Course title: Energy Systems Modelling			
Course code: NRC 186	**No. of credits:** 3	**L-T-P:** 32-10-00	**Learning hours:** 42
Pre-requisite course code and title (if any): NA			
Department: 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 policy 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 modeling approach to be deployed for the problem/research question at hand, defining the model structure, setting up the model database including the input parameters and model assumptions and, analyzing model outputs and to develop proficiency in model design and application. Students will also be trained in methods for deriving the appropriate input drivers used in energy system modelling.

Course objectives

The purpose of the course is to give the students an overview of the methods and tools used for energy modelling and how to use these.

Course content

Module	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 internal; Benefit to cost ratio; Levelised costs, Variable and fixed costs	8	3	
3.	**Energy database** Energy data: some basic features; Data base development, Data identification; 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; Co-benefit analysis	6	4	
6.	**Translation of model output into policy** Perspective of policy analysis; 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%

Learning outcomes

After completing this course students will be able to

(a) Evaluate options for energy supply, distribution and utilisation

(b) Understand the role of long term energy-economic- environment modelling in the planning process

(c) Understand important outputs of bottom-up energy-economic- environment modelling outputs in terms of their economic implications

(d) Define and understand linkages between energy and climate change from an energy planning perspective

(e) Understand and evaluate different scenarios of energy demand and supply with implications on energy policy thereof.

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 in the subject.

Materials

Textbooks

1. Bhattacharyya, S C. (2011), Energy Economics: Concepts, Issues, Markets and Governance, Springer
2. Kandpal T.C. & Garg, H.P. (2003), Financial Evaluation of Renewable Energy Technologies, Macmillan India
3. Kornelis Block, 2009. Introduction to Energy Analysis, Techne Press
4. Munasinghe, M., & Meier, P. (1993). Energy policy analysis and modelling. Cambridge University Press.

Suggested readings

1. Giannakidis, G., Labriet, M., OGallachóir, B. P., & Tosato, G. (2015). Informing energy and climate policies using energy systems models. Springer International Publishing.
2. ETSAP, IEA. "TIMES home page." *URL: https://iea-etsap.org/index.php/etsap-tools/model-generators/times*
3. Loulou, R., Goldstein, G., & Noble, K. (2004). *Documentation for the MARKAL Family of Models*, ETSAP.
4. Loulou, R., & Labriet, M. (2008). *ETSAP-TIAM: the TIMES integrated assessment model Part I: Model structure*. Computational Management Science, 5(1), 7-40.
5. Loulou, R., Remme, U., Kanudia, A., Lehtila, A., & Goldstein, G. (2005). *Documentation for the TIMES Model Part II*. Energy technology systems analysis programme (ETSAP).
6. 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

1. Applied Energy
2. Computational Management Science

3. Energy Policy 4. Energy Economics 5. Energy
Advanced Reading Material
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.