INDUSTRIAL FLEXIBILITY FOR REDISPATCH PROVISION - AN OPTIMIZATION-BASED APPROACH FOR BID GENERATION

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Abstract: The industry as a flexibility provider will play a more important role in future energy systems, e.g. for redispatch provision. This work proposes a method to derive industrial flexibility as bids for a redispatch clearing process using Mixed Integer Linear Programming. The presented approach is applied to determine the flexibility potential of a baking factory by shifting the cleaning hours of each of their production lines, which leads to a temporary decrease in electricity consumption. Firstly, we formulate an optimization problem for the optimal cleaning period of each line, considering operational constraints, such as working hours, and minimum time between cleaning of the same production line. Secondly, we derive possible bids that can be offered to system operators for the redispatch process. Each bid corresponds to a shift in the planned cleaning hours. We compare a reference use case without flexibility with two further use cases, which differ in terms of operational constraints and electricity price assumptions. The results show that smaller industrial plants can offer flexibility by shifting demands. However, the overall impact on industrial energy savings might be very small depending on the actual production scheme and energy supply system.

Keywords: Industrial flexibility; Optimization; Mixed Integer Linear Programming; Redispatch

1 INTRODUCTION

A side effect of the ongoing transition of the energy sector and the respective decommissioning of conventional thermal power plants in Austria is an increased need for new flexibility sources in power grids [1]. Also, challenges coming along with climate change and related changes in weather conditions make new flexibility sources necessary [2]. When speaking about new flexibility sources, several candidates pose an interesting option. From the perspective of flexibility suppliers, there are different ways to (financially) benefit from flexibility provision. An overview of possible suppliers and consumers for flexibility is shown in Esterl et al. [1].

The research project “Industry4Redispatch”, aims to set up frame conditions, interfaces, and process flows for all involved stakeholders to involve the Austrian industry in future redispatch (RD) provision by offering flexibility with its different technical assets. Thus, the remainder of this paper will address the provision of industrial flexibility for RD, the tasks involved and present an approach to derive optimal operation and flexible bids for a production site in the food processing industry.

2 MATERIALS AND METHODS

2.1 Industrial Redispatch Provision and Mathematical Programming as Enabler

The following prerequisites need to be fulfilled when providing industrial flexibility. First, a baseline for the planned operation and planned consumption of electricity from the grid needs to be derived. In a second step, possible bids are derived and – in combination with the corresponding baseline - submitted to the system operators. When deriving bids, compensation effects (anticipatory or catch-up effects) must be considered. After an RD clearing process, the operational trajectories - defined by the baseline and the accepted bids - need to be executed. Mathematical programming has been applied to realize optimal planning and – combined with model predictive control – the realization of optimal operation. Fuhrmann et al. [3] presented optimal planning with mixed-integer linear programming and model predictive control for a lab system. The present paper extends their formulation to derive industrial flexibility bids.

2.2 Industrial Site

For the analyzed site, the flexibility offered is provided by the interplay of production processes and its energy-consuming machines. Flexibility is offered by shifting the cleaning procedure of two production lines listing six hours. During cleaning of the respective line, energy-intensive processes, e.g., shaping, fermenting, and freezing, must be stopped, resulting in a reduction in the electricity demand. To fulfill the RD prerequisite, first, the energy demand and energy-related costs for the non-flexible operation were determined as a *reference use case (RUC)*. The two considered production lines are cleaned every Thursday and Friday (9 a.m - 3 p.m). In two further use cases (UC), different assumptions are made for the time constraints of the cleaning as well as for the electricity prices –UC1: cleaning times: 8 a.m. to 8 p.m., fixed prices, and *UC2*: no time constraints, prices from the day-ahead market.

3 RESULTS

The proposed adaption of the optimization model can integrate flexibility from scheduling processes with catch-up effects as shown in Figure 3-1. For an annual simulation, the following results are achieved: In UC 1 and UC 2, 616 and 2142 bids are generated, respectively. The difference in the number of possible bids can be explained by the higher degree of freedom to shift cleaning time slots in UC 2. Nevertheless, only a maximum of one bid per day can be accepted by the system operator, since the cleaning can only be shifted once per week. For both UCs, average bid power, bid duration, and bid costs are determined. Optimal starting times differ strongly in both UCs: In UC 1, starting times are more common during lunchtime since the energy demand is higher due to higher outside temperatures. In contrast, for UC 2 starting times are more common in the morning or in the afternoon. This is because the spot market prices are often lower during lunchtime. The overall energy savings in the operation of the production lines are marginal for both UCs compared to the RUC. For UC 2 longer average bid durations are possible due to more shift options.

The bid costs are, in general, lower, which can be explained by a comparison of day-head prices (lower) to fixed prices (higher). The same effect leads to overall cost savings mainly in UC2.

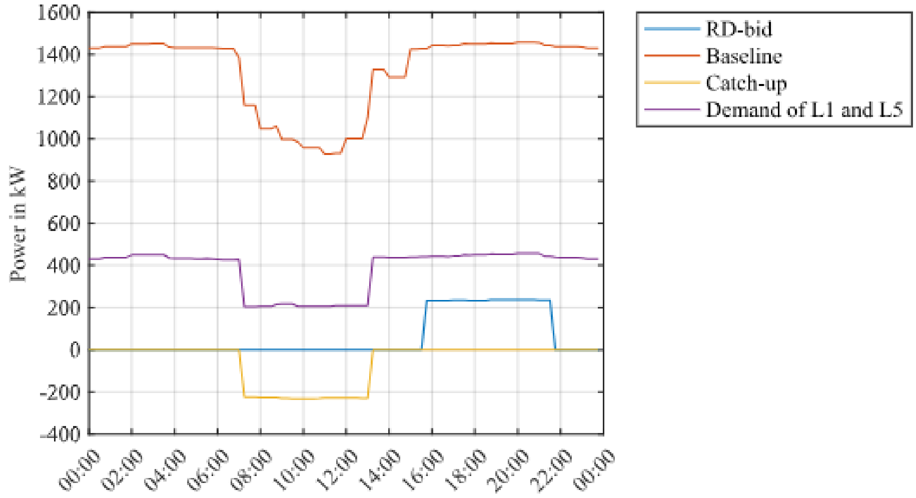

Figure 3-1 – Visualization of RD-bid, baseline including the demand of the two considered production lines (L1 and L5), and catch-up of one specific bid starting at 15:45

4 DISCUSSION

This work presents an adapted formulation to consider flexibility bid derivation in optimal planning models for industrial energy system operation. The formulation can derive a baseline and flexibility bids under consideration of necessary catch-up effects. Optimal planning of the cleaning times in UC 1&2 can only save about 0.1 % compared to the RUC. This means, on the other hand, that shifting the cleaning time slots - and hereby offering RD bids - can be done with low additional energy costs. For factories and processes with higher degrees of freedom in their energy systems, the economic impact may be significantly higher.

5 References

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