31xxx – Optimization in modern power systems
5 ECTS – 3 week course, January 2017

Course Information
Language: English
Points (ECTS): 5
Course Type: MSc
Technological Specialization course, MSc. Eng., Wind Energy
Technological Specialization course, MSc. Eng., Sustainable Energy
Technological Specialization course, MSc. Eng., Electrical Engineering

Schedule: 3-week course, January 2017
Location: Campus Lyngby
Contact: 13 Lectures, 2x hours, office hours: 2 hours every day over the 3-week period
Scope and form: Lectures, exercises, computer exercises, project work
Duration of course: 3 weeks
Type of assessment: Evaluation of assignments, oral exam
Aid: All aid
Evaluation: 7 step scale, Internal examiner

Recommended Prerequisites
31370 – Fundamentals of Electric Power Engineering or equivalent
Linear Algebra or equivalent
Complex Analysis or equivalent
Programming in Matlab; Python or another programming language also ok.

General Course Objectives
Optimization is a powerful tool that has several applications in power system operation. Optimization tools are used by electricity market operators, power system operators, and other players. Such tools define the market clearing, identify optimal bidding strategies for generators, determine optimal control actions for operators to e.g. minimize losses, and help devise optimal investment strategies for the future electricity grid. This course introduces the students to general optimization algorithms, explains their principles, and shows them how to formulate and solve the relevant problems in power systems. The knowledge acquired through this course could be applied to any decision making process, e.g. devise the optimal stock portfolio for a bank, find the fastest transportation route, and others.

Learning Objectives
A student who has met the objectives of this course will be able to:

- Recognize and formulate problems for operation and investments in power systems
- Describe the basic principles of Linear programming, Quadratic programming, Nonlinear programming, and Semidefinite programming
- Formulate the dual of an optimization problem and the optimality conditions (KKT)

- Explain what locational marginal price is in electricity markets
- Design and solve optimal power flow problems (DC-OPF, AC-OPF)
- Understand and apply convex relaxations (e.g. semidefinite programming)
- Describe three advantages and disadvantages of each formulation
- Organize, plan, and carry out work in a group project
- Analyze and present the results in front of an audience

Content

This course focuses on how to take optimal decisions that deal with both the economic and the technical operation of power systems. We learn how to analyze and formulate optimization problems, for different objectives and accuracy. From an economic point of view, we cover electricity market operation, optimal bidding strategies for power producers, and optimal investment strategies for transmission owners. From a technical point of view, we cover the minimization of losses, minimization of reactive power needs, and optimal location of grid reinforcements. The course also focuses on the basic principles of how an optimization solver works, their strengths and weaknesses. This will lead to a better understanding of how to formulate a general optimization problem, which can be applied to any decision making process in the real world.