code and title (if any): Familiarity with the mathematics at CBSE/ISC +2 Level			
Department: Department of Energy and Environment			
Course coordinator(s):	**Course instructor(s): Nirupam Datta**		
Contact details:			
Course type: Elective	**Course offered in:** Semester 1 bridge course		
Course description This course gives a general orientation to the students on basic concepts of economics to students who do not have a background in this subject. It will introduce the students to the existing economic theories and market mechanisms. After the course the student will be able to appreciate the microeconomic principles behind consumer, producer and market behavior enabling him/her to pursue courses that require basic understanding of microeconomic theory.			

Course objective

- The course encompasses basic topics in producer and consumer theory and different market forms in economics.

Course content

Module	Topic	L	T	P
1.	**Basics of Consumer Theory** Budget Constraint, Preferences, Utility, Choice, Demand, Revealed Preference, Slutsky Equation, Consumer's Surplus, Market Demand, Equilibrium	5	0	0
2.	**Basics of Producer Theory** Technology, Profit Maximisation, Cost Minimisation, Cost Curves	2	0	0
3.	**Basics of Market Forms** Firm Supply, Industry Supply, Monopoly, Monopoly Behaviour, Factor Markets, Oligopoly	3	0	0
	Total	**10**	**0**	**0**

Evaluation criteria

- End-Term: 100%

Learning outcomes

Pedagogical approach

Classroom teaching will involve black board, building up on basic concepts.

Materials

Textbooks (Tentative)

- 1. Varian Hal R. (2014) *Intermediate Microeconomics*, W. W. Norton Company.

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr. Sarthak Gaurav, Assistant Professor, SJMSOM, IIT Mumbai.
2. Dr. Thiagu Ranganathan, Assistant Professor, IIM Nagpur.

Annexures II: Semester 1 Courses

1. Earth System Sciences

Course title: Earth system sciences			
Course code:	**No. of credits**: 3	**L-T-P**: 42-0-0	**Learning hours**:42
Pre-requisite course code and title (if any): None			
Department: Department of Energy and Environment			
Course coordinator(s): Dr. Chubamenla Jamir	**Course instructor(s):** Dr. Chubamenla Jamir		
Contact details: chubamenla.jamir@teriuniversity.ac.in			

Course type: Compulsory Core	**Course offered in**: Semester 1

Course description

The purpose of the course is to develop a holistic understanding of Earth's system. Earth System Science is inherently interdisciplinary in scope, linking oceanography, atmospheric and terrestrial sciences, climatology, hydrology, biology, physics, and chemistry to understand the environment and climate. After the course, the students will be able to appreciate the importance of taking a systemic approach in understanding the earth system and for management of different earth components, natural resources and climate.

Course objectives

- To understand the basic principles of Earth's system, its various components and the inter-linkages between these components.
- To understand how the interplay between various earth's spheres influences climate.

Course content:

Module	**Topic**	**L**	**T**	**P**
1.	Overview; Systems approach to understand and analyze environmental systems; Sustainability and challenges	2		
2.	**Ocean** Marine food and economic resources; sustainability issue; distribution of temperature and salinity; ocean currents; ocean and climate	5		
3.	**Climate** Temperature and pressure belts of the world; Heat budget of the earth; Atmospheric circulation; atmospheric stability and instability. Air masses and fronto-genesis, Temperate and tropical cyclones; Climatic regions; Global climatic change and role and response of man in climatic changes	6		
4.	**Biogeography** Genesis, classification and distribution of soils; Factors influencing world distribution of plants and animals; conservation measures; Sustainability issues.	5		
5.	**Earth dynamism** Earth's interior; Geosynclines; Plate tectonics; mountain building; Volcanicity; Earthquakes and Tsunamis, management of natural disasters.	4		
6.	**Human population** Growth and distribution of world population; demographic attributes; concepts of over-under-and optimum population; Population theories, Regional planning and planning for sustainable development.	5		
7.	**India's environmental setting** Structure and relief; Drainage system and watersheds; Mechanism of Indian monsoons and rainfall patterns, Floods and droughts; Climatic regions; Soil types and distribution.	7		
8.	**India's Environmental resources and management** India's environmental and economic resources; agriculture and	8		

	food security: Infrastructure: irrigation, seeds, fertilizers, power; Institutional factors: land holdings, land tenure and land reforms; Cropping pattern, agricultural productivity, agricultural intensity, crop combination, land capability; Green revolution and its socio-economic and ecological implications.			
		42	**0**	**0**

Evaluation criteria

- 2 Minor exams: 40%
- Assignments: 10%
- Major test: 50%

Learning outcomes

Upon completion of the course, students would be able to:

- Understand the various components of the earth's system and its interlinkages
- Explain the workings of the earth's system and feedback mechanism

Pedagogical approach: Lectures, tutorials and case studies

Suggested Readings

Textbooks

Strahler, 2010. Physical geography, John Wiley & Sons, Inc., USA.
Holden, 2012. An Introduction to Physical Geography and the Environment. Pearson Education Limited, Essex, England.
Knowled R. and Wareing J., 1990. Economic and Social Geography: Made Simple, New Delhi, Rupa Publications, India.
Singh, 2015. Physical Geography, Pravilika Publications, India.
Bryant R.H. (1990) Physical Geography: Made Simple, Rupa Publications, New Delhi, India.
Thornbury WD (2004), Principles of Geomorphology, CBS publication

Additional information (if any)

- Research paper reading and discussions

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr Pawan Kumar Jha, Earth and Planetary Sciences, University of Allahabad.
2. Dr. Tamoghna Archarya, Xaviers School of Sustainability, Bhubaneshwar.
3. Dr. Gurmeet Singh, Futuristic Research Division, National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, Chennai.

2. Basics of Climate Science

Course title: Basics of climate science			
Course code: NRC 131	**No. of credits**: 3	**L-T-P**: 28-14-0	**Learning hours:** 42
Pre-requisite course code and title (if any): None			
Department: Department of Energy and Environment			

Course coordinator(s): Dr. Kamna Sachdeva	**Course instructor(s):** Dr. Kamna Sachdeva
Contact details: kamna.sachdeva@trei.res.in	
Course type: Compulsory Core	**Course offered in**: Semester 1

Course description

The aims of this course are to provide basic understanding about the climate system: its attributes, underlying processes, and the drivers of climate change. The course explores the physical processes that control sub systems of climate such as atmosphere and ocean. The course will include topics like water in atmosphere, severe storms, global warming, and energy budget to provide basic understanding about the important concepts underlying the climate-system and changes therein.

Course objectives

- To understand the essential principles of Earth's climate system and getting basic knowledge about Science behind the phenomenon of Climate Change.

Course content:

Module	Topic	L	T	P
1.	Introduction to Climate Science Introduction to atmospheres: retaining the atmosphere, its vertical structure and residence time. Fundamentals of physical meteorology: perfect gas law; Energy budget and greenhouse effect	6	4	
2.	Components of Climate Science Climate System and Interaction among components of climate system and feedback mechanisms. Water in the atmosphere; clouds and precipitation. Global climate change and Coriolis force, Coriolis force and storms.	6	4	
3.	Paleoclimatology Evidences of climate change; Ice and climate change; Isotope evidence for Climate Change; Heinrich events; Dansgaard-Oeschger events	6	4	
4.	Aerosol Science Introduction and overview of aerosols, radiative effects of aerosols: direct and indirect; scattering and absorbing behaviour of aerosols.	6	2	
5.	Climate Modeling Introduction to global and regional climate models, its applications and importance.	4		
		28	**14**	**0**

Evaluation criteria

Course grades will be based on the following criteria:

- Three mid-term exams: 60%
- Final Exam: 40%

Learning outcomes

Upon completion of the course, students would be able to:

- Understand that any change /variability we are observing today is not arbitrary, everything has scientific basis

▪ Explain the workings of the climate systems and feedback mechanisms
Pedagogical approach Lectures, tutorials, lab experiments and case studies
Material **Suggested Readings** **Textbooks** Ahrens, C. Donald. Essentials of Meteorology. Brooks Cole, 2004. **Other Readings** Barbara J. Finlayson Pitts and James N. Pitts,Jr (2000). Chemistry of the upper and lower atmosphere- theory, experiments and applications Academic Press, San Diego John H.Seinfeld and Spyros N.Pandis (2006). Atmospheric Chemistry and physics-from air pollution to climate change, John Wiley and Sons, INC Potter, Thomas D (2003). Handbook of weather, climate, and water: Dynamics, climate, physical meteorology, weather systems, and measurements. John Wiley and Sons, USA
Additional information (if any) • Research paper reading and discussions • Symposium on latest work in the related areas
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Ramesh P. Singh, Ph.D., Professor, Earth System Science and Remote Sensing, Department of Physics, Computational Science and Engineering, Schmid College of Science, Chapman University.
2. Professor Arun K. Attri, Atmospheric Chemistry and Aerosol Science Lab, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi**.**

3. Environmental Law and Policy

Course title: Environmental law and policy			
Course code: NRE 155	**No. of credits:** 3	**L-T-P:** 42-0-0	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s): Dr M V Shiju		**Course instructor(s):** Dr M V Shiju	
Contact details:			
Course type: Core		**Course offered in:** Semester 1	
Course description Law and policy plays a major role in the conservation and management of natural resources as well as pollution control. This course intends to introduce the students to the vast field of Environmental Law and Policy. The course would be divided into three broad areas. The first part would cover the basic concepts and principles of Environmental Law. This would include judicial precedents, which now forms an essential part of environmental jurisprudence. The second part			

would be divided into specific introductory modules on forests and wild life including bio-diversity related laws; Air and Water related laws including mega projects and marine laws; and laws relating to hazardous substances. The third part would discuss the developments at the international level in the field of environmental law. At the end of the course it is expected that the students would be familiar with the overall Environmental Law and Policy regime of the country as well as its international obligations. It is expected that the case studies would equip them with basic knowledge and skills to understand environmental law issues.

Students are expected to attend the class after going through the reading material.

Course objectives

- To explain the role of law, policy and institutions in the conservation and management of natural resources as well as pollution control
- To introduce the laws and policies both at the national and international level relating to environment
- To equip the students with the skills needed for interpreting laws, policies and judicial decisions

Course content

Module	**Topic**	L	T	P
1.	Basic Concepts in Environmental Law. An introduction to the legal system; Constitution, Acts, Rules, Regulations; Indian Judiciary, Doctrine of precedents, judicial review, Writ petitions, PIL–liberalization of the rule of locus standi, Judicial activism. Introduction to environmental laws in India; Constitutional provisions, Stockholm conference; Bhopal gas tragedy; Rio conference. General principles in Environmental law: Precautionary principle; Polluter pays principle; Sustainable development; Public trust doctrine. Overview of legislations and basic concepts.	2 3 2 1		
2.	**Module II–Forest, Wildlife and Biodiversity related laws** Evolution and Jurisprudence of Forest and Wildlife laws; Colonial forest policies; Forest policies after independence Statutory framework on Forests, Wildlife and Biodiversity: IFA, 1927; WLPA, 1972; FCA, 1980; Biological Diversity Act, 2002; Forest Rights Act, 2006. Strategies for conservation–Project Tiger, Elephant, Rhino, Modulew leopard.	2 5 1		

3.	**Module III–Air, Water and Marine Laws** National Water Policy and some state policies Laws relating to prevention of pollution, access and management of water and institutional mechanism: Water Act, 1974; Water Cess Act, 1977, EPA, 1986. Pollution Control Boards Ground water and law Judicial remedies and procedures Marine laws of India; Coastal zone regulations. Legal framework on Air pollution: Air Act,1981; EPA, 1986	1 5 1 1 2 3		
4.	**Module IV–Environment protection laws and large Projects** Legal framework on environment protection-Environment Protection Act as the framework legislation–strength and weaknesses; EIA; National Green tribunal The courts infrastructure projects	3 3		
5.	**Module V Hazardous Substances and Activities** Legal framework: EPA and rules made thereunder; PLI Act, 199 Principles of strict and absolute liability	2 1		
6.	**Module VI International Environmental law** An introduction to International law; sources of international law; law of treaties; signature, ratification Evolution of international environmental law: Customary principles; Common but differentiated responsibility, Polluter pays.	2 2		
	Total	**42**	**0**	**0**

Evaluation criteria

- 2 minor tests: 40%
- 1 major test (end semester): 50%
- Term paper: 10%

Learning outcomes

- be familiar with the laws, policies and institutions in the field of environment
- acquire the skills needed for interpreting laws, policies and judicial decisions in a holistic perspective
- acquire the ability to evaluate the role of law and policy in conservation and management of natural resources and prevention of pollution

Pedagogical approach

Materials

Required text

Divan S. and Rosencranz A. (2005) *Environmental Law and Policy in India***,** 2nd ed., Oxford,

New Delhi
Leelakrishnan P. (2008) *Environmental Law in India*, 3rd ed., Lexis Nexis, India.

Suggested Readings
Birnie P. (2009) *et al., International Law and the Environment*, 3rd ed., Oxford.
Desai A. (2002) *Environmental Jurisprudence***,** 2nd ed., Modern Law House**,** Allahabad.
*G*adgil M. and Guha R. (1995) *Ecology and Equity***,** Oxford, New Delhi.
Gadgil M. and Guha R. (1997) *This Fissured Land*, Oxford, New Delhi.
Guha R. (2000) *Environmentalism: A Global History*, Oxford, New Delhi.
Kamala S. and Singh U.K. (eds.) (2008) *Towards Legal Literacy: An Introduction to Law in India*, Oxford, New Delhi.
Leelakrishnan P. (2006) *Environmental Law Case Book*, 2nd ed, Lexis Nexis, India.
Sands P. (2002) *Principles of International Environmental Law*, 2nd ed, Cambridge.
Singh C. (1986) *Common Property and Common Poverty*, Oxford, New Delhi.
Upadhyay S. and Upadhyay V. (2002) *Hand Book on Environmental Law- Forest Laws, Wildlife Laws and the Environment*; Vols. I, II and III, Lexis Nexis- Butterworths-India, New Delhi.

Case studies
Websites

Journals
Economic and Political Weekly
Journal of Indian Law Institute

Additional information (if any)

Student responsibilities
The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Prof Arup Poddar, Professor, Kolkata (NUJS), Kolkata.
2. Dr. Stellina Jolly, Assistant Professor, South Asian University, Akbar Bhawan, Chanakyapuri, Chanakyapuri, New Delhi-110021.

4. Energy: Science, Technology and Policy

Course title: Energy: science, technology and policy			
Course code ENR xxx	**No. of credits:** 2	**L-T-P**: 28-0-0	**Learning hours:** 28
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s): Dr Atul Kumar	**Course instructor(s):** Dr Atul Kumar		
Contact details: atul.kumar@teriuniversity.ac.in			
Course type: Core	**Course offered in:** Semester 1		

Course description

This course will cover a variety of topics related to energy demand, energy supply, transformation, global environmental consequences of energy consumption and production as well as some important issues in energy policy and regulation.

Course objectives

- To provide understanding of the complexity of energy and climate change issues.
- To understand the basic scientific principles of renewable energy applications.
- To understand the advantages and limitations of different renewable and non-renewable energy sources

Course content

Module	Topic	L	T	P
1.	**Introduction to Energy Analysis** Classification of energy sources, energy supply chain, sectoral energy demand, energy data/statistic, accounting energy uses, energy balance, organization of energy sector in India, national and global energy demand supply situation.	6	0	0
2.	**New and Renewable Energy** Types of renewable sources of energy, solar energy principles and applications, wind energy potential and conversion, biomass generation and its use as energy source, classification of hydropower schemes, classification of water turbine, tidal power, geothermal energy and ocean thermal energy conversion, policies and regulation for promotion of renewable energy.	10	0	0
3.	**Conventional Energy Sources** Coal: formation of coal, coal reserve, types of coal, mining and transportation of coal, coal utilization technologies Hydrocarbons: Types of hydrocarbons, production and refining of various petroleum products, movement of petroleum products, sources of natural gas production & supplies, historical perspective of petroleum Industry in India Nuclear energy: Radioactivity, nuclear fission and fusion, nuclear reactors, India's nuclear energy programme	10	0	0

4.	**Energy and Climate Change Linkages** Energy and the climate change dimension, energy access, climate change and equity, international response to climate change, India's responses to climate change	2	0	0
	Total	**28**	**0**	**0**

Evaluation criteria

- **Minor test 1: 15%**
- **Minor test 2: 15%**
- **Assignment/Tutorials: 20%**
- **Major test: 50%**

Learning outcomes

By the end of this course, the student will be able to:

- Identify and distinguish between various renewable and non-renewable energy sources
- Explain the physical principles governing energy transformations using correct terminology
- Describe the main features of the Indian energy system
- Understand of the role energy has played and continues to play in human development
- Identify selected policy and regulation that are required for large scale deployment of renewable energy

Pedagogical approach

The course will be delivered through class room lectures. Relevant case studies shall be discussed in class so that students are introduced to the latest stage of development in the subject.

Materials

Textbooks

Kishore V.V.N. (Edited) (2008) Renewable Energy Engineering and Technology–A Knowledge Compendium, Published by TERI Press, New Delhi, pp 925.

Block K., (2009). Introduction to Energy Analysis, Techne Press

Reference Books

Twidell, J., & Weir, T. (2015). Renewable energy resources. Routledge.

Sukhatme S and Nayak J.K. (2008), Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill

Klass D.L. (1998), Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, 1998

Sarkar, S. (1989). Fuels and Combustion. Orient Blackswan.

Kreith, F., Kreider, J. F., Principles of Sustainable Energy, CRC Press, 2011.

TERI (2017). TERI Energy & Environment Data Diary and Year Book 2015/16, The Energy and Resources Institute

TERI, 2006. National Energy Map for India: Technology Vision 2030, The Energy and Resources Institute

British Petroleum (2016), BP Statistical Review of World Energy

Journals

Energy

Energy Policy

Renewable Energy Renewable and Sustainable Energy Reviews Biomass and Bioenergy Energy for Sustainable Development **Website** Ministry of New and Renewable Energy, Government of India Ministry of Coal, Government of India Ministry of Petroleum and Natural Gas, Government of India Ministry of Environment Forests and Climate Change, Government of India NITI Aayog United Nations Framework Convention on Climate Change
Additional information (if any)
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr Pallav Purohit, Institute of Applied System Analysis, Vienna, Austria.
2. Dr Deepak Sharma, University of Technology Sydney, City Campus, 15 Broadway, Ultimo NSW 2007.

5. Impacts of Climate Change

Course title: Impacts of climate change			
Course code:	**No. of credits:** 1	**L-T-P:** 18-10-0	**Learning hours:** 28
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s): Dr Chubamenla Jamir	**Course instructor(s):** Dr Chubamenla Jamir		
Contact details: chubamenla.jamir@teriuniversity.ac.in			
Course type: Compulsory Core	**Course offered in:** Semester 1		
Course description The course is designed to inform students about causes and impacts of climate change. It introduces the students to different types of changes in the climate system and explores observed impacts on both natural and human managed systems on various sectors and regions throughout the world. It would also explore the state of science with respect to tipping points in the Earth System and projections for the future.			
Learning objectives ▪ To provide basic understanding of the nature of climate change ▪ To explore climate change impacts on different sectors and regions			
Course content:			

S. No.	Topic	L	T	P

1.	**Introduction to extreme events and gradual changes of the climate; tipping elements and proxies for future climate change** (paleo-climatic evidences; astronomical factors); natural earth system activities (e.g. volcanic activity; earthquakes)	4	2	
2.	**Observed impacts of climate change on natural and managed systems** − Natural systems – ecosystems (forest, freshwater and marine aquatic systems) − Managed systems - agriculture, urban infrastructure, society	6	2	
3.	**Future climate impacts** − Future climate projections of climate parameters and sea-level rises and its impacts on natural systems (physical and biological) and society	4	2	
4.	**Sectoral and regional climate impacts – Case studies** − Case studies on infrastructure, agriculture and food system, water intensive industries, health, urban heat island.	4	4	
		18	**10**	**0**

Evaluation criteria

Course grades will be based on the following criteria:

- Assignments 20 %
- Two Minor Exams 15% each
- Major Exam 50 %

Learning outcomes

Upon completion of the course, students would be able to:

- Have a profound view about causes of climate change and the impacts of advancing climate change on different systems and regions.

Pedagogical approach

Lectures and discussion of assigned readings. Students would be required to do an assignment and presentation which will be evaluated by the course instructor.

Materials

Suggested Readings

Pittock B (2009) Climate change: The science, impacts and solutions 2nd edition. CSIRO, Melbourne, and Earthscan, London.

IPCC (2007) Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability, Working Group II, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Alley, R. B., Marotzke J., Nordhaus W.D. et al., (2003) Abrupt Climate Change. Science 299, 2005.

WMO, (2013) The Global Climate 2001-2010, A Decade of Climate Extremes.

Gosling (2013) The likelihood and potential impact of future change in the large-scale climate-earth system on ecosystem services.

Kelkar, U., Bhadwal, S. (2007) South Asian Regional Study on Climate Change Impacts and

Adaptation: Implications for Human Development. Human Development Report 2007/2008.Fighting Climate Change: Human Solidarity in a Divided World. Human Development Report Office, Occasional Paper.
Kovats, S., Akhtar, R. (2008) Climate, climate change and human health in Asian cities. Environment and Urbanization 29 (1): 165-175.
Lenton TM and Ciscar J (2013) Integrating tipping points into climate impact assessments. Climatic Change 117:585–597
Fischer G, Shah M, Tubiello FN and van Velhuizen H. (2005) Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. Phil. Trans. R. Soc. B 360, 2067–2083

Additional Readings

Hulme M., (2009), Why do we disagree about Climate change? Cambridge University Press.

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Prof. Eddy Moors, Head Climate Change & Adaptive Land & Water Management, Wageningen Environmental Research, Wageningen University & Research, Alterra, Netherlands.
2. Dr. Paresh Bhaskar Shirsath, Climate Change Adaptation Specialist, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) BISA, International Maize and Wheat Improvement Center (CIMMYT) – New Delhi.
3. Dr. Anjal Prakash, Programme Coordinator, Himalayan Adaptation, Water and Resilience (HI-AWARE) Research, ICIMOD.

6. Environmental Statistics

Course title: Environmental statistics			
Course code: NRE 111	**No. of credits:** 3	**L-T-P:** 28-14-0	**Learning hours:** 42
Pre-requisite course code and title (if any): No pre-requisite required			
Department: Department of Energy and Environment			
Course coordinator(s): Prof. Prateek Sharma		**Course instructor(s):** Prof. Prateek Sharma	
Contact details:			
Course type: Elective		**Course offered in:** Semester 2	

Course description

As the world gets more crowded and technology continues to develop, environmental problems multiply. There are many aspects of these problems–economic, political, psychological, medical, scientific and technological. Addressing such problems often involves quantitative aspects; in particular, the acquisition and analysis of environmental data. Treating these quantitative problems effectively involves the use of statistics. When one is confronted with a new problem that involves the collection and analysis of data, two crucial questions exist: "How will using statistics help this problem?" and "Which techniques should be used?"

The course has been designed and intended to help budding environmental scientists/managers to answer these questions in order better to understand and design systems for environmental protection. The course is about how to extract information from data and how informative data are generated in the first place. Analysing data is part science, part craft and part art. An effort has been made through this course to provide some useful tools 'to get to the grips' of environmental problems and to encourage the students to develop the necessary craft and art.

Course objectives

- Need for studying statistics
- Become aware of a wide range of applications of statistics in environmental management, life sciences & decision making
- Define statistics
- Understand the relation between probability and statistics
- Differentiate between descriptive and inferential statistics

Course content

Module	Topic	L	T	P
1.	**Introduction** Mathematical models–deterministic and stochastic; generation of environmental data; stochastic processes in environment; the nature of random variables; populations and samples; parameters and statistics.	1		
2.	**Review of basic concepts** Measurement theory, levels of measurement; statistical descriptors of environmental data–numerical and graphical; Chebyshev's theorem; measurement uncertainty–accuracy, precision and bias. Probability theory: probability concepts; probability distribution functions and their applications–discrete and continuous distributions.	3 3	2 2	
3.	**Data sampling** Methods for selecting sampling locations and times; types of sampling designs–probability and non-probability sampling; sampling theory, sampling distributions; parameter estimation, point and interval estimates; confidence interval estimation of–means, differences of means, proportions, difference of proportions, variances, ratio of variances sample size determination for different sampling designs	10	5	
4.	**Tests of hypothesis** Hypothesis testing–parametric and non-parametric tests (concerning means, differences of means, proportions, difference of proportions, variances, ratio of variances)	8	4	
5.	**Correlation and simple regression analysis** Correlation analysis: graphical analysis, bivariate correlation, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Simple regression analysis: assumptions and definitions, principle	3	1	

	of least squares, regression parameters their distribution and statistical significance, applications in process description and prediction			
		28	**14**	

Evaluation criteria

- 2 minor test: 20% each
- Tutorials: 20%
- Major test: 40%

Learning outcomes

After completing this course the students will be able to

- develop an intuitive statistical sense
- analyse, model and quantify uncertainty
- extract information and draw scientific inference from large amount of data collected to solve environmental problems
- take informed decisions under uncertainty

Pedagogical approach

Materials

Textbooks

Ayyub, B.M. and McCuen, R.H. (2011) *Probability, Statistics and Reliability for Engineers and Scientists*, CRC Press, Boca Raton, FL.

Helsel D.R. and Hirsch R.M. (1997) *Statistical Methods in Water Resources*, Elsevier Science Ltd., UK.

Hoshmand A.R. (1997) *Statistical Methods for Environmental and Agricultural Sciences*, CRC Press, Boca Raton, FL.

Kottegoda N.T. and Rosso R. (2008) *Applied Statistics for Civil and Environmental Engineers*, McGraw-Hill, International Edition.

Shaefer S.J. and Theodore L. (2007) *Probability and Statistics Applications for Environmental Science*, CRC Press, Boca Raton, FL.

Suggested Readings

Berthouex P.M. and Brown L.C. (1994) *Statistics for Environmental Engineers*, Lewis Publishers, CRC Press, Boca Raton, FL.

Caulcutt R. and Boddy R. (1983) *Statistics for Analytical Chemists*, Chapman & Hall, London.

Cothern C.R. and Ross N.P. (1994) *Environmental Statistics, Assessment and Forecasting*, Lewis Publishers, Boca Raton, FL.

Csuros M. (1997) *Environmental Sampling and Analysis, Lab Manual*, Lewis Publishers, Boca Raton, FL.

Ebdon D. (1984) *Statistics in Geography*, 2nd edn., Blackwell, Oxford.

Everitt B.S. (1999) *Chance Rules: An Informal Guide to Probability*, Risk and Statistics, Springer-Verlag, New York.

Fisher L.D. and Van Belle G. (1993) *Biostatistics: A Methodology for the Health Sciences*, John Wiley & Sons, New York.

Gibbons R.D. (1994) *Statistical Methods for Groundwater Monitoring*, John Wiley & Sons, New York.

Gibbons R.D. and Coleman D.E. (2001) *Statistical Methods for Detection and Quantification of Environmental Contamination*, John Wiley & Sons, Inc., New York.

Gilbert R.O. (1987) *Statistical Methods for Environmental Pollution Monitoring*, New York, Van Nostrand Reinhold.
Ginevan M.E., Splistone D.E. (2004) *Statistical Tools for Environmental Quality Measurement.* John Wiley & Sons Hoboken, NJ.
Graham R.C. (1993) *Data Analysis for the Chemical Sciences: A Guide to Statistical Techniques*, VCH Publishers, New York.
Gregoire T.M. and Valentine H.T. (2008) *Sampling Strategies for Natural Resources and the Environment,* Chapman & Hall/CRC, Boca Raton.
Keith L.H. (1991) *Environmental Sampling and Analysis: A Practical Guide,* Lewis Publishers, Boca Raton, FL.
Keith L.H. (ed) (1996) *Principles of Environmental Sampling*, Second Edition, American Chemical Society, Washington, D.C., Distributed by Oxford University Press, New York.
Manly B.F.J. (2001) *Statistics for Environmental Science and Management*. Chapman & Hall/CRC, Boca Raton, FL.
McBean E.A. and Rovers R.A. (1998) *Statistical Procedures for Analysis of Environmental Monitoring Data & Risk Assessment,* Prentice-Hall PTR, Upper Saddle River, NJ.
McBride G.B. (2005) *Using Statistical Methods for Water Quality Management: Issues, Problems and Solutions,* John Wiley & Sons, Hoboken, NJ, USA.
Meier P.C. and Zund R.E. (1993) *Statistical Methods in Analytical Chemistry,* John Wiley & Sons, New York.
Moore D.S., McCabe G.P. and Craig B.A. (2009) *Introduction to the Practice of Statistics,* W.H. Freeman and Co., New York.
Ott W.R. (1995) *Environmental Statistics and Data Analysis,* Lewis Publishers, Boca Raton, FL.
Piegorsch W.W. and Bailer A.J. (1997) *Statistics for Environmental Biology and Toxicology*, Chapman & Hall, New York.
Reichman W.J. ((1961) *Use and Abuse of Statistics*, Penguin, Harmondsworth.
Rogerson P.A. (2006) *Statistical Methods for Geographers: A Student's Guide*, Los Angeles, CA.
Taylor J.K. (1987) *Quality Assurance of Chemical Measures,* Lewis Publishers, CRC Press, Boca Raton, FL.
Walford N. (2011) *Practical Statistics for Geographers and Earth Scientists,* John Wiley & Sons, New Jersey, USA.
Williams R.B.G. (1984) *Introduction to Statistics for Geographers and Earth Scientists*, Macmillan, London.
Wrigley N. (1985) *Categorical Data Analysis for Geographers and Environmental Scientists*, Longman, Harlow.
Zhang C. (2007) *Fundamentals of Environmental Sampling and Data Analysis*, John Wiley & Sons, NJ, USA.

Journals

Applied Statistics
Biometrika
Environmental and Ecological Statistics
Environmetrics
International Statistical Review
Journal of Statistical Computing and Simulation
Journal of the American Statistical Association
Risk Analysis

Statistical Science Technometrics The American Statistician
Additional information (if any)
Student responsibilities The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Prof. Bilal M. Ayyub, University of Maryland, College Park, USA.
2. Prof. Richard H. McCuen, Department of University of Maryland, College Park, USA.

