Rolling horizon optimization: new approaches to balance short-term and long-term decisions for energy planning

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1 Introduction

Rolling horizon is a well-known strategy for optimal planning, applied when recurrent short-term decisions (e.g., within hours or days) must be embedded in a long-term strategy (e.g. years) [1]. The idea is to solve the problem over a chosen planning horizon based on current knowledge of the future, but only the most immediate decisions are fixed, while next decisions are reconsidered at further optimization steps with updated information.

In this work, we are interested in the optimization of the operation of an energy system. Short-term decisions correspond to the hourly control of production means, while long-term decisions correspond to various storage capabilities. It is essential that short-term decisions are balanced with long-term ones.

Short-term decision must be handled with a very detailed discretization of time which, if used on the long-term, increases too much the temporal dimension of the problem and makes it too hard to solve. Furthermore, long-term decisions strongly depend on less accurate and less reliable forecasts (e.g. weather conditions) and thus using detailed data would tends to overestimate the confidence level in long-term previsions. Recent research proposed approaches to conciliate short with long-term decisions [2, 3, 4, 5]. However, drawbacks were identified including computation burdens, lack of continuity between time steps, arbitrary compromise between short and long-term decisions, *etc.*

2 Two models using aggregated time steps

To overcome these issues, we introduce the idea of a long-term planning horizon with aggregated time steps. The full planning horizon is divided into a short-term horizon and a long-term one. A detailed problem formulation with a precise time discretization is kept over the short-term horizon, while the time discretization is coarser over the long-term horizon. Time aggregations are made on the more distant time steps for which uncertainty increases i.e. the more distant, the bigger the aggregation. This enables a long-term vision (up to a year for instance) while limiting the total number of time steps. Furthermore, the aggregation is adapted to the immediate decision need: upcoming decisions are accurately modelled while long-term ones are reduced to necessary variables.

We propose two different problem formulations to cope with the long-term horizon and to capture long-term data and decisions. The first model uses means for each aggregated time step and the problem formulation is lightened and only includes decisions that are consistent with such larger time steps. This results in an approximation of future costs (or benefits) that is problem dependent.

In the second model, future costs are embed in pre-computed cost functions. Such functions provide expected futures costs depending on variables that describe the long-term evolution of the system. They are computed on the basis of representative periods of future aggregated time steps. Representative periods are selected among original data according to [6].

The two proposed models rely on two different ways to aggregate information: mean or representative periods. The latter is expected to be more accurate because oscillations of time dependent data are not ignored. In both cases, long-term forecasts can be based on historical data, while short-term decisions can rely on present forecast.

3 Computational results and perspectives

The two modelling approaches are tested on an original energy planning case study where heat production units and storage must be managed to supply a network that delivers heat to 5000 inhabitants. The demand is time dependant and must be supplied at minimal cost and every hour by the mean of a flexible production unit and an inflexible one. Storage units allow to store the produced heat over several months. Results are compared with two benchmark approaches: a myopic optimization (the planning horizon is limited to two days) and an a posteriori optimization (future hourly demand is perfectly known over a year). Additionally, a sensitivity analysis is performed over the problem data and over the quality of long-term forecasts.

Both approaches show robust and significant savings compared to the myopic benchmark under similar computation times. The selection of one approach corresponds to different compromises between simplicity, computation time, performance and robustness. The first one is fast and easy to implement but can miss optimal solutions depending on the problem data. The second is more costly to apply but outperforms the other under controlled computation times. Future work will include a comparison with other state-of-the-art methods and application to further case studies for both optimization and simulation purposes.

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