Popular science summary of the PhD thesis

PhD student  Mattia Baldini
PhD school/Department  DTU Management Engineering, System Analysis Division

Science summary

Energy efficiency is part of the plans for a decarbonised and fossil-fuels independent future, and it is expected to cover an essential role to reduce green-house gasses emissions. Albeit consistent sectorial energy savings options are available, a through overview of which sectors possess the most cost-efficient options do not exist, particularly from an energy systems viewpoint. This thesis investigates on cost-effective energy saving measures, evaluating investments in the framework of interconnected energy systems, from a socioeconomic and private end-user perspective. The main objective is explored thoroughly by means of developing modelling studies in diverse demand areas, seeking optimal levels of heat and electricity savings opportunities in the household and industry sector, combining engineering-economic methods.

This dissertation is developed by considering different approaches and methods: (i) investigation on methods to identify optimal trade-offs between energy efficiency improvements and additional renewable energy supply; (ii) assessment of optimal households electricity saving investments, from a consumer and energy systems perspective; (iii) analysis on the influence of socioeconomic and behavioural factors for investments in energy efficient household appliances; (iv) evaluation of cost-efficient heat conservation measures in residential sector, focusing on changes in district heat-tariffs to foster consumer investments; and (iv) modelling of industrial characteristics in the framework of an energy systems model, to investigate industrial processes and options for energy savings and fuel-switching.

Each task addresses attractive energy saving measures with multidisciplinary methodologies tailored to the scope of the analysis, leveraging tools ranging from energy systems analysis, consumer investment models and economical assessment based on net present value of investments. Existing methodologies are thus tested and extended according to the needs. Balmorel, a bottom-up energy systems model with high levels of details in regard to energy supply and technologies, is used to perform energy systems analyses. To identify optimal levels of cost-effective saving measures under different objectives, the model is extended in several ways: first including specifics about absolute and temporal characteristics of end-use sectors energy demand, with particulars about heterogeneous consumer behaviour; second, including investment opportunities in heat and electricity energy saving measures.

The thesis contributes with modelling techniques, methodologies, applications and policies, illustrating what makes end-use sectors invest in energy savings. Based on the knowledge of cost-effective savings and resulting effects at energy systems and consumer level, the findings pave the way for designing new and more efficient policy instruments, highlighting a more cost-efficient way to reach both energy savings, renewables and climate targets for Denmark.