7. Concepts and Theories of Development

Course title: Concepts and Theories of Development			
Course code:	**No. of credits:** 3	**L-T-P:** 38-4-0	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s):		**Course instructor(s):** Dr Swarup Dutta	
Contact details: swarup.dutta@teriuniversity.ac.in			
Course type: Core	**Course offered in:** Semester 1		

Course description

This course will cover development theories indicating various ways in which social and economic factors impact upon the environment and are linked to climate change and other intertwined issues. The first and second part of the course will provide a broader understanding of the concepts development and various development theories. This will provide a critical assessment of conservative forms of development models and indicate required changes in values and perspectives with respect to problems of climate change and related issues.

Course objectives

The course aims (1) to provide an understanding of development theories (2) in highlighting the complexities of development processes (3) to get an understanding of sustainable development. 4) to get an idea of new theoretical development in the field of climate change and development

Course content:

Module	Topic	L	T	P
1.	**Introductory Session:** − Conceptualization of Development	1		
2.	**Overview of development;** − Globalisation and the structural adjustments; − Governance and welfare state; − Agency and the development triad;	14		

3.	**Various Development Theories** − Modernization theory − Dependency theory − Neoliberalism − Human Development − Alternative and Post development theory	13	4	
4.	**Concept of Sustainable Development** − Definitions & Principles of Sustainable Development − Changing perception of development − Sustainable Development Goals (SDGs)	4		
5.	**Human-Environment Interaction** − Culture and Environment (Environmental Determinism, Cultural Ecology and Political Ecology)	4		
6.	**Some emerging theoretical aspects** − Climate Change and the concept of Anthropocene as a critique of industrial technology based development models	2		
		38	**4**	**0**

Evaluation criteria

Course grades will be based on the following criteria:

- Individual Assignment 1: 20 %
- Group work: 20 %
- Final Written Exam: 60 %

Learning outcomes

Upon completion of the course, students would be able to:

- Get proper understanding of Sustainable Development and related issues
- recognize the issues related to man-environment interactions and various established theoretical perspective
- discuss environmental problems from an social perspective
- apply theoretical knowledge into practice while dealing with contemporary environmental problems

Pedagogical approach

Class sessions will entail a lecture component, combined with discussion of assigned readings. Students would be required to participate in two workshops, for which they would be assigned to read 2-3 articles / research papers. Students would have to write short (1-2 pages) summary / critical remarks on the articles, which would be evaluated by the instructor.

Materials

Suggested Readings

Adger, W.N. & Kelly, P.M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change*, 4(3-4): pp. 253-266

Alwang, J., Siegel, P.B. & Jorgensen, S.L. (2001). Vulnerability: a view from different disciplines. *Social Protection Discussion Paper No. 0015*. The World Bank: Washington, D.C. [Available at: www.worldbank.org/sp].

Batterbury, S.P.J. & Fernando, J.L. (2005). Rescaling governance and the impacts of political and environmental decentralization: an introduction. *World Development*, 34(11): pp. 1851—1863.

Braun, Bruce (2015). From critique to experiment? Rethinking political ecology for the Anthropocene, in The *Routledge Handbook of Political Ecology* edited Tom Perreault, Gavin

Bridge James McCarthy, Routeledge UK, pp. 102-114
Bryant, R. & Bailey, S. (1997). *Third World Political Ecology*. London: Routledge. Introduction & Chapter 1: pp. 1-26.
Crutzen, P.J. & E.F. Stoemer (2000) " The Anthropocene" Global Change Newsletter 41:17-18
Ehlers, Eckhart; Moss, C; Krafft Thomas (2006) Earth System Science in the Anthropocene: Emerging Issues and problems, Springer Science + Business Media,
Forsyth, T. (2003). *Critical Political Ecology*. London: Routledge. Chapter 7: pp. 168-201.
Gadgil, M and Vartak, V.D. 2004. The Sacred Uses of Nature. In Ramachandra Guha (ed.). *Social Ecology*. New Delhi: Oxford University Press. Pp. 82-89
Hannigan, John. (2006) Environmental Sociology, Routeledge UK
Liverman, Diana (2015) Reading climate change and climate governance as political ecologies, in The *Routledge Handbook of Political Ecology* edited Tom Perreault, Gavin Bridge James McCarthy, Routeledge UK, pp. 303-319.
Robbins, Paul; (2012) Political Ecology: A Critical Introduction, John Wiley & Sons
Sutton, M and Anderson, E.N. 2004, *An Introduction to Cultural Ecology*, New York: Altamira Press.
Scott, J.C. (1986). Everyday forms of peasant resistance. *Journal of Peasant Studies*, 13(2): pp. 5-35.
Zalasiewicz, Jan etal(2008) "Are We Now living in the Anthropocene" GSA Today18(2):4-8

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Professor Subhadra Channa, University of Delhi, Delhi-110 007.
2. Dr Ragini Sahay, Associate Professor, Galgotia College of Engineering and Technology, Greater Noida, UP.

8. Climate Lab

Course title: Climate lab			
Course code: NRC 101	**No. of credits:** 2	**L-T-P:** 14-0-28	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s): Dr Kamna Sachdeva		**Course instructor(s):** Dr Kamna Sachdeva	
Contact details:			
Course type: Core		**Course offered in:** Semester 1	

Course description

The course is intended to provide practical knowledge to the students of MSc climate science and policy related to air pollution, water pollution and combustion processes. Also under this course students will be taught to study thermodynamic graphs to understand microphysical processes of the atmosphere.

Course objectives

- The course is intended to provide practical knowledge related to air pollution, water pollution & combustion processes.

- To provide basic practical understanding related to meteorology and its relation with climates studies

Course content

Module	Topic	L	T	P
1.	Introduction to Sample collection techniques and error calculations	4		
2.	Air **Ambient monitoring:** SPM, RSPM, SOx, NOx Data analysis and interpretation	3		10
3.	Water and soil Dissolved oxygen: General considerations, environmental significance of dissolved oxygen, collection of samples for determination of dissolved oxygen, methods of determination. BOD: General consideration, nature of BOD reaction, method of measurement, application of data COD: General consideration, methods of measurement, application of data in environmental science Soil: soil moisture and organic carbon determination	4		10
4.	Combustion Calorific value determination and fuel efficiency calculations	1		4
5.	Thermodynamic diagrams Introduction of concepts of thermodynamic diagrams and its application in climate studies. Determination of cloud height and extreme weather 4events	2		4
		14		**28**

Evaluation criteria

- Viva test: 50%
- Practical/project: 50%

Learning outcomes

- Able to read basic thermodynamic diagrams for few atmospheric phenomenon and extreme event
- Students will be able to relate connection between environmental pollution and climate change issues

Pedagogical approach

Materials

Required Text

Standard Methods for the Examination of Water and Wastewater Published by APHA 15th ed.
Thomas D.P. (2003) Handbook of Weather, Climate and Water: Dynamics, Climate, Physical Meteorology, Weather Systems and Measurements, John Wiley and Sons, USA.

Suggested Readings

For heat of combustion tables of various fuels and organic compounds on Wikipedia, see:

http://en.wikipedia.org/wiki/Heat_of_combustion#Heat_of_ combustion_tables
Harrison T., Shallcross D. and Henshaw S. (2006) Detecting CO_2–the Hunt for Greenhouse-gas Emissions, *Chemistry Review,* **15,** 27-30.
Marshall J. and Plumb R.A. (2001) Atmosphere, Ocean and Climate, *Elsevier*, Amsterdam.
Seinfeld J.H. (1986) Atmospheric Chemistry and Physics of Air Pollution, *John Wiley & Sons*.
Wallace and Hobbs (2006) Atmospheric Science-an Introductory Survey, Second Edition, *Academic Press Elsevier*.

Case studies
Websites

Journals
Combustion and Flame
Environmental Pollution
Environmental Science and Technology

Additional information (if any)

Student responsibilities
The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr Umesh Kulshreshta, Professor, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi.
2. Dr. Minal Pathak, CEPT, Ahemdabad, Gujarat.
3. Dr. Pankaj Mehta, Faculty, Jammu University, Jammu, Jammu and Kashmir.

9. Technical Writing

Course title: Technical writing			
Course code: NRE 101	**No. of credits:** 2	**L-T-P:** 16-12-0	**Learning hours:** 28
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator(s):		**Course instructor(s):** Ms Namrata Yadav	
Contact details:			
Course type: Core		**Course offered in:** Semester 1	

Course description
Students in the technology professions are proficient in their particular disciplines, but often unable to communicate effectively through reports or even scientific publications. Given that many students taking this course will not have a strong background in English, we propose to tackle this course in two ways.

One, by exposing the student to the requirements of technical writing as opposed to other kinds of formal writing and two, by providing a large number of exercises aimed at improving basic grammar, which will be assessed.

The student should be able to organize information for a report, a scientific paper and a proposal. He should be able to proofread his work, write concise emails and make technical presentations in PowerPoint. The use of graphs, tables and illustrations will also be taught.

Course objectives

Upon satisfactory completion of the course, students will be able to:

- Understand and use structures of argument appropriate to technical
- documents
- Understand and use a range of current web platforms and technologies

Course content

Module	Topic	L	T	P
	Critical thinking, reading and writing ▪ Why critical thinking is important in reading and writing? ▪ Ideating and developing an argument ▪ Understanding our audience and who we are writing for?	2		
1.	Academic writing: An interdisciplinary approach ***Understanding different styles in the science and social science space:*** ▪ Thesis, dissertation (Understanding the difference in science and social science writing) ▪ Publications, reports ▪ Op eds, critiques ▪ Blogs, journals ***On writing, well - positioning yourself as an author*** ▪ Audience, purpose and strategy ▪ Style, flow and formality ▪ Developing a discussion, argument and analysis ▪ Types of abstract and its development ▪ Words and its usage - looking at various writing styles and guidelines ▪ Use of infographics (tables, graphs, charts and visuals) ▪ Paragraph development: unity, lead and ending ▪ Reference styles ▪ Proof reading & editing ▪ Understanding the peer review process ▪ Presentation and form	6	6	
2.	**Business Writing** ▪ How to develop a good research proposal ▪ How to develop a project proposal ▪ Report writing ▪ Developing a good power point presentation ▪ Thinking about communication ▪ Communication skills	6	4	
3.	**Professional Writing** ▪ Email Writing ▪ CV and cover letters	2	2	

	▪ Letters & Memos			
		16	**12**	

Evaluation criteria

- Assignments: 35%
- Presentations: 15%
- Major Test: 50%

Learning outcomes

Pedagogical approach

Materials

Required text

Beer D. (1991) **Writing and Speaking in the Technology Professions: A Practical Guide,** Wiley-IEEE Press.

Markel M. (2009) *Technical Communications*, 9th Edition, Bedford/St Martin's.

Markel M. (1994) **Writing in the Technical Fields: A Step-by-Step Guide for Engineers, Scientists and Technicians**, publisher.

Suggested readings

http://courses.washington.edu/hcde231/Readings.html
http://www.writing.engr.psu.edu/
http://owl.english.purdue.edu/owl/resource/629/01/
http://www.writing.engr.psu.edu/exercises/

Case studies
Websites

Journals

Journal of Technical Writing and Communications

Additional information (if any)

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

Annexure 7

Course title: Social, Economic and Health dimensions of Water, Sanitation and Hygiene			
Course code:	**No. of credits:** 3	**L-T-P:** 40-2-0	**Learning hours:** 42
Pre-requisite course code and title (if any): Basic knowledge of Economics and Social Science			
Department: Coca Cola Department of Regional Water Studies			
Course coordinator: Dr. Swarup Dutta	**Course instructor(s):** Dr. Prashant Kumar Singh, Dr. Swarup Dutta, Dr. Sukanya Das		
Course type: Elective	**Course offered in: 3rd Semester**		

Course Description

Water, sanitation and hygiene (WASH) is very closely linked to quality of life. Safe water access, suitable sanitation and appropriate hygiene knowledge help in reduction of prevalence of disease, resulting in better health conditions leading to overall socio-economic development of society. The course aims to provide an understanding of socio-economic and health dimensions of WASH.

Course objectives

- To understand the global and local context of WASH and health.
- To understand socio-economic and cultural factors of WASH in developing countries.
- To understand the concept of community participation and its role in the context of sustainable development.
- To understand the approaches for economic valuation in health WASH
- To comprehend appropriate policy prescriptions related to WASH

Course Contents

Module	Topic	L	T	P
1.	**Introduction to WASH and Social issues** WASH: concept and definition; historical perspective - Indus valley civilization, concept of water and sanitation in Biblical times, decline of sanitation in the middle ages, WASH in pre- and post-colonial period in India, developments and incentives; social movements in water and sanitation in India; relevance – sustainable development goals (SDGs) & quality of life in WASH context; delineation and geospatial aspects in WASH Access to WASH services; discrimination towards specific social groups in WASH related services (gender, ethnicity, caste and class.); Gender and WASH; interlinkages between WASH and gender equity; WASH and human rights; role of state and non-state actors	10		
2.	**WASH, Health and Nutrition** Defining the problem: relationship between WASH and health in context of demographic, socioeconomic and	10		

	environmental perspectives ; WASH and - global burden of disease in the Indian context, its implications with respect to health & disease, mortality; health impacts of low cost WASH interventions; improving quality of care through WASH Facility Improvement Tool (WHO-WASH FIT); value-chain analysis Direct and indirect linkages between WASH related factors and child nutrition; nutritional morbidity in all population groups; multi-sectoral approach in addressing WASH and nutrition (case studies from South Asian countries)			
3.	**WASH and Economics** Introduction: disease control strategies for water, sanitation and hygiene intervention, inequities in regard to accessibility to WASH; approaches for economic valuation to health and application in WASH–cost effectiveness analysis: concepts of utility measurement, concept of DALY, QALY; comparing cost benefit and cost effectiveness analysis: methodology of social cost benefit analysis and application in WASH – foundations of cost benefit analysis and investment, aggregation in cost benefit analysis; time preference–private and social; net present value; internal rate of return on investment; payback period; choice of discount rate; shadow prices, weights: aggregation across agents; project valuation and uncertainty identification of relevant costs and benefits; UNIDO /World Bank/JICA;	10	2	
4	**Different options for financing WASH programmes** Health care in India in regard to WASH – Various health indicators in relation to WASH and its recent trend, health care expenditures, target of health care and achievements, different options for financing healthcare, taxation, user fees; policies in urban water and sanitation, urban area landscaping-socio economic aspects of WASH	8		
		40	**2**	**0**

Evaluation procedure

- Minor 1: 20%
- Minor 2: 20%
- Term paper: 20%
- Major examination: 40%

Learning outcomes

At the end of the course, the students will be able to

- Explain the linkages between WASH and various socio-economic aspects
- Understand the global and regional issues of WASH and health
- Develop analytical skill to analyse WASH related issues
- Assess the right-based approach of WASH in larger policy framework
- Perform economic analysis of WASH issues

Pedagogical approach

Classroom teaching will involve black board, power point presentations and case study analysis. Interactive sessions, including field visits will be held on management of WASH issues with various stakeholders.

