Course title: Energy Systems Modelling			
Course code: NRC xxx	**No. of credits:** 3	**L-T-P:** 32-10-00	**Learning hours: 42**
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Professor Atul Kumar	**Course instructor:** Professor Atul Kumar		
Contact details: atul.kumar@terisas.ac.in			
Course type: Elective	**Course offered in:** Semester 3		

Course description:

As a part of the course, the students will be acquainted with the framework for energy modelling and analysis, including a detailed overview of various modelling approaches deployed for policy research and analysis for facilitating decisions makers in energy planning and policy formulation. An understanding of the fundamentals of the energy systems modelling allows students to develop skills for critically evaluating the modelling approach to be deployed for the problem/research question at hand. Students will also be trained in methods for deriving the appropriate input drivers used in energy system modelling.

Course objectives:

- To introduce students to the basics of energy modelling including terminology, methods, tools and techniques of energy modelling available to energy practitioners for understanding, assessing and analysing energy systems;
- To impart knowledge on financial analysis of energy technologies
- To successfully equip students on application of modelling techniques for energy-economy-environment interaction related policy analysis and research

Module no.	Topic	L	T	P
1	**Introduction:** Introduction to modelling and decision analysis; rationale for energy systems modelling; classification of energy models: top-down, bottom up and hybrid models.	2	0	
2	**Background tools:** Time value of money; simple and discounted payback period; net present values; internal rate of return; benefit to cost ratio; levelized costs; variable and fixed costs; case studies on techno-economic evaluation of renewable energy technologies.	8	3	
3	**Energy database** Energy data: basic features of energy data; energy data base development; data identification; energy data collection; data analysis	2	0	
4	**Energy demand and supply analysis**: Energy demand driver analysis; Sectoral disaggregation of energy; Energy demand projections: Methodologies - Trend analysis; - End-use method; - Econometric approach Energy supply perspective; Energy supply systems; Resource assessment.	8	3	
5	**Energy modelling** Reference Energy System (RES); integrated energy planning; introduction to multi criteria decision analysis; fundamentals of the TIMES energy model; case study on co-benefits of climate change mitigation options such as health benefits due to improved air quality from replacement of fossil fuel by renewables.	8	4	

6	**Translation of model output into policy** Perspective of policy analysis; policy responses: reduce, replace, and restrict; energy governance and policies: Electricity Act (EA), National Electricity Policy (NEP), Feed-in-Tariffs, Renewable Portfolio Standards; evaluation of alternatives; scenario analysis	6	0	
	Total	32	10	0

Evaluation criteria:

- Test 1: 15%
- Test 2: 15%
- Test 3: 50%
- Assignment/Tutorials: 20%
  (Assignment one will be given after the completion of 3 modules, students need to submit case studies in this linking to the teaching covered; tutorials will have based on module 4 and 5, tool-based understanding will be assessed)

Learning outcomes:

After completing this course students will be able to

- Evaluate options for energy supply, distribution and utilisation (Test 1)
- Understand the role of long term energy-economic- environment modelling in the planning process (Test 1)
- Understand important outputs of bottom-up energy-economic- environment modelling outputs in terms of their economic implications (Test 2 and Assignment 1)
- Define and understand linkages between energy and climate change from an energy planning perspective (Test 2, Test 3 and tutorials)
- Understand and evaluate different scenarios of energy demand and supply with implications on energy policy thereof. (Test 3)

Pedagogical approach:

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

Materials:

Textbooks

Bhattacharyya, S C. (2011), Energy Economics: Concepts, Issues, Markets and Governance, Springer

Kandpal T.C. & Garg, H.P. (2003), Financial Evaluation of Renewable Energy Technologies, Macmillan India

Kornelis Block, 2009. Introduction to Energy Analysis, Techne Press

Munasinghe, M., & Meier, P. (1993). Energy policy analysis and modelling. Cambridge University Press.

Suggested readings

Giannakidis, G., Labriet, M., OGallachóir, B. P., & Tosato, G. (2015). Informing energy and climate policies using energy systems models. Springer International Publishing.

ETSAP, IEA. "TIMES home page." *URL: https://iea-etsap.org/index.php/etsap-tools/model-generators/times*

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).

Herbst, A., Toro, F., Reitze, F., and Jochem, E. (2012). Introduction to Energy Systems Modelling. *Swiss Journal of Economics and Statistics*, Vol. 148, No. 2, pp. 111-135.

Journals

Applied Energy

Computational Management Science

Energy Policy

Energy Economics

Energy

Additional information (if any): NA

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

Course Reviewers

1. Professor Jyotirmay Mathur, Centre for Energy & Environment, Malaviya National Institute of Technology Jaipur
2. Dr. Pallav Purohit, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria