Advanced Mathematical Modelling
- Related to Comprehensive Energy System Models

Stefanie Buchholz, PhD project

Energy Strategy 2050 – independence from oil, coal and gas

With the Danish government setting an ambitious target of weaning Denmark off fossil fuels by 2050, there is a need of green alternatives in order to secure a stable future energy system. Gas has a number of advantages seen from a system perspective, which makes it an interesting fuel for achieving the transition goals. But including the comprehensive gas system in the energy models makes these models even more complex to solve. It is important that solution times do not get too large, and therefore improved mathematical modelling is needed to secure an optimal integration of gas in the overall energy system.

Challenges of modelling large integrated systems

How can solution times of complex mathematical problems originating from modeling of large integrated systems be reduced? What is a good compromise between precision and solution time when aggregating such models? How can we effectively handle the logical variables in these models in order to keep them solvable? And lastly how can uncertainty in energy systems be modeled without the models getting too complex?

Increasing complexity without increasing solution time

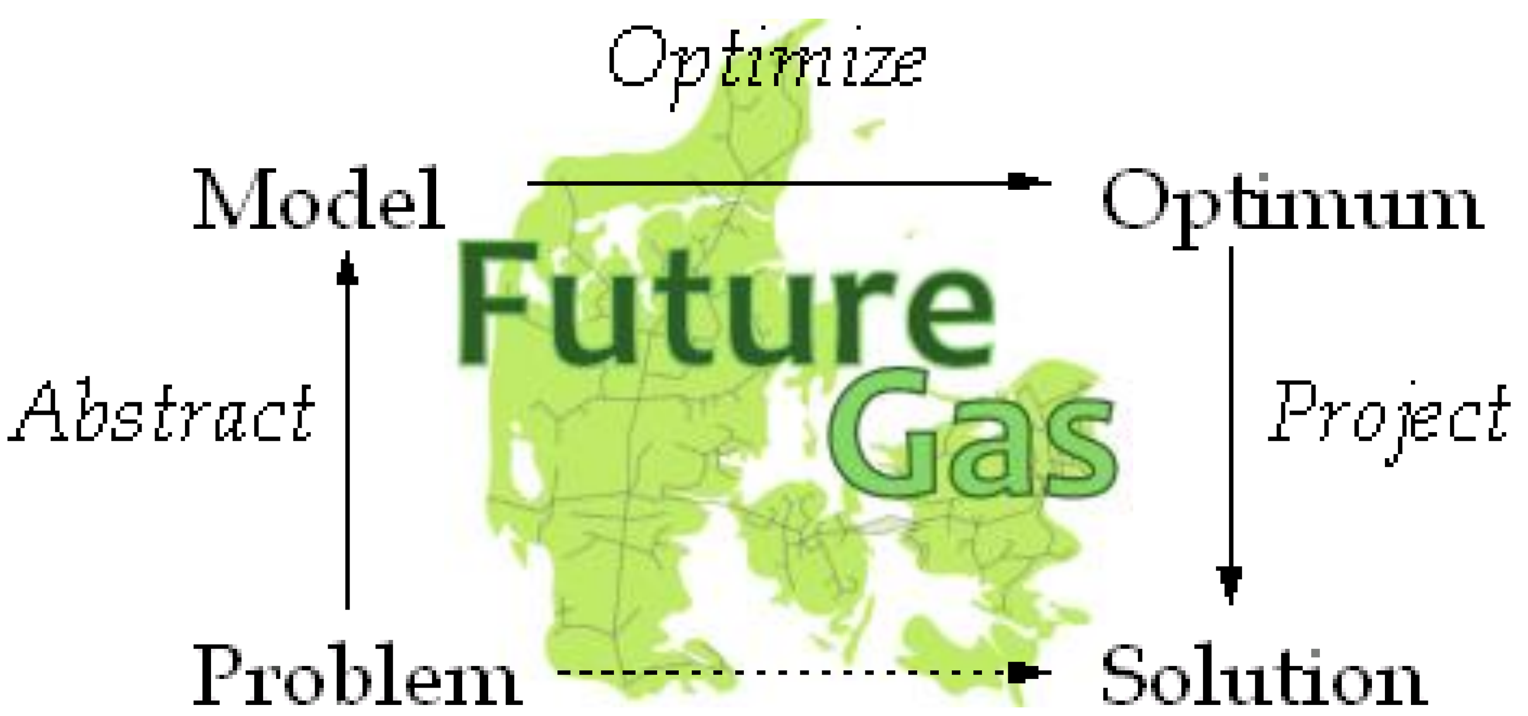
Adding variables and constraints to a mathematical problem increases the complexity according to increased sizes and solution times, and it risks making the problem un-solvable. Parameter tuning is used to achieve better solution times while the problem size can be reduced using dynamic aggregation or tailored solution methods such as decomposition methods and metaheuristics. Though such methods are often associa-ted to less precision which makes it important to balance performance against solution times. Handling uncertainty is often related to stochastic programming resulting in large problem sizes. Though robust optimization can in general be seen as; 'finding a smart way to cut away "risky" solutions from the solution space of an optimization problem', which can be achieved using various cutting strategies.

"All models are wrong but some are useful" (Box, G.E.P.,1979)

The different methods/theories to decrease solution time and problem size will be developed and tested on the Unit Commitment problem. Methods showing promising results are then applied to energy models such as Sifre/Balmorel and the performance is evaluated based on the precision and solution time. Relevant test cases and data will be collected from Energinet.dk and the Systems Analysis Group at DTU.

Expected results

- Develop improved solution methods to handle the large number of variables and constraints in energy models without solution times getting too large.
- Develop improved automation/semi-automation methods using aggregation with a good compromise between precision and solution
- Develop improved solution methods and/or guidelines to handle uncertainty.



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