Suggested Readings

Bateman, I.J. and Willis, K.J. (eds.) (1999). *Valuing Environmental Preferences: Theory and Practice of the Contingent valuation method in the US, EU, and developing countries*. Oxford University Press, Oxford.

Culyer, A. J. and Newhouse, J.P. (eds.) (2000). *Handbook of Health Economics.* Volumes 1A & B, North-Holland.

Folland, S., Goodman, A.C. and Stano M. (2006). *Economics of Health and Health Care*, Pearson Prentice Hall.

Saxena, A. (2015). *Sociology of Sanitation – Themes and Perspective*. Young Publishers, India.

Saxena, A. (ed) (2013). *Marginality, exclusion and Social Justice*. Rawat Publishers, India.

Smith, V. Kerry (1997). *Estimating Economic Values for Nature: Methods for Non-Market Valuation*, Brookfield: Edward Elgar.

Zweifel, P. (1997). *Health Economics*. Oxford University Press.

Curtis, V., & Cairncross, S. (2003). Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *The Lancet Infectious Diseases*, *3*(5), 275-281.

Lee, L. F., Rosenzweig, M. R., & Pitt, M. M. (1997). The effects of improved nutrition, sanitation, and water quality on child health in high-mortality populations. *Journal of Econometrics*, *77*(1), 209-235.

Moe, C. L., & Rheingans, R. D. (2006). Global challenges in water, sanitation and health. *Journal of Water and Health*, *4*(S1), 41-57.

Additional information (if any)

There are certain portions within the syllabus for which there are no standard texts and are required to be covered through original research articles, published WHO and state of environment reports and case studies. The relevant reference from various WHO reports, state of environment reports, research papers for case studies would be separately provided

Student responsibilities

The students are expected to submit assignments in time and come prepared with readings when provided.

Course Reviewers

1. Dr Ashish Saxena,Professor and Head, Department of Sociology, Allahabad University, Allahabad.
2. Dr.Wangshimenla Jamir, Associate Professor, Department of Geography, University of Nagaland.
3. Dr Pranjal Deekshit, Assistant Professor, Water Policy, Tata Institute of Social Sciences.

Annexure 8

Public Policy and Sustainable Development Programme

Course Outline

Course Title: Society and Development Policy			
Course code: PPS 106	**No. of credits:** 2	**L-T-P:** 16-12-0	**Learning hours:** 28
Department: Policy Studies			
Course Coordinator: Dr L N Venkataraman		**Course Instructor:** Dr L N Venkataraman	
Contact Details: venkataraman.ln@teriuniversity.ac.in			
Course Type: Core		**Course offered in:** Semester 1	

Course description:

This course is designed to give the students an overview of some of the major areas where sociological concepts, theory and practice have enabled better understanding of socio-cultural processes, and have influenced / are influencing public policy. The course will focus primarily on Indian examples in order to give the students a sense of the ways that their own experiences relate public policy. The course would highlight a range of issues covered by social policies, such as marginalization of women, access to resources, reservations and equal opportunity, and human rights. These issues would be discussed from the help of sociological concepts like functionalism and holism, social stratification, gender and status, identity, social change and social movements. A thorough understanding of social phenomena and various social forces that influence government decision-making will enable students to reflect on the intended outcomes and consequences of various government policies on the society.

Course objectives:

- Develop an understanding of structure of human society and key social institutions namely caste, religion, class and patriarchy with a focus on Indian society.
- Be able to look at current public policy issues with an Sociological perspective on the social institutions
- Appreciate the significance of Sociological concepts as contributing to a critical and informed understanding of the contemporary world
- Have an understanding of some key concepts in social policy debates, such as mobility, economic and social aspirations, equality as a goal of the Constitution and equity as a guiding principle of policy framework, opportunities needs, rights and responsibilities vis-à-vis socialization, westernization and sanskritization.
- Be aware of how social inequalities and the development processes get entangled in a complex web of factors.
- To appreciate the need based policy frameworks that aim at bringing social equality through equitable provisions such as reservation and so on

Course contents

Module	Topic	L	T	P
1	**Society and Development** Sociology and the Common-sense [Socialization; Social Structure; Community; & Institutions] Political-economy of Development; (Perspectives on Development; Welfare State & Development Ethics]	4	3	0

	Case analysis: India's Five Year Plans (FYPs)			
2	**Social Inequalities** Individuals and Institutions; Social Stratification; Social Exclusion; Dignity in Development **Case analysis**: Reservation in India	4	3	0
3	**Social Movements and Public Policy** Social change; Social movements; Public action; Participation & Decentralization **Case analysis**: Right to Food campaign (RtF)	4	3	0
4	**Rights Based Approaches to Development Policy** Governance and Welfare State; Social Justice and rights-based approaches **Case analysis**: Right to Education (RtE); Right to Information (RtI)	4	3	0
	Total	16	12	0

Evaluation criteria: **Weightage (%)**

- Discussions & Critiques 25
- Article Review 25
- Course-works (Individual & Group presentations) 25
- Book Review 25

Learning outcomes:

At the end of the course, the participants would be able to (1) know the sociology of development; and (2) critically reflect on the development policies.

Pedagogical approach:

Instructions will be facilitated through lectures, interactive sessions and critical readings. The sessions will be dealt in light of relevant Sociological perspectives where each module will be followed by an assignment and group presentations by the participants. Thus, the learning expectation is to enhance critical and informed understanding.

Materials:

Required text

Suggested readings

1. Aggarwal, B. (1998), "Widows versus Daughters or Widows as Daughters? Property, Land, and Economic Security in Rural India", *Modern Asian Studies*, Vol 32, No. 1. (pp. 1-48).
2. Agrawal, A. & Gibson, C.C. (1999), "Enchantment and disenchantment: the role of the community in natural resource conservation", *World Development*, Vol. 27, No. 4, (pp. 629-649).
3. Barnard, Allan (2000), *History and theory of anthropology*, Cambridge University Press, Cambridge.
4. Beteille, A. (2002), Sociology: Essays on Approach and Method, Oxford University Press, New Delhi.
5. Beteille, A. (1983), *Equality and Inequality: Theory and Practice*, Oxford University Press, New Delhi.
6. Campbell, Dave (2011), "Anthropology's Contribution to Public Health Policy Development", Mcgill Journal of Medicine, Vol. 13, Issue 1, (pp. 76-83). Published online.
7. Chakravarti, U, (1995), "Gender, Caste, and Labour", *Economic and Political Weekly*, Vol. 30, No. 36, (pp. 2248-56).

8. Deshpande, Satish (2003), *Contemporary India: A Sociological View*, Penguin Books, New Delhi.
9. Drèze, J. (2004), "Democracy and the right to food", *Economic and Political Weekly*, Vol. 39, Issue 17 (pp. 1723-1731).
10. Drèze, J., and A. Sen (1989), *Hunger and public action*, Oxford University Press, Oxford.
11. Dube. S.C (1993), *Indian Society*, National Book Trust, New Delhi
12. Escobar, A. 1995. *Encountering Development: The Making and Unmaking of the Third World*, Princeton University Press, Princeton, NJ (selected chapters).
13. Giddens, Anthony, Mitchell Duneier, Richard P. Appelbaum. (2003), *Introduction to Sociology*, W W Norton & Company Incorporated
14. Moore, Henrietta L. (1988), *Feminism and Anthropology*, Polity Press, Cambridge.
15. Leach, M., Mearns, R. & Scoones, I. (1997), "Challenges to community-based sustainable development: dynamics, entitlements and institutions", *IDS Bulletin*, 28(4), (pp. 4-14).
16. Nussbaum, M (1999), "Women and equality: The capabilities approach", *International Labour Review*, 138 (3): (pp. 227–245).
17. Sen, A. (2000) *Development as Freedom*, Oxford University Press, New Delhi.
18. Srinivas, M.N. (1987), *The Dominant Caste and Other Essays*, Oxford University Press, Delhi.
19. Srinivas, M N (1966), *Social Change in Modern India*, University of California Press, Berkeley
20. Thorat, S and Chittaranjan Senapati. (2006), Reservation Policy in India – Dimensions and Issues, *Working Paper Series*, Vol.1.No.2. Indian Institute of Dalit Studies, New Delhi.

Case Studies

Websites

Journals

Other readings

Additional information (If any):

Student Responsibilities:

1. Active participation in the processes of Learning;
2. Critical reflections for discourse creation;
3. Punctuality (according to the Course criterion).

Course reviewers:

1. Dr. Latika Gupta, Central Institute of Education, *University of Delhi*, New Delhi
2. Dr. Suresh Babu, Zakir Husain Centre for Educational Studies, *Jawaharlal Nehru University*, New Delhi

Course title: Sustainable Consumption and Production			
Course code:	**No. of credits:** 2	**L-T-P:** 24-4-	**Learning hours:**

		0	28

Pre-requisite course code and title (if any): None

Department: Policy Studies

Course coordinator: Dr Shaleen Singhal	**Course instructors:** Dr Lakshmi Raghupathy and Dr Shaleen Singhal
Contact details: ssinghal@teri.res.in	
Course type: Core	**Course offered in:** Semester 1

Course description:

Countries in South Asian region are witnessing rapid transformation. It is evident that future prosperity and transition to sustainability in this region will be highly influenced by changes in development of the countries and businesses as well as in consumption patterns and lifestyles. There are noticeable awareness generation and capacity building initiatives aiming to promote a shift towards sustainable consumption and production (SCP) patterns and resource efficiency for green growth and poverty reduction in South Asian region. The enabling policy environment needs to be strengthened through enhanced capacity of future decision makers in order to ensure balance between demand and supply side towards SCP. Advanced knowledge, skills and commitment of policy makers and graduates today are critical constituents necessary to structure and successfully implement sustainable development policies in future. India in particular, with its young population is likely to rise from twelfth-largest consumer market today, to become world's fifth-largest consumer market by 2025. While the significance of SCP and resource efficiency is well accepted in India, imparting knowledge to policy and decision makers shall facilitate an enabling environment for comprehensive integration of SCP into policy making. This is being aimed through the first-of-its-kind post graduate course in India for young policy and decision makers.

Course objectives:

- To impart knowledge on SCP concepts, significance and advancements within India and wider South Asia region in order to create a pool of better informed future policy makers.
- To equip young policy makers with knowledge on demand side and supply side challenges and opportunities relating to SCP
- To equip young policy makers for policy analysis of select sectors targeting to mainstream SCP into policy.

Course Contents

Module	Topic	L	T	P
1	**Introduction to Sustainable Consumption and Production (SCP)** **a) Significance** – SCP and its significance for Sustainable Development – Linking SCP with Sustainable Development Goals – Review of SCP Targets under SDG and crosscutting targets and indicators – Internalizing SCP elements in development goals of poverty reduction, resource efficiency, sustainable livelihoods, climate change mitigation/adaptation	4		

	b) Theoretical context – Sustainable Consumption in conjunction with Sustainable Production – Life Cycle Thinking and Systems Approach Customize policy discussion for India's economic/environmental scenario with specific reference to consumption, production and links with economic growth **c) Contemporary thinking** – Reviewing SCP and SDG's transformative indicators. Gap analysis relating to achieving SDGs (policy, practice, financing, technology gaps) – International approaches: Global SCP Policies and Practices (Cases examples from countries which have adopted SCP goals). – Innovative ideas for SCP that can integrate with existing policy features.			
2	**SCP in Regional, National and Local Policy Frameworks** – Challenges and opportunities for SCP in emerging economies o Regional focus on European Union, ASEAN and South-Asian sub-regional integration of SCP into public governance frameworks – National focus on India – State level focus and progress across Indian states on SCP topics	2		
3	**Demand-side: Sustainable Behaviours and Lifestyles** – Consumer Choices and Behaviours: How do consumers determine eco-friendliness of products? Behavioural vs. regulatory obstacles to sustainable consumption choices, consumption 'hot spots', 'choice editing' and its effectiveness, advertisement control, etc. – Mechanisms for promoting behavioral changes, o Promotional activities to attract consumers o Sustainable Public Procurement 'Green procurement' in government and private sector targeted through awareness and education campaigns on sustainability for consumers Production optimization based on prevailing consumption patterns	4		

4	**Minor I Project on SCP applications (oral presentations)**		4	
5	**Mainstreaming SCP I - SCP for Resource Efficiency and Cleaner Production** – Designing for sustainability: Process, product and systems innovation – improved production processes, eco-friendly products, innovative low-impact technologies, supply chain management – Zero waste / Circular economy across interlinked sectors – Adoption of cleaner production processes (efficiency in production, resources management including energy, water and materials) – *Cleaner Production Process in SME Sectors*	6		
6	**Mainstreaming SCP II - Development and Implementation of Policies** – Existing SCP elements/practices in development goals Regional, national and sectoral specificities – Identifying the target policies and instruments for implementing SCP Current policy provisions: o Enhancement for effectiveness o Cross ministry interface – Need for alternatives Planning and implementation: SCP integration into existing policy structures. Exploring stakeholder engagement in policy-making – Monitoring and Evaluation: Assessment of sustainable production (upstream) and sustainable consumption (downstream) activities and policies. – Ensuring implementation of SCP practices in production and consumption activities, adherence to directives as well as effectiveness and efficacy of said practices.	6		
7	**Mainstreaming SCP III - Economic and Fiscal instruments** – Financial models for SCP: o Government based taxes and subsidies and user fees o Green public procurement o Using polluter pays principle – such as air, water pollution tax, carbon tax etc. o Green investment loan	2		

	○ Conditional cash transfer programmes – SCP in MSMEs: ○ Internalizing SCP in business strategies and supply chains ○ Investment allowance for energy-efficient / green technologies ○ Environmental Fiscal Reforms (EFR) ○ Reduction of environmentally harmful subsidies (like reduce fuel subsidies			
	Policy Analysis & Final Report			
	Total	**24**	**4**	**0**

Evaluation criteria:
Course assessment will be conducted through:

Minor I: Project Presentation (Individual assignment): 40%

Oral presentation on literature review for critical analysis of an existing policy in thematic areas such as - sustainable public procurement; resource efficiency and cleaner production; behavioral aspects of consumer choices ; production optimisation based on prevailing consumption pattern; green budgeting and macroeconomics; sustainable energy access, policy and management; strategic planning and investment for resource efficient cities; sustainable tourism and environmental services; and any other sectorial policies. These shall be examined for India with related case examples of other countries.

Minor II: Policy Analysis Report (Individual assignment): 60%

Policy analysis report for an identified policy/sector. Detailed critical analysis of gaps in existing policy, challenges in implementation, governance etc. and appropriate changes proposed to mainstream sustainability and SCP principles into the policy. Written report (around 3500 words).

Learning outcomes:

On successful completion of this course, the students shall,

- Have an improved understanding of SCP and interrelationship between sustainable consumption and sustainable production
- Be able to compare and contrast effective applications and business case for SCP in sustainable development with reference to specific countries and economic sectors
- Be able to examine the potential synergy of SCP with existing plans and policies
- Have learned the significance of various policy instruments, strategy options and institutional arrangements to mainstream SCP for effective sustainable development governance.

Pedagogical approach:

The course will be delivered through a mix of classroom lectures, brainstorming tutorial and presentation sessions, study visits and exposure to national, regional and global case studies on the theme.

