Optimal scheduling of energy systems: a practical introduction. State-of-the-art modelling techniques and practical examples.

Reducing the human carbon footprint encourages the adoption of optimal management strategies in energy systems, aiming for more efficient energy use and deeper integration of renewables.

Energy systems are ubiquitous, from industry's combined heat and power plants to net zero energy buildings. Today, optimal strategies to manage energy systems become even more relevant due to the increasing complexity (i.e., the number of components), the more diverse services to be offered to the electric grids, and the rising of new market opportunities. In this landscape, devising an optimal strategy based purely on engineering common sense can be challenging because of the multiple and seemingly conflicting available options. Luckily, the use of automated procedures to systematically find the optimal management strategy is becoming a commercial reality, enabled by the recent developments in digitalisation, automation and forecast techniques.

Although computational resources are becoming increasingly cheaper, calculating the optimal management strategy of even straightforward systems can be extraordinarily challenging unless specialised modelling techniques are used. These come with a trade-off here between the model interpretability (i.e., the problem “natural” formulation) and solvability (i.e., the ability to find reliably and quickly the problem optimum). The state-of-the-art optimisation techniques (mixed integer linear programming, MILP) require a linear problem formulation. In contrast, the performance of the system components (Internal combustion engines, turbines, chillers, etc.) is rarely linear with, e.g., the load or operating temperatures. Therefore, several “linearisation” methods have been developed to describe the components accurately while still being able to solve the optimisation problems quickly and reliably.

The linearisation techniques are an essential, but not the sole, item in the toolkit of whoever approaches the optimisation of energy systems. For example, other valuable notions include how to model startup cost and minimum load of the system components. These and other practical concepts will be covered in the seminar from both mathematical and software implementation standpoints.

Agenda

- First lesson (2 h), 19th of February, 9:30 – 11:30, Room TBD
  - Introduction
    - Energy systems promoting energy efficiency and integration of renewables
    - Examples of energy systems and traditional management strategies
    - Practical limitations to the use and effectiveness of optimal management
  - General notions on the optimal management of energy systems
    - Brief references to the concept of optimisation
    - Optimal management of energy systems: problem statement, potential objective functions, optimisation variables, boundary conditions and constraints
    - Selection of optimisation horizon: practical pros and cons, hidden assumptions on the knowledge of future
- Second lesson (2 h), 20h of February, 9:30 – 11:30, Room TBD
  - Optimisation-oriented modelling of energy systems
    - Objective function formulation
    - Modelling of energy fluxes in and out of the system and between the components
    - Modelling of on-offs, minimum loads and mutually exclusive operating modes
    - Linearisation of component performance curves with increasing accuracy and complexity
- Third lesson (2 h), 21th of February, 9:30 – 11:30, Room TBD
  - Practical details of the optimisation problem software implementation
    - Non-exhaustive list of available modelling languages and solvers
  - A Matlab example of practical implementation
    - Problem implementation in MATLAB
    - Comparison between traditional and optimised strategies