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Modelling, Simulation and Optimization of the operation of electric chillers

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The goal of the research project BaMa (Balanced Manufacturing) is to increase energy efficiency of industrial production sites. A toolchain, consisting of the three main parts monitoring, simulation and optimization, is developed to optimize the operation strategy and production plan of a given production facility. Additionally to usual parameters such as production time and delivery reliability, energy consumption and CO_2-emissions are taken into consideration.

In order to illustrate the method, the development of an energy-optimized operation strategy for a refrigeration plant, consisting of four electric chillers, supplying a semiconductor production plant is presented. Several different methods for modelling, as well as optimization were identified and applied to the problem. Without any additional measurement equipment or interruption in the operation of the plant, it was possible to build sufficient models. The results of the application are propitious and indicate the feasibility of the BaMa-method in general.

By measuring relevant input- and output signals, a model is parameterized. This model makes the prediction of the behavior of the electric chillers possible. The generation, preprocessing and aggregation of data results in models that can be used to optimize the underlying plant's operation.

A model proposed by Monfet and Zmeureanu which is based on the work of Hydeman et al is used. The root mean square prediction errors for electrical energy demand are 11.8%, 4.7%, 5.3% and 3.3%, respectively.

Using the chiller models, a simulation of the underlying chiller plant consisting of four electric chillers was set up. As a baseline for the assessment of the optimized operation strategy, chiller operation states for a period of 80 days in 2015 were used. Together with the information about the corresponding temperature signals in that period, alternative chiller operation states were found by choosing the, optimal chiller unit (i.e. the one with the lowest electrical energy demand at a given time).

Keywords: energy efficiency, electrical chillers, predictive modelling, optimization