Materials:

Required text

Suggested readings

1. Akenji, L. and Bengtsson, M., 2014. Making Sustainable Consumption and Production the Core of the Sustainable Development Goals, Sustainability, 6 (2014): 513-529. Available at: http://www.mdpi.com/2071-1050/6/2/513
2. Chiu, S.F., Ward, J. V., and Massard, G., 2009. Introduction to the special issue on Advances in Life-Cycle Approaches to Business and Resource Management in the Asia-Pacific Region, Journal of Cleaner Production, 17(14): 1237-1240. Available at: http://www.sciencedirect.com/science/article/pii/S0959652609001383
3. Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W. –P., Suh, S., Weidema, B.P., and Pennington D.W., 2004. Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications, Environment International, 30 (5): 701-720. Available at: http://www.sciencedirect.com/science/article/pii/S0160412003002459
4. Sustainable Consumption and Production in the Proposed Sustainable Development Goals – A paper from the Inter-Agency Coordination Group (IACG) of the 10 Year Framework of Programmes on SCP (10YFP). June, 2014. Available at: www.unep.org/10yfp/Portals/50150/10YFP%20IACG.pdf
5. Zhao, W. and Schroeder, P., 2010. Sustainable consumption and production: Trends, challenges and options for the Asia-Pacific region, Natural Resources Forum, 34(1): 4-15. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1477-8947.2010.01275.x/pdf
6. Low-Carbon Green Growth in Asia Policies and Practices: A Joint Study of the Asian Development Bank and the Asian Development Bank Institute. 2013. Available at: http://www.adb.org/publications/low-carbon-green-growth-asia-policies-and-practices
7. Decoupling 2: technologies, opportunities and policy options. A Report of the Working Group on Decoupling to the International Resource Panel. von Weizsäcker, E.U., de Larderel, J, Hargroves, K., Hudson, C., Smith, M., Rodrigues, M.
8. Tseng, S. and Hung, S., 2013. A framework identifying the gaps between customers' expectations and their perceptions in green products, Journal of Cleaner Production, 59: 174-184. Available at: http://www.sciencedirect.com/science/article/pii/S0959652613004411
9. Green Public Procurement in Bhutan (GPP Bhutan), 2015. Executive Summaries of Year 1 Activity Reports. Available at: http://gppbhutan.bt/project-publications
10. Rathi, A.K.A., 2003. Promotion of cleaner production for industrial pollution abatement in Gujarat (India), Journal of Cleaner Production, 11(5): 583-590. Available at: http://www.sciencedirect.com/science/article/pii/S095965260200094
11. Wuppertal Institute for Climate, Environment and Energy, 2013. Lighting: Energy Efficient Lighting for Sustainable Development.
12. Access to Finance for Sustainable Consumption and Production in Asia – An Overview of Finance Trends and Barriers in India. Available at: http://www.switch-

asia.eu/fileadmin/user_upload/Publications/2016/Green_Finance_Study_-_2016_-_India.pdf

13. FICCI/UNEP, 2015. Designing a Sustainable Financial System for India: Interim Report. Available at: http://ficci.in/spdocument/20546/UNEP-Interim-Report.pdf
14. J.M., and Nathadwarawala, K.M., 2011. Sustainable Business Initiatives in the Context of Emerging Economies, In B. Unhelkar (Ed.), Handbook of Research on Green ICT: Technology, Business and Social Perspectives: 265-281. Available at: http://www.igi-global.com/chapter/sustainable-business-initiatives-context-emerging/48433
15. The Energy and Resources Institute (TERI) Policy Brief (2013). Engagement with Sustainability Concerns in Public Procurement in India: Why and How. Available at: http://www.teriin.org/policybrief/index.php?a=9

Case Studies

Websites

Intended Nationally Determined Contributions to UNFCCC; Online at: http://unfccc.int/focus/indc_portal/items/8766.php

SCP Clearinghouse

The Global SCP Clearinghouse is a unique one-stop hub dedicated to Sustainable Consumption and Production (SCP) and convened by the United Nations Environment Programme (UNEP) acting as the Secretariat of the 10 Year Framework of Programmes on SCP (10YFP on SCP); Online at: http://www.scpclearinghouse.org/

SCP Policies and the 10 Year Framework Programme, UNEP; Online at: http://www.unep.org/resourceefficiency/Policy/SCPPolicies/tabid/55539/Default.aspx

SWITCH-Asia projects funded by the European Union; Available at: http://www.switch-asia.eu/projects/

UNDP projects on environmental aspects related to SCP in India; Available at: http://www.in.undp.org/content/dam/india/docs/UNDP%20Fact%20Sheet%20-%20MEFCC.pdf

UNEP's Resource Efficiency Programme; Online at: http://www.unep.org/resourceefficiency/Home/Society/tabid/55529/Default.aspx

UNIDO projects on cleaner production topics; Available at: http://www.unido.org/en/where-we-work/asiaandthepacific/selected-projects.html

Journals

Other readings

1. UNEP, 2012. Global Outlook on SCP Policies: Taking action together. Available at: http://www.unep.org/pdf/Global_Outlook_on_SCP_Policies_full_final.pdf
2. SWITCH-Asia Projects, Case studies. See: http://www.switch-asia.eu/publications/?tx_switchasia_publications[category]=3&cHash=187075de03e4a5e1f168fb8ab798b9fb
3. SWITCH-Asia Project Impact Sheet: Green Retail India – Greening the food and beverage

supply chain in India. Available at: http://www.switch-asia.eu/publications/greening-the-food-and-beverage-supply-chain-in-india/

4. UNEP, 2010. ABC of SCP – Clarifying Concepts on Sustainable Consumption and Production: Towards a 10-Year Framework of Programmes on Sustainable Consumption and Production.
5. UNEP, 2012. Sustainable Consumption and Production for Poverty Eradication. Available at: http://www.unep.org/10yfp/Portals/50150/downloads/publications/poverty/SCP_for_Poverty_full.pdf
6. UNEP, 2015. Sustainable Consumption and Production Indicators for the Future SDGs. Available at: http://www.scpclearinghouse.org/upload/publication_and_tool/file/440.pdf
7. UNDP-UNEP, 2014. Building Inclusive Green Economies – Stories of Change from the Poverty-Environment Initiative in Asia-Pacific.
8. UNEP, 2013. Redefining Ecolabels to Improve Sustainability and Trade in Developing Countries: Lessons and Recommendations from the UNEP project
9. SWITCH-Asia Case Study: Up-scaling Biogas Technology for Sustainable Development and Mitigating Climate Change in Sri Lanka. Available at: http://www.switch-asia.eu/publications/bio-gas-case-studies/
10. UNEP, 2009. Mainstreaming Sustainable Consumption and Production and Resource Efficiency into Development Planning. Available at: http://www.unep.fr/shared/publications/pdf/DTIx1235xPA-MainstreamingSCPintoDevPlanning.pdf
11. UNEP, 2014. The Business Case for Eco-Innovation.
12. UNEP, 2015. Indicators for a Resource Efficient and Green Asia and the Pacific - Measuring progress of sustainable consumption and production, green economy and resource efficiency policies in the Asia-Pacific region. Schandl, H., West, J., Baynes, T., Hosking, K., Reinhardt, W., Geschke, A., and Lenzen, M. United Nations Environment Programme, Bangkok. Available at: http://www.switch-asia.eu/fileadmin/user_upload/RPSC/Publications/Indicator-for-a-RE_Low-resolution_.pdf
13. SWITCH-Asia SCP E-book Module 2 (3rd Edition) - Designing and Implementing National SCP Policies: The Policy Cycle and SCP in National Governance Structures
14. UNEP, 2012. Sustainable Consumption and Production: A Handbook for Policy Makers with Cases from Asia and the Pacific (First Edition)
15. UNEP, 2015. Sustainable Consumption and Production: A Handbook for Policymakers, Second Edition – Asia-Pacific Region.
16. Castro-Hallgren, S., 2016. UNEP Background Paper to Inform National Policy Activities in India on Sustainable Consumption and Production in 2016
17. UNEP, 2013. SWITCH-ASIA Regional Policy Support Component, Capacity Building and Policy Needs Assessment for Sustainable Consumption and Production. Available at: www.switch-asia.eu/.../policy-assessment/Needs-Analysis-Final-report.pdf
18. SWITCH-Asia, 2014. Access to Finance for SMEs – Engaging in Sustainable Consumption and Production Practices. Available at: http://www.switch-

asia.eu/fileadmin/user_upload/Switch-AsiaMAG_Winter14-15_Screen.pdf

19. UNEP, 2010. Pre-SME – Promoting Resource Efficiency in Small & Medium Sized Enterprises.

20. UNEP, 2013. Sustainable Public Procurement: A Global Review.

Additional information (if any):

This first-of-its-kind post graduate course on Sustainable Consumption and Production has been developed for young policy and decision makers as part of the SWITCH-Asia Regional Policy Support Component supported by UNEP and European Union.

Student responsibilities:

Attendance, feedback and discipline: As per university rules.

Course reviewers:

1. Dr Suneel Pandey, TERI
2. Dr Malini Balakrishnan, TERI

Course title: India and the World			
Course code:	**No. of credits:** 2	**L-T-P:** 26-2-0	**Learning hours: 2**8
Pre-requisite course code and title (if any): None			
Department: Policy Studies			
Course Coordinator(s): Dr. Prodipto Ghosh		**Course Instructor(s)**: Dr. Prodipto Ghosh; Mr. Nitya Nanda & Amb. Ajai Malhotra	
Contact details: prodipto@teri.res.in			
Course type: Core		**Course offered in**: Semester 1	

Course Description:

This course will discuss the debates surrounding globalization, climate change and geo-political and security challenges from an Indian perspective. It will provide an understanding of how international agreements and institutions have been shaping up due to political, technological and economic forces. The role of India as well as the shrinking policy space at the national level will also be discussed. The discussions on how ethics and equity can be mainstreamed into in international law and global institutions will form an important part of the course.

Course objectives:

- To understand the process of globalization, the related institutional structure and their impact on Indian economy
- To understand the climate politics and related economic considerations and how India has shaped the global discourse on it as well as how India is responding to the climate change concerns
- To understand the global geopolitics including security concerns from an Indian perspective and how India has been shaping the global discourse and institution

Course content

Module I	**Globalisation and National Priorities**	**L**	**T**	**P**

1	**Basic Theories** ▪ Theories of industrialisation and development ▪ Export led vs. import substituting industrialisation ▪ Gains from trade ▪ Free trade vs restricted trade	1		
2	**Evolution of Economic Policy in India** ▪ Planned development model ▪ Licencing and import restriction ▪ FDI and capital control ▪ Economic Reforms of 1991 ▪ Growth Performance	1		
3	**GATT/WTO** ▪ Evolution of GATT/WTO ▪ India at GATT ▪ India's Position in Uruguay Round ▪ Doha Round and India ▪ Trends in Global Economy	2		
4	**Regional Trade Agreements** ▪ SAARC, BIMSTEC and BBIN ▪ India's approach to FTAs	1		
5	**Sectorial Issues** ▪ WTO and agriculture in India ▪ Services trade liberalisation ▪ WTO and Indian Industry ▪ Intellectual Property Rights ▪ Standards and non-tariff measures	2		
6	**Investment and Development Cooperation** ▪ Indian Approach to BIT and investment ▪ FDI into India ▪ Outward FDI from India ▪ India and development cooperation	2		
7	**Group Presentation**		1	
Module II	**Changing Geo-politics and Implications for India**			
1	**India's Foreign Policy and its Relations with Major Powers** ▪ Main Directions, Priorities and Pillars ▪ Non-Alignment and Strategic Autonomy ▪ India-USA: Partner Democracies ▪ India-China Relations: Current Status and Speed-breakers ▪ India-Russia: Strategic Partnership & Continuity with Change ▪ India-EU Relations	1		
2	**USA-Russia-Europe** ▪ Roots of Geopolitical Tensions in the 21st Century ▪ USA-Russia-EU contemporary ties ▪ Deterioration in Russia-West relations ▪ Trump-Putin-Merkel/May/Macron	1		

3	**Major Contemporary Geopolitical Fissures (1 Lecture)** ▪ Syria ▪ Ukraine ▪ South China Sea ▪ DPRK	1		
4	**India's Immediate Neighbourhood** ▪ India Relations with Pakistan and its other neighbours ▪ China: A Rising Power ▪ Russia-China: Partnership Trends since 2000 ▪ USA-China Relations ▪ One Belt - One Road, China-Pakistan Economic Corridor and its Implications for India	1		
5	**Geopolitics in India's Extended Neighbourhood** ▪ West Asia ▪ Central Asia ▪ RIC, BRICS, SCO, CICA, CSTO and the Eurasian Economic Union ▪ India's Act East Policy; Japan, ASEAN & Australia ▪ Africa ▪ Indian Ocean	2		
6	**India at the UN & Other Multilateral Bodies** ▪ India and the UN ▪ UN Reforms & India's Quest for a Permanent UN Security Council Seat ▪ India and Multilateral Environmental Negotiations - Ozone Layer Depletion, Climate Change, Forestry and Biodiversity; Sustainable Development and the SDGs)	1		
7	**Group Presentations**		1	
Module III	**Climate Change - Politics, Vulnerability and Adaptation**			
1	**Science of Climate Change** ▪ The Scientific Method ▪ The mainstream view: The IPCC process ▪ Alternative views	2		
2	**Climate Change Mitigation** ▪ Concepts of GHG abatement costs ▪ The theory and practice of the carbon market	2		
3	**Climate Change Abatement** Concepts of Abatement Costs	1		
4	**Equity in Climate Change** ▪ Approaches of developed and developing countries ▪ Need for formal justification	1		
5	**Climate Change Finance** ▪ International ▪ National	1		
6	**Climate Change Policy**	2		

	▪ International Climate Change Policy ▪ National Climate Change Policy			
7	**Group Presentations** ▪ The course grade will be based on the Group Presentations	1		
	Total	**26**	**2**	**0**

Evaluation criteria:

- Class discussion 25%
- Presentation 25%
- Book Review 25 %
- Article Review 25 %

Learning outcomes

On completion of this course, the students would:

- Have acquired an understanding of the concept and theoretical background of globalization, climate and security geo-politics and the role of India in the process
- 2. Have developed critical thinking on the global discourse on trade, climate change and geo-politics including the role global institutions and agreements and their impacts on Indian policies and institutions

Pedagogical approach:

The course will be delivered through a mix of classroom lectures and discussions on select readings. Students will be encouraged to read scholarly works from different disciplines.

