Course title: Optimization techniques for energy management and planning			
Course code ENR 155	**No. of credits:** 3	**L-T-P:** 32-10-00	**Learning hours:** 42
Pre-requisite course code and title (if any):			
Department: Department of Energy and Environment			
Course coordinator: Dr. Atul Kumar		**Course instructor(s):** Dr. Atul Kumar	
Contact details: atul.kumar@terisas.ac.in			
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.	6	1	0
3	**Introduction to optimization** Problem formulation: decision variables, objective function, maxima, minima, constraints. Analysis techniques: simulation, optimization, stochastic optimization	4	0	0
4	**Linear programming and application** Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis. Power system planning using optimization techniques, case study	8	4	0
5	**Dynamic programming and application** Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming. Optimal energy resource, technology mix in micro and macro level energy planning exercises. Power generation expansion planning, case study	8	4	0
6	**Multi objective optimization** Introduction, non-inferior solutions, trade off analysis, weighted and constraints method	2	0	0
		32	**10**	**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)