Materials:

Required text

Suggested readings

1. Thirlwall, A P (2013) Economic Growth in an Open Developing Economy, London: Edward Elgar
2. Basu, Kaushik and Annemie Maertens (2012) The New Oxford Companion to Economics in India. New Delhi: Oxford
3. WTO (2015) Understanding the WTO (Fifth Edition), Geneva: WTO
4. Nanda, Nitya (2008) Expanding Frontiers of Global Trade Rules: The political economy dynamics of the international tradeing system, London: Routledge
5. CUTS (2015) India's FTAs and RCEP Negotiations, Jaipur: CUTS
6. Chaturvedi, Sachin and Anthea Mulakala (Eds) (2016) India's Approach to Development Cooperation, Londin: Routledge.
7. Nayyar, Deepak (2017) Economic Liberalisation in India: Then and Now, Economic and Political Weekly, January 14, 2017 vol 52 no 2 41-48
8. Nagraj, R (2017) Economic Reforms and Manufacturing Sector Growth: Need for Reconfiguring the Industrialisation Model, Economic and Political Weekly, January 14, 2017 vol 52 no 2 61-68
9. Nanda, Nitya (2009), "The Indian Growth Story: Myths and Realities", Journal of Asian and African Studies, 44 (6), pp74-765**.**
10. Fifth Assessment Report of The Inter-governmental panel on Climate Change (IPCC): 2013-14: www.ipcc.ch
11. The Report of the Nongovernmental International Panel on Climate Change (NIPCC), 2009: The Heartland Institute: climatechangereconsidered.org

12. The UN Framework Convention on Climate Change, 1992: www.unfccc.int
13. The Kyoto Protocol, 1997: www.unfccc.int
14. The Bali Action Plan, 2007: www.unfccc.int
15. The Copenhagen Accord: 2009: www.unfccc.int
16. Cancun Decisions: 2010: www.unfccc.int
17. The Durban Platform: 2011: www.unfccc.int
18. The Paris Agreement: 2015: www.unfccc.int
19. A Guide to the Climate Change Convention Process, Climate Change Secretariat, 2002: www.unfccc.int
20. The Principle of Common But Differentiated Responsibilities: Origins and Scope, A CISDL Legal Brief, 2002.
21. State and Trends of the Carbon Market 2010: The World Bank, Washington DC, May 2010:www.carbonfinance.org
22. Report of the High Level Panel on the Clean Development Mechanism: www.unfccc.int
23. Implementation of the Kyoto Protocol, Prodipto Ghosh (Ed.), Asian Development Bank, Manila, 2000.www.adb.org
24. Stern Review on the Economics of Climate Change, 2006: Government of UK: http://www.webarchive.nationalarchives.gov.uk
25. Comment on the Stern Review: William Nordhaus, May 2007
26. India's GHG Emissions Profile: Results of Five Climate Modeling Studies, 2009, Ministry of Environment & Forests, Government of India: http://www.envfor.nic.in
27. Pathways to a Low-carbon Economy, 2009, McKinsey and Co: http://www.mckinsey.com/globalGHGcostcurve
28. Economics of Adaptation to Climate Change: Synthesis Report, 2010, The World Bank: www.worldbank.org/eacc
29. Country presentations at the AWG-LCA Workshop, Bonn: June 2009: http://www.unfccc.int
30. "Contraction and Convergence": Aubrey Meyer: Green Books, 2001: ISBN 13: 9781870098946
31. "Greenhouse Development Rights": Stockholm Environment Institute, 2008: http://www.GreenHouseRights.org
32. Equity in Climate Change: A suggested approach: Prodipto Ghosh, Economic and Political weekly, Vol. XLVIII No. 12, March 23, 2013
33. Earth Negotiations Bulletin: Daily coverage of climate change negotiations: www.iisd.org
34. Third World Network: Daily coverage of climate change negotiations from a developing country standpoint, and periodic thematic analyses: www.twnside.org.sg

Case Studies

Websites

Journals

Other readings

Additional information (if any)

Student responsibilities:
Active classroom participation; Critical reflections and timely submission according to the evaluation criterion.

Course reviewers:

1. Amb. C Dasgupta, Emeritus Distinguished Fellow, The Energy and Resources Institute (TERI), New Delhi
2. Prof. B S Chimni, School of International Studies, Jawaharlal Nehru University, New Delhi

Course title: Industrial Development and Sustainability			
Course code:	**No. of credits:** 2	**L-T-P distribution:** 18-10-0	**Learning hours:** 28
Pre-requisite course code and title (if any): None			
Department: Policy Studies			
Course coordinator (s): Dr Manipadma Datta		**Course instructor (s):** Dr Manipadma Datta	
Contact details: manipadma.datta@teriuniversity.ac.in			
Course type: Core		**Course offered in:** Semester 1	

Course description:

This course would expose the students to the idea of integrating the sustainability goals with industrial and economic development process. It is likely to act as a vehicle of conceptualizing the sustainable development the world over with a particular reference to India in the context of industrialization process.

Course objectives:

- Understanding the interface between industrial policies and sustainable development goals;
- Integrating the principles and practices of sustainability into industrial policy perspective;
- Internalizing the dynamics of sustainable industrial growth both in national and international context.

Course contents

Module	Topic	L	T	P
1	Idea of a sustainable inclusive industrial development- an introduction: Triple bottom line(TBL), inclusiveness and industrial development; Historical evolution of industrialization and its different phase; Shifting paradigms of development theories and the emerging challenges; Millennium development goals and development agenda; India's goals and strategies for sustainable development; Problems and prospects of developing development indicators.	4	2	
2	Industrial development, economic growth and inclusiveness-development theories and the interconnected issues: Inequality ; Poverty; Population;	3	1	

	Job creation; Regional imbalances; Rural urban divide.			
3	India's industrial development policies- a critique: Industrial development scenario in pre and post-independence era; Industrial policies since independence; India's position on global industrial map; Contemporary trends; India's prospects and challenge	3	1	
4	Green and Sustainable industrialization: the policy perspective: Enabling the sustainable industrial environment; Encouraging industry-led initiatives; MSME sector; Public sector; Private sector. Harnessing environmental technologies; Instruments development for promoting sustainable industry; Value chain analysis for better stakeholders' management.	2	2	
5	Sustainability and industrial relations: Role and structure of industrial relations; Need for structural adjustments; Social partnering and its challenges; Introducing sustainable performance parameters at organizational levels and its challenge.	2	2	
6	Sustainability and the market: Market awareness and indicators; Responsible investment principles; Role of market indices; Market instruments and sustainable financing; Market capitalization and sustainability issues; Role of market regulators.	2	1	
7	Politics and sustainable industrial development: The national and international dynamics; International efforts, differences and divides; National priorities and sustainability issues; Problems and prospects of funding.	2	1	
	Total	**18**	**10**	**0**

Evaluation criteria:

- Assignments and presentations 60%
- End term Exam 40%

Learning outcomes:

- Students are expected to develop a clear and objective perspective of the sustainability dynamics in the context of industrialization;
- Will be able to contribute to the policy making exercises undertaken for sustainable industrial development.

Pedagogical approach The course will be delivered through class room lectures, group-discussions and case discussion.
Materials: **Required text** **Suggested readings** Kapila, Uma (ed.), Indian Economy since Independence, Academic Foundation, Delhi, 2016. Occasional hand-outs and references as shared from time to time by the faculty. **Case Studies** **Websites** **Journals** **Other readings**
Additional information (if any):
Student responsibilities Expected to interact with the faculty. Original ideas would be appreciated.

Course reviewers:

1. Prof Sonu Goyal, Professor, International Management Institute, Delhi
2. Prof. S Bhattacharya, Director, Institute of Management Technology, Nagpur

Course title: Energy Policy and Sustainable Development			
Course code:	**No. of credits:** 2	**L-T-P:** 16-10-4	**Learning hours:** 28
Pre-requisite course code and title (if any): None			
Department: Policy Studies			
Course coordinator: Dr Jami Hossain		**Course instructor:** Dr Jami Hossain, Dr Atul Kumar	
Contact details: jami.hossain@teriuniversity.ac.in			
Course type: Core		**Course offered in:** Semester 1	
Course description: Energy is at the centre of achieving both the climate and the sustainable development goals that the world has committed to. At the same time ensuring its availability, efficient use and access is critically important to the growth and development of any country. The course is designed to enable the student to understand the challenges of understanding energy security, its complex interactions with the economy and society as well as the tools available to assess impact on multiple, often competing goals.			
Course objectives The objective of the course is to sensitize the student to the role of energy in society, the multiple means of meeting energy service demands, global energy linkages, emerging scenarios of			

vulnerability and the instruments and tools available for effective energy policy formulation. At the end of the course, the student will have an enhanced understanding of the need for an integrated energy policy and the impact of alternative policies on the energy security of a country and its populace. By the end of the course, the students will be able to:

- Frame issues from a public policy energy and sustainability perspective
- Create a matrix of cross-sectoral issues and linkages
- Assessment of unintended outcomes and risks
- Assessment of Policy implementation challenges
- Have an understanding of path dependencies

Course contents

Module	**Topic**	**L**	**T**	**P**
1	**Basic Introduction to Energy:** Comprehensive overview of different forms and sources of energy being used, particularly in the context of India; Distinction between primary and secondary forms of energy; Different units of measurement used conventionally and their equivalence. Total energy mix of the country with regard to the availability of different forms of energy, distribution, supply mechanism and end-uses.	1	1	
2	Energy and Sustainable Development: Many linkages of energy with other sectors and areas such as economic development, environment, health, gender, agriculture, livelihoods etc.; Linkage between energy and sustainable development	2	1	
3	Energy Security: Energy security and energy dependence for different levels in the society such as – household, community, company and a country; Geopolitics associated with energy security concerns, trading and transnational flow and the issue of control over strategic areas from an energy security perspective.	1	1	
4	Energy, Technology & End-use: Policy implication of energy conversion, technology, process and end-use. Three dimensions of energy from a policy intervention perspective.	2	1	
5	Energy Infrastructure and Path Dependencies: Weighing options, making tradeoffs and judgments w.r.t. technology and infrastructure approaches. Assessment of pathways for energy intensity and path dependencies.	2	1	
6	Energy Poverty: Policy implications of Energy poverty, distinction between energy poverty and poverty, infrastructure access, remoteness and affordability.	1	1	
7	Evolution of Energy Policy in India: Evolution of Energy policy in India; Pre Reforms; Post Reforms; Recent Trends. Electricity generation, transmission and distribution; PSUs, mini and maha-ratna; Oil & Gas	2	1	

	In the pre-reform period, the focus of energy policies was mainly on development generation and transmission capacities under public sector. Private investments, unbundling of the state utilities, Electricity Bill 2003 and formation of State and Center Electricity Regulatory Commissions. Electricity generation tariffs arrived at through competitive bidding in renewable energy.			
8	Energy Scenarios and energy vulnerabilities: Scenarios analysis in policy formulation, building futuristic and long-term scenarios with modeling techniques, quantitative and qualitative parameters in future associated with the chosen policy options. Vulnerabilities associated with policies. Multi-dimensional, cross-sectorial and intended and unintended fallouts of a given policy option.	2	1	
9	Policy Tools & Techniques: Tools and methods to address complex Energy policy problems in the context of sustainable development. Assessment of the desirability of a policy option. Different kinds of analysis such as GIS, cost-benefit, social cost benefit, tradeoffs, technology evaluation etc.	2	1	3
10	Policy Case Studies: Analysis of case studies to examine linkages with other sectors, risks, dependencies, sustainable development, scale etc. Energy policies from past and present. For example : Bio Fuel Policy, UMPP, current Bidding and Auctions in Wind and Solar projects	2	1	1
	Total	**16**	**10**	**4**

Evaluation criteria:

- Assignment 40%
- Term Paper 30%
- Case Study Analysis and Presentation 30%

Learning outcomes:

At the end of the course, the course participant will have:

- Comprehensive understanding of the Indian energy sector, its evolution, the sustainability issues and the evolution of the policy landscape
- A deeper understanding of the nature of the policy issues and the interplay of many cross-sectorial aspects that must be considered in policy making in the energy sector
- A broad understanding of tools and techniques needed for policy making in the context of energy sector and sustainable development
- Ability to analyse a given policy for risks and intended and unintended outcomes
- A deeper understanding of path dependencies, scenarios and vulnerabilities in policy making
- An understanding of what may or may not work through an analysis with case-studies.

Pedagogical approach:

A combination of class-room interactions, participative group discussion and presentations, tutorials and assignments

Materials:

Required text

1. Power Sector Outlook IEA
2. India :Five Years of Stabilization and Reform and the challenges ahead
3. Electricity Act 2003
4. TERI Energy Data Directory (TEDDY) 2016 (TERI Press, 2016)

Suggested readings

Websites and Links:

5. Ministry of new and renewable energy
6. Planning commission
7. Ministry of Power
8. Niti Ayog
9. Energy Access in India – Today, and Tomorrow : CEEW Report **(http://ceew.in/pdf/CEEW-Energy-Access-in-India-Today-and-Tomorrow-1Jul14.pdf)**
10. The Status of Rural Energy Access in India: A Synthesis (BELFER Center) (http://www.belfercenter.org/sites/default/files/files/publication/ETIP_DP_2010_09.pdf)
11. Additional select Presentations and papers will be circulated.

Case Studies

Journals

Other readings

Additional information (if any):
There will be a test after the completion of the course

Student responsibilities:
Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharing within the class

Course reviewers:

1. Alok Srivastava (IAS), Ministry of shipping, GOI; Transport Bhawan, Sansad Marg,New Delhi,110001
2. Arunabha Ghosh, CEO, Council on Energy, Environment and Water, Thapar House, 124, Janpath, New Delhi 110001, India
3. Varsha Joshi (IAS), Secretary Power & Transport , Gov of NCT of Delhi

Course Title: Governance and Law

Course Code:	**No. of Credits:** 2	**L-T-P Distribution:** 28-0-0	**Learning hours:** 28
Pre-requisite course code and title (if any): None			
Department: Policy Studies			
Course coordinator: Dr M V Shiju		**Course instructor:** Dr M V Shiju	
Contact details: mvshiju@teriuniversity.ac.in			
Course Type: Core		**Course offered in:** Semester 1	

Course description:

This course is designed keeping in mind that the participants are professionals who have experience in implementing policies and have meaningfully contributed to policy making. With that assumption, the course starts with a module intended to refresh some basic concepts that try to locate the role of law in public policy. The remaining modules are intended to study in somewhat detail two dynamic areas of governance that have huge relevance to public policy: independent regulation and environmental governance. This course will directly help the participants in their major projects.

Course objectives:

- To critically analyse the role of independent regulators in governance and the impact of independent regulation in policy making
- To understand the competition law regime and its impact on governance
- To appreciate the importance of law in addressing environmental concerns, influence of international norms and the role of judiciary in environmental governance

Course contents

Module	**Topic**	**L**	**T**	**P**
1.	**Law and Public Policy: Introduction** Importance of law and institutions in public policy Constitution: Source and limitation on governmental power International law and its influence on policy making An introduction to Administrative Law	6		
2.	**Independent regulation: Concept and Theories** Theories of regulation- Types of regulation Genesis of Independent regulation-evolution of regulation in different jurisdictions – Different routes to regulation Scope and functions - regulatory process- regulatory autonomy and accountability	4		
3.	**Regulation in Infrastructure sector in India: Case study** Independent regulatory bodies in different infrastructure sectors: Electricity, Telecom and Transport Review of the reforms - Role of the sector regulator and the Government Measuring Regulatory Performance: Impact on consumer welfare; improvement in efficiency in service; ensuring equity, justice and environmental protection Policy directives by the government – Different approaches Regulatory Impact Assessment	6		
4.	**Competition law and policy**	4		

	Need for competition law and policy - Origins and scope – development dimensions – government procurement Regulation-Competition interface; Role of sector regulators in promoting competition			
5.	**Environmental law and policy** Evolution of environmental laws in India – Role of Judiciary Constitutional provisions – Overview of laws and institutions Role of judiciary in policy making; general principles Public participation in environmental decision making	8		
	Total	**28**	**0**	**0**

Evaluation criteria:

- Presentations: 50%
- Term paper: 50 %

Learning outcomes:

On completion of this course, the participants would be able to:

- Make contributions in the form of articles and policy briefs that analyses the role of independent regulatory bodies in ensuring equity, justice and socio-ecological integrity
- Critically analyse the role of judiciary in policy making and implementation especially in the field of environmental law.

Materials:

Required text

Suggested readings

Reading material in the form of articles, case studies, orders by regulatory commissions, judgments by higher judiciary etc. will be circulated for each topic of discussion. In addition the following readings would give a broad background to the course:

1. Khosla, Madhav (2012). The Indian Constitution. Oxford University Press, New Delhi.
2. Baxi, Upendra (2016). Law, Politics, and Constitutional Hegemony: The Supreme Court, Jurisprudence, and Demosprudence. In Choudhry, Sujit et.al. The Oxford Handbook of the Indian Constitution. Oxford University Press, New Delhi.
3. Singh, M. P. (2016). The Federal Scheme. In Choudhry, Sujit et.al. The Oxford Handbook of the Indian Constitution. Oxford University Press, New Delhi.
4. Moran, Michael (2002). Understanding the Regulatory State. British Journal of Political Science, 32 (2): 391-413.
5. Thiruvengadam, Arun and Joshi, Piyush (2013). Judiciaries as Crucial Actors in Southern Regulatory Systems: A Case Study of Indian Telecom Regulation. In Dubash, N. K. and Morgan, M. The Rise of the Regulatory State of the South. Oxford University Press, Oxford.
6. Dubash, Navroz K. (2006). Emergent Regulatory Governance in India: Comparative Case Studies of Electricity Regulation. http://regulation.upf.edu/bath-06/10_Dubash_Rao.pdf
7. Singh, Ajit (1999). Competition Policy, Development and Developing Countries. Working Paper, ICRIER, New Delhi.
8. Guha, Ramachandra (2006). How Much Should a Person Consume? Chs. 4 and 5. Permanent Black, New Delhi.

Case Studies **Websites** **Journals** **Other readings**
Additional information (if any):
Student responsibilities: Attendance, timely feedback, discipline: as per university rules, adopt peer learning and knowledge sharing within the class

Course reviewers:

1. Prof. M. P. Singh, National Law University, Delhi.
2. Prof. S. Sundar, Distinguished Fellow, TERI, New Delhi.

Course title: Challenges of a Digital Economy			
Course code	**No. of credits:** 2	**L-T-P:** 21-7-0	**Learning hours:** 28
Pre-requisite course code and title (if any): Brief understanding of digital technology			
Department: Policy Studies			
Course Coordinator(s): Mr Atul Tripathi		**Course Instructor(s)**: Mr Atul Tripathi	
Contact details: atul.tripathi2007@gmail.com			
Course type: Core		**Course offered in**: Semester 1	
Course Description Digitization and internet connectivity has become the backbone of the Fourth Industrial Revolution. There has been an exponential growth in digitization and internet connectivity. It has the potential to propel societies forward, enable innovative business models and help governments address legitimate policy concerns. Digitization is transforming business models, the policy landscape and social norms. In the Digital Economy and Society a shared, trusted digital environment is created which is driver of inclusion, economic development and social progress. The digital environment aims to create networks that enable and encourage action to promote the long-term health and stability of digitally enabled economies and societies. The course aims to provide inputs on appropriate elements required for national strategy, provide a brief understanding of various aspects of how digitization has impacted various aspects of life in general for common man.			
Course objectives ▪ Understand the various aspects of digitization of data ▪ Understand the impact on economy, society on digitization of data			

- Understand the impact of digitization of data on financial crime, analytics
- Become mindful of a wide range of applications of digitization & decision making

Course content

Module	Topic	L	T	P
1	**Big Data in Action for Development** What is Big Data? How can we better understand and utilize big data? What is the business impact of big data? What can big data look like for development sector? How can we work with big data? How to reach big data maturity? What are some of the challenges and considerations when working with big data?	3	1	
2	**Internet of Things – Unleashing the Potential of Connected Products and Services** The state of the market. The four phases of the evolution. Key near-term opportunities and benefits. Major challenges and risks. Convergence on the outcome economy. The emergence of the outcome economy. Delivering outcomes through connected ecosystems and platforms. Shift towards an integrated digital and human workforce. Enhancing productivity and work experience through augmentation. Reskilling for digital industries.	3	1	
3	**Smart Cities – Future of Urban Development & Services** Emerging urban landscape. Challenges in urbanization. Urban development initiatives. Challenges Due to Urbanization. The Future of Cities. Challenges in Urban Transformation. The Business of Running Cities: Urban Services. Enablers for Adopting New Models for Urban Services. Accelerating Public-Private Partnerships for Urban Services. Recommendations for Accelerating Urban Rejuvenation Programs – Business environment reforms, Sector-specific recommendations, Private-sector action items, State Specific Action Items. Roadmap for Urban Transformation – Approaches & Action Plan	3	1	
4	**Big risks big data thinking – Anti Money Laundering/Trade Based Money Laundering** Big risks require big data thinking. Why use FDA: key benefits and adoption. Technology: the right tools for the right job. Turning data into information. Leverage analytics, mitigate risks. Secure the buy-in, execute the build. Essentials of an effective program. Extent and prevalence of Trade Based Money Laundering (TBML) Problem. Role of agencies responsible for TBML. Domestic and international cooperation and training. Significance of TBML. The trade finance environment.	3	1	
5	**Digital Transformation of Healthcare Industry** Value in Healthcare – Defining the problem, What value means in healthcare. Foundational Principles of Value-Based Care Delivery – Measuring outcomes and costs, Focusing on distinct population segments, Customizing segment-specific interventions, A preliminary roadmap for system transformation. Industry Context. Key Enablers of Value in Healthcare. Role of Public Policy. Future Horizons.	3	1	

	Recommendations – Government and all stake holders. Next Steps for the Value in Healthcare Project.			
6	**Impact of Big Data on the Future of Insurance** What is big data? What is insurance? How is data currently used in insurance? Implications for society due to data usage in insurance industry – Better risk signaling, Greater premium dispersion, Other consequences. Benefit for Society – Recent developments in risk monitoring and reduction. Challenges faced – Privacy concerns. Considerations for Policy Makers.	3	1	
7	**Digital Dividends** Overview: Strengthening the analog foundation of digital revolution. Facts and Analysis – Accelerating growth and Expanding opportunities (Focus on sectors – Agriculture, Digital Finance, Education, Social Media, and Digital Identity). Policies – Sectoral Policies, National priorities, Global Cooperation (Focus on – Energy, Environment Management).	3	1	
	Total	**21**	**7**	**0**

- **Evaluation criteria**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Quiz + Presentation: 10%**
- **Essay: 30%**

Learning outcomes:

- Develop an understand on the impact of digitization on economy, society at large
- Understand the upcoming trends and directions in the digital world

Pedagogical approach:

The course will be delivered through class room lectures, discussion of case studies from relevant research articles.

Materials:

Required text

Suggested readings

1. Big Data @ Work by Davenport
2. Big Data: A Revolution That Will Transform How We Live, Work and Think by Viktor Mayer-Schonberger, Kenneth Cukier
3. The Internet of Things by Samuel Greengard
4. Getting Started with the Internet of Things by Cuno Pfister
5. Smart Cities – Big Data, Civic Hackers, and the Quest for a New Utopia by Anthony M. Townsend

6. Building Smart Cities: Analytics, ICT, and Design Thinking by Carol L. Stimmel 7. Data-Driven Healthcare: How Analytics and BI are Transforming the Industry by Laura B. Madsen 8. Healthcare Disrupted: Next Generation Business Models and Strategies by Jeff Elton and Anne O′Riordan 9. Analytics for Insurance: The Real Business of Big Data by Tony Boobier **Case Studies** **Websites** **Journals** **Other readings**
Additional information (if any) Students to carry laptops.
Student responsibilities The students are expected to come prepared with readings when provided and undertake tests at the end of each session.

Course reviewers

1. Supid Ratan Chandra **–** Senior Independent Consultant with over 15 years' experience. Email – sudipratan@gmail.com. M - +919831358849
2. Prof H. Karnick **–** Professor – Dept. of Computer Science & Engineering, IIT Kanpur. Email – hk@ iitk.ac.in. M - +919307324012

Course title: Policy Lab-I			
Course code:	**No. of credits:** 2	**L-T-P**: 10-0-36	**Learning hours:** 28
Pre-requisite course code and title (if any): None			
Department: Policy Studies			
Course coordinator(s): Prof Shri Prakash		**Course instructor(s):** Prof Shri Prakash and Dr Leena Srivastava	
Contact details: shri.prakash@teri.res.in			
Course Type: Core		**Course offered in:** Semester 1	
Course Description ▪ Analyse a major existing or proposed policy of the Government, Central or State, from the lens of promoting sustainability ▪ Evaluate from the perspective of promoting inclusive growth, protecting the environment and social progress and mainstreaming SDGs; ▪ Assess the policy for any unintended systemic consequences			
Course objectives ▪ The group of students assigned to examining a policy would bring a multi-disciplinary and			

multidimensional perspective in policy formulation exercise. Other students from across the University would be invited to join the group to assist with data collection and detailed analysis as required.

- The disciplines covered may include Engineering, Science, Law, Social science and Economics
- The Dimensions to be addressed would include: Policy, Regulation, Management, Finance, Land, Community and Institution etc.
- Final product after the completion of exercise will be a policy brief or a policy discussion paper

Course content

Module	Topic	L	T	P
1	**Policy Analysis:** Context; History, Objective and the process of policy formulation Linkages of the identified policy with other Goals (SDGs and MDGs etc.)	6		20
2	**Stakeholder analyses:** Map the stakeholders, discuss their interests and how they would help in moving forward Linkage with various Government departments and State Governments, Business and industry, Consumers, Environmental and Social activists/Think Tanks etc.	4		16
	TOTAL	**10**	**0**	**36**

Evaluation criteria:

- At the end of the First Semester, the Group is expected to produce an end semester report that would contain the analytical results.
- At the end of Second Semester, the Group will submit the final document in terms of a policy brief or a discussion paper.
- There will be detailed presentation at the end of both the Semesters by the Group.
- A Jury comprising faculty and policy makers would evaluate the work at both the stages.

Report - 60%
Presentation - 40%

Learning outcomes

A diagnostic assessment and recommendations to the relevant government(s) on enhancing sustainability outcomes and minimising any unintended negative consequences

Pedagogical approach

This course is based on diverse pedagogies like the content analysis; group-work and individual presentation etc.

Materials:

Not applicable

Required text

Suggested readings

Case Studies

Websites

Journals
Relevant material and literature will be made available for understanding and examining a particular policy

Other readings

Additional information (If any):

Student responsibilities:
- The course is based on group work by the course participants under the guidance of both faculty and outside experts.
- Attendance and discipline

Course reviewers:
1. Dr. S K Sarkar, Distinguished Fellow, TERI and former Secretary to Government of India
2. Mr Vijay Kumar, Distinguished Fellow, TERI and former Secretary to Government of India
3. Dr. Pradipto Ghosh,, Distinguished Fellow, TERI and former Secretary to Government of India

Annexure 9

PhD REGULATIONS -2017

Preamble

1. TERI University provides an environment that encourages academic excellence. The university offers PhD programs in wide range of areas including Natural resources management, Energy and Environment, Economics, Biotechnology and Social sciences etc.

Scope

2. This policy will be called "TERI University PhD Regulations-2017" and shall be applicable to the faculty members and PhD students of the university.

A. Eligibility criteria for admission to Ph.D. programme:

3. Subject to the conditions stipulated in these Regulations, the following persons are eligible to seek admission to the Ph.D. programme:

a. 02 yr M.Sc/MA or M Phil in a relevant field or equivalent. 01yr PG degrees may be accepted in exceptional cases.

b. In extremely exceptional cases the admission committee may consider an application from a candidate who possesses a BTech in a relevant field or equivalent. Only those who have a minimum CGPA of 8.0 on a 10 point scale or 75% marks should consider applying in this category. It may be noted that consideration under this category would be evaluated by an evaluation committee and would entail extended pre-Ph.D course work requirement.

c. Candidates (sponsored/non-sponsored) applying on part-time basis need to have a minimum work experience of 3 years in organizations approved by the Department Research Committee.

d. Additional requirements for full-time sponsored candidates

(i) Sponsored candidates are required to submit a sponsoring certificate from their employers on proper letterhead stating that for the period of his/her studies in the programme, the candidate would be treated as on duty with usual salary and allowances and that he/she will be fully relieved for the period of study for pursuing his/her study and the fee of the candidate will be paid by the sponsoring organization.

(ii) Candidates seeking admissions to Ph D programmes on the basis of study leave must show proof at the time of interview of the fact that they will be/have been granted study leave for a minimum period of three years.

e. Additional requirements for part-time (sponsored and non-sponsored) candidates

(iii) Non-sponsored candidates are required to submit a 'No Objection Certificate' at the time of interview from their employer stating that the candidate is permitted to pursue studies on a part-time basis and that:

aa. His/her official duties permit him/her to devote sufficient time for research;

ab. The candidate shall be provided access to the facilities in the field of research;

ac. He/she shall be permitted to attend classes at the University as required by the University.

B. Admission:

4. Admission will be made on the basis of a test/interview conducted by the University. Candidates may apply at any time throughout the year. Admission is subject to vacancies available in the relevant specializations. Categories of admission:

(a) Full time with assistantship/without assistantship

(b) Full time with UGC/CSIR/DBT/other research scheme scholarship

(c) Sponsored

(d) Part-time

C. Duration of the programme:

5. Ph.D. programme shall be for a minimum duration of three years, including course work and a maximum of six years. This may be waived by the Academic Council only in extremely exceptional cases when recommended by the Department Research Committee.

D. Extension criteria

6. This maximum time limit for submission of thesis may be extended by the Academic Council based on the recommendation of DRC as a special case for a period of 1 year (on a maximum of 2 occasions), after which the registration will stand cancelled. While recommending to the Academic Council, the DRC may consider one or more of the following criteria as accentuating Circumstances (based on the evidence produced by the candidate):

a. Medical exigency.

b. Forced break due to employment requirement (in case of part time candidates only).

c. Discontinuity in supervision (due to non-availability of supervisor).

d. Change in focus of research due to emergence of any new/unforeseen challenges in conducting research (e.g. security threat).

e. Candidate at an advanced stage of research requiring a defined time only after approval from DRC and SRC. The DRC in such caseshould consider research output achieved such as publication(s).

7. After 04 years (including Course work), the Supervisor has to justify as to why extra time is needed.

8. The University has to specify for part time students as to how many zero semesters could be permitted.

9. Full/Part time candidate may be allowed to convert his/her registration into Part/Full time on the recommendation of the SRC/DRC. This change will be allowed only once.

E. Allocation/Eligibility of Research supervisor:

10. As per UGC letter No. F. No. 14-4/2016(PS), following are the eligibility criteria to be a Research Supervisor/Co- Supervisor:

a. PhD supervisor has to be amongst the regular faculty of TERI University only and co- supervisor can be appointed from within or outside of the university, if necessary.

b. All Adjunct faculty members can act as co-supervisor.

c. Department concerned can appoint Co-supervisor from outside the Department/Faculty/university in case of topics of inter-disciplinary nature.

d. Any regular Professor should have at least five (5) research publications in refereed journals and any Associate / Assistant Professor with at least two (2) research publications in refereed journals in order to be recognized as Research Supervisor. Further, if there is limited number of referred journals in the particular discipline, these rules can be relaxed with a written explanation.

e. A faculty at the rank of Professor is allowed to supervise at most Eight (8) PhD Scholars, at a time. An Associate and Assistant Professor can supervise up to six (6) and four (4) PhD Scholars respectively, at a time.

11. Change of Research Supervisor:-

a. If a Research Supervisor takes up a short-term assignment outside TERI University, the candidate will be permitted to continue his / her research under the same Research Supervisor OR he/she may be permitted to change his / her Research Supervisor, after obtaining the approval of DRC. However, the duration of PhD, the area of research and the title of the study shall remain unaltered.

b. In case the Research Supervisor leaves TERI University permanently, he/she cannot continue to guide any scholars in TERI University. The candidate is encouraged to identify a potential supervisor in consultation with the DRC Chairperson/PhD Coordinator, and seek approval of DRC for such a change within a reasonable period, but not more than one month from departure of the former Supervisor from the University. The DRC can Suo

motu assign a new supervisor, if it feels so, which will be binding on the student. However, a Research Supervisor who has left TERI University can continue as a Co-Supervisor, if approved by the DRC.

c. A supervisor may request to relinquish a student in case he/she feels that a conflict of interest may arise or if there is a change of research topic outside his area of expertise. However, in such exceptional circumstances, the interest of the student is to be safeguarded and such a change must have the approval of the DRC.

d. In exceptional circumstances, a candidate wishing to have a change of supervisor can make an appeal to the Chairperson DRC with clear and specific reasons for the request. The Chairperson DRC on the merit of the case may recommend the matter for consideration to a Committee set up for this purpose comprising of both Deans and the Chairperson DRC. The decision of the Committee will be binding on all concerned. The Committee, if recommending a change of supervisor, will also make recommendations on the rights of the supervisor and the student for using the past-work.

F. Pre-PhD course requirements

12. The Pre-PhD course requirements shall be as follows:-

a. In order to overcome any deficiency in the breadth of fundamental training for advanced work, several courses are offered across disciplines taught at the University. Such courses would include those at Masters level or could be special ones created only for the doctoral student/s.

b. The courses will be offered by TERI University.

c. The credit assigned to the Ph.D. course work shall be a minimum of 8 credits and a maximum of 16 credits.

d. Four credits shall be assigned to one or more courses related to Research Methodology which could cover areas such as quantitative methods, such as statistics, computer applications, research ethics and review of published research in the relevant field, training, field work, etc. Other courses shall be advanced level courses preparing the students for Ph.D. degree.

e. The course requirement will be determined by the DRC (Department Research Committee)/ on the recommendations of the SRC (Student Research Committee) after considering the student's background in relation to the proposed topic of research.

f. Grades in the course work, including research methodology courses shall be finalized after a combined assessment by the SRC and the Department and the final grades shall be communicated to Registrar.

g. The minimum CGPA requirement will be 7.0.

h. The pre-PhD course work must be completed within the first two semesters and the first three semesters of joining the programme by full-time and part-time students, respectively.

G. Comprehensive examination

13. A student shall be formally registered/ admitted to a PhD programme only after s/he has cleared the comprehensive examination. Students will be permitted to take the comprehensive examination only after they have completed the pre-PhD course work as decided by the SRC and defined in F.12.d. Full-time and part-time students must clear the comprehensive examination within a period of 18 months and 24 months, respectively, from the date of joining. Every student, after having completed the comprehensive examination, must formally register for the PhD programme.

14. As part of the comprehensive examination the student shall submit a PhD research proposal document, prepared in consultation with the supervisor. The same should be submitted to the examination panel members at least one week in advance of the comprehensive examination. An external examiner may be part of the comprehensive examination panel if suggested by the SRC.

15. The student's evaluation will be based on an oral presentation and the accompanying write-up of the research proposal that should include its proposed title, introduction and literature review, rationale for research, aim, research objectives/questions, broad framework/tentative methodology, expected outcomes and proposed timeline. The presentation should also list the pre-PhD courses attended, grades scored and any other research-related activity undertaken.

16. There shall be a repeat of comprehensive examination decided by the SRC, in case of failure in 1st attempt or major change in focus of proposed research.

H. Attendance requirements for Ph D students

17. The attendance requirement for PhD students shall be as follows:-

a. A Ph D student, whether full-time or part-time, is expected to attend all classes in each course in which he/she is registered. In case his/her attendance is less than 75%, he/she will be debarred from the test/examination for the course and will be awarded an Ab. Grade.

Attendance requirement for PhD students with assistantship/scholarship

b. If a PhD student's attendance falls below 75% in any taught course(s) during a month, s/he will not be paid assistantship/scholarship for that month. Further, if his/her attendance again falls short of 75% in any course in any subsequent month in that semester, his/her assistantship/scholarship will be terminated. A research scholar, after having completed the course work, must attend to his/her research work on all the working days and mark attendance except when s/he has been sanctioned leave. The requirement of 75% attendance will apply as above on daily attendance except in cases where longer leave has been duly sanctioned within the leave entitlement of the student.

Note: For the above purpose, if 75% works out to be a number that is not a whole number; the immediate lower whole number will be treated as the attendance.

I. Grant of leave to Ph.D. students:-

18. The leave regulations for PhD students shall be as follows:-

a. During course work a full-time Ph.D. student, during his/her stay at the University will be entitled to leave for 30 days, including leave on medical grounds, per academic year. He/she will not be entitled to mid-semester breaks, summer and winter vacations. Leave beyond 30 days in an academic year may be granted to a Research Scholar in exceptional cases subject to the following conditions:

i. the leave beyond 30 days will be without assistantship/scholarship; and

ii. such an extension of up to additional 30 days will be granted only once during the programme of the scholar.

The leave will be subject to the approval of the Head of Department/ Dean/ Faculty/ Programme Coordinator concerned on the recommendation of the Supervisor

b. After completing the course work a full-time Ph.D. student during his/her stay at the University, will be entitled to leave for 30 days per academic year. He/she will not be entitled to mid-semester breaks, summer and winter vacations. In addition, a Ph.D. scholar who has completed his/her course work may be granted leave on medical grounds up to 10 days per academic year. Women research scholars will be eligible for maternity leave with assistantship for a period not exceeding 240 days once during the tenure of their programme.

c.

J. Research Committees and their functions:

19. The PhD degree of the University may be conferred on a student who fulfils all the requirements detailed in these rules.

a. Applications for PhD registration, that is, for entry to a course of study and research leading to a PhD degree, must be made to the University on the approved form. The date of registration is the date when candidate registers for Pre-PhD courses. However, in exceptional cases, the date of registration may be advanced by a maximum of six months by the Academic Council if it is convinced that the student has spent enough time on the research earlier.

b. The academic programme of all the PhD students in a Department/Centre will be coordinated by the DRC as per the rules and regulations of the University upon recommendation of the SRC.

c. The supervisor shall be appointed during the first semester. If desirable, the DRC/CRC, based on the recommendation of the SRC, may appoint Co-supervisor(s) (not exceeding two) from within or outside the University. Appointment of any Co-supervisor would not be permitted after the comprehensive examination of the student, except in cases where none of the supervisors is available to supervise for a year or more at a stretch.

d. In the event of the supervisor being unavailable for supervision the SRC will recommend to the DRC that another faculty member as per the provisions given in 11.a & b.

20. The progress of each student will be monitored by the SRC and the DRC/CRC. For this purpose, the following procedures will be followed. PhD research work will be given a course number as is done for other courses.

a. The DRC will coordinate the collection of progress reports, written and signed by the scholar and forwarded by the supervisor every semester.

b. An 'X' grade will be awarded along with comments for that semester if the progress is 'satisfactory'.

c. If the progress is 'unsatisfactory', a 'U' grade will be awarded along with comments. When a 'U' grade is awarded for the first time, a warning will be issued to the student. If his/her performance does not improve after the warning, the fellowship/assistantship may be withheld.

d. If there are two consecutive 'U' grades, the student will have to withdraw from the doctoral programme and his/her studentship will be terminated.

e. The progress of PhD research work will be discussed in the DRC/CRC as per the semester schedule.

f. The above process will continue until the synopsis of the thesis is submitted.

K. Evaluation and Assessment Methods, minimum standards/credits for award of the degree, etc.:

21. The procedure wrt the above shall be as follows:-

a. The student may submit his/her thesis at any time provided that s/he has completed the minimum period of registration and S/he has completed the course work requirement as prescribed by the DRC/SRC with a CGPA not below 7.0 and has also cleared the comprehensive examination, and S/he has submitted, at least two months earlier, the title and a synopsis of the thesis.

b. Upon satisfactory completion of comprehensive examination, and obtaining the marks/grade prescribed, Ph.D. scholar shall be required to undertake research work and complete the same within a reasonable time as stipulated by TERI University.

c. Prior to the submission of the synopsis, the scholar shall make a presentation in the Department before the SRC which shall also be open to all faculty members and other research scholars. The feedback and comments obtained from them may be suitably incorporated into the draft thesis in consultation with SRC.

d. Synopsis submission: On evaluating PhD work, SRC shall approve the Synopsis for submission to DRC.

e. Pre-submission defence: DRC shall call the student to present his/her PhD work through an oral presentation made to all faculty members and PhD students.

f. Ph.D. scholars must publish at least one (1) research paper in refereed journal which is direct outcome of their PhD research (review paper will not be counted as referred paper) and make two paper presentations in conferences/seminars before submission of the thesis

for adjudication, and produce evidence for the same in the form of presentation certificates and/or reprints.

g. The Academic Council shall evolve a mechanism using well developed software and gadgets to detect plagiarism and other forms of academic dishonesty. While submitting for evaluation, the thesis shall have an undertaking from the research scholar and a certificate from the Research Supervisor attesting to the originality of the work, vouching that there is no plagiarism and that the work has not been submitted for the award of any other degree/diploma of the TERI University where the work was carried out, or to any other Institution.

h. Examiners: The DRC shall evaluate and recommend the list of potential Indian and Foreign examiners to the Chairman, Academic Council.

i. The thesis shall be written in English in the specified format and shall contain a critical account of the student's research. It should be characterized by discovery of facts or a fresh approach towards the interpretation of facts and theories or a significant contribution to the knowledge of design or development, or a combination of them. It should bear evidence of the student's capacity for analysis and judgment, and also his/her ability to carry out independent investigation, design, or development. No part of the thesis, or supplementary published work, shall have been submitted for the award of any other degree. Three copies of thesis in soft cover have to be submitted in the prescribed format . In case of joint supervision, four copies of the thesis are required to be submitted. Additionally a soft copy of the thesis shall be submitted for the required plagiarism check. The DRC/ SRC shall deal appropriately with any case of plagiarism

j. On receipt of the title and synopsis of the thesis, the Chairman, Academic Council, will appoint a Board of Examiners for each student. The Board will consist of at least one internal examiner, members from the SRC and two external examiners, one from within India and one from abroad, who shall be an expert in the subject of the thesis. These external examiners shall be selected from a list of six to eight examiners to be recommended by the supervisor(s) through the DRC/CRC while forwarding the title and synopsis of the thesis. The student will be required to submit an updated synopsis, if more than nine months have passed before the submission of the thesis.

k.Each examiner will submit a detailed assessment report recommending to the Chairman, Academic Council, one of the following courses of action.

That the thesis be deemed satisfactory and that the student may defend his/her thesis orally before a committee constituted for the purpose and any members of the faculty and research students who wish to be present.

That the student may submit a revised thesis. In normal circumstances, s/he may submit the revised thesis within a period of one year from the date of communication in this regard from the Chairman, Academic Council.

However, in exceptional circumstances, this period may be extended by the Chairman by another one year; the total revision time, irrespective of the number of revisions allowed, will not exceed a period of two years.

22. In the event of disagreement between the external examiners, the Chairman, Academic Council, may, as a special case, appoint another external examiner, if the merit of the case so demands. The examiner will report independently to the Chairman, Academic Council.

a. The oral defence of the thesis shall be conducted by a committee consisting of the internal examiner(s) and one external examiner. If for some reasons, the external examiner for the oral examination is not available for the conduct of the oral defence, an alternative external examiner shall be appointed by the Chairman, Academic Council. It is recommended that the Pre-submission defence seminar is made at least 2 weeks before the oral defence by each doctoral candidate to all faculty members and PhD students.

b. On completion of all stages of the examination, the Oral Defence Committee shall recommend to the Chairman, Academic Council, one of the following courses of action.

i. That the degree be awarded.

ii. That the student should be examined further on another occasion in a manner they shall prescribe.

iii. That the degree shall not be awarded.

In case of (b. ii), the Oral Defence Committee shall also provide the student a list of all corrections and modifications, if any, suggested by the examiners.

23. The degree shall be awarded by the Academic Council, provided that:-

a. the Oral Defence Committee, through the Academic Council, so recommends;

b. the student produces a 'no dues certificate' from all concerned in the prescribed form and gets it forwarded by the supervisor along with the report of the Oral Defence Committee; and

c. The student has submitted three hard-bound copies of the thesis, after incorporating all necessary corrections and modifications in the version submitted earlier. The hard-bound copies of the PhD thesis, submitted after the viva voce examination.(One of the copies is to be kept at TERI University library.)

24. Candidates will be awarded PhD degree with the title of dissertation irrespective of the discipline or department of graduation.

25. The University shall develop appropriate methods so as to complete the entire process of evaluation of Ph.D. thesis within a period of six months from the date of submission of the thesis.

26. Treatment of Ph.D through Part-time:

Part-time Ph.D will be allowed provided all the conditions mentioned in the extant Ph.D Regulations are met. A member of the non-academic staff of the University, who satisfies the eligibility criteria, may be considered for admission to the degree as a part-time student, provided his/her application is duly approved by the Vice-Chancellor.

Note: Part-time candidates will be required to attend all classes of the pre-Ph D programme.

L. Award of Ph.D degrees prior to Notification of these Regulations, or degrees awarded by foreign Universities.

27. Award of degrees to candidates registered for the Ph.D programme on or before the date of Notification of these Regulations shall be governed by the earlier regulations under which initial admission has been granted.

M. Depository with INFLIBNET:

28. As mandated by UGC the following norms shall be followed:-

a. Following the successful completion of the evaluation process and before the announcement of the award of the Ph.D degree, the Librarian, TERI University shall submit an electronic copy of the Ph.D thesis to the INFLIBNET, for hosting the same so as to make it accessible to all Universities/Institutions/Colleges.

b. Prior to the actual award of the degree, a provisional Certificate shall be issued to the effect that the Degree has been awarded in accordance with the provisions of UGC Regulations, 2016.

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