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Integration of load management into an energy-oriented production control

Cedric Schultz[a,*], Sebastian Braun[a], Stefan Braunreuther[a], Gunther Reinhart[a]

[a]*Project Group Resouce-efficient Mechatronic Processing Machines of Fraunhofer IWU, Beim Glaspalast 5, Augsburg 86153, Germany*

* Corresponding author. Tel.: +49-821-56883-40; fax: +49-821-56883-50. E-mail address: cedric.schultz@iwu.fraunhofer.de

Abstract

In order to be more energy-cost-efficient, companies may choose time-variable tariffs with their energy provider or expand their energy self-supply depending on their capability for flexible energy consumption. Therefore, flexible energy consumption has to be reflected in the companies' production planning and control.
This paper presents a strategy for an energy-oriented production control, which treats electric energy as a limited production capacity where load profiles for manufacturing are predetermined. The focus of this strategy is the identification and integration of measures for load management into production control in order to cope with unexpected events and disruption on the shop floor which in turn have adverse effects on the overall energy consumption. This energy-oriented production control aims to synchronize the energy demand in manufacturing with a limited energy supply and thereby to minimize energy costs.

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Keywords: Renewable energies; production management; production control; energy flexibility; energy efficiency

1. Introduction

The nuclear phase-out is changing the energy system in Germany. Since baseload power plants are substituted by an increased share of renewable energy sources, mainly wind and solar power, costs for electric energy for industrial consumers have risen by roughly 150 % in the last 15 years [1, 2]. And since the power generation by wind turbines and photovoltaics is volatile, significant differences in regional power generation as well as differences between energy supply and energy demand may occur more frequently. As a result of the volatility, short-term energy prices such as the EPEX SPOT fluctuate more strongly.

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In the past, the power generation by flexible power plants was adjusted to the expected power demand. However, this concept is now reversed and flexibility on the demand side gains more importance. Flexible consumers, who are capable of shifting their loads from peak to off-peak hours may contribute to the stability of the power grid. Also, since energy prices in off-peak hours are typically lower, these consumers may gain a financial benefit [3]. This form of demand side management and the advantage of time variable energy prices should be implemented in a company's production planning [4].

2. Target for an energy-oriented production control

If a company wants to benefit from time-variable energy prices, it has to combine the purchasing of energy with its production planning process. Since production planning generates the machine schedules, it has a direct influence on the prospective energy demand of the company. If variable energy prices are considered in production planning, the machine schedule as well as the company's energy purchase can be adapted mutually to minimize energy costs [5]. In addition to a machine schedule an energy schedule can be generated. This energy schedule specifies the amount of electric energy which is available in a given period. This schedule is generated using different tariffs like baseload tariffs, peak tariffs or spot market blocks and thereby making use of time variable energy prices. The energy schedule should be fixated on the day prior to the manufacturing process at the latest. This is due to the fact that the intraday market in Germany shows high fluctuation in energy prices which in turn increases the price risk. On the left side of Figure 1 an example for an energy schedule is given which specifies the expected mean power demand for every 15 minute period of a shift. If deviations from this mean power demand are expected, the missing or surplus energy has to be traded on a short-term market, otherwise penalties may occur. This effect is shown on the right side of Figure 1 for a single 15 minute period of the schedule. Therefore, a company should use its production control to minimize the deviations from the contracted and the actual load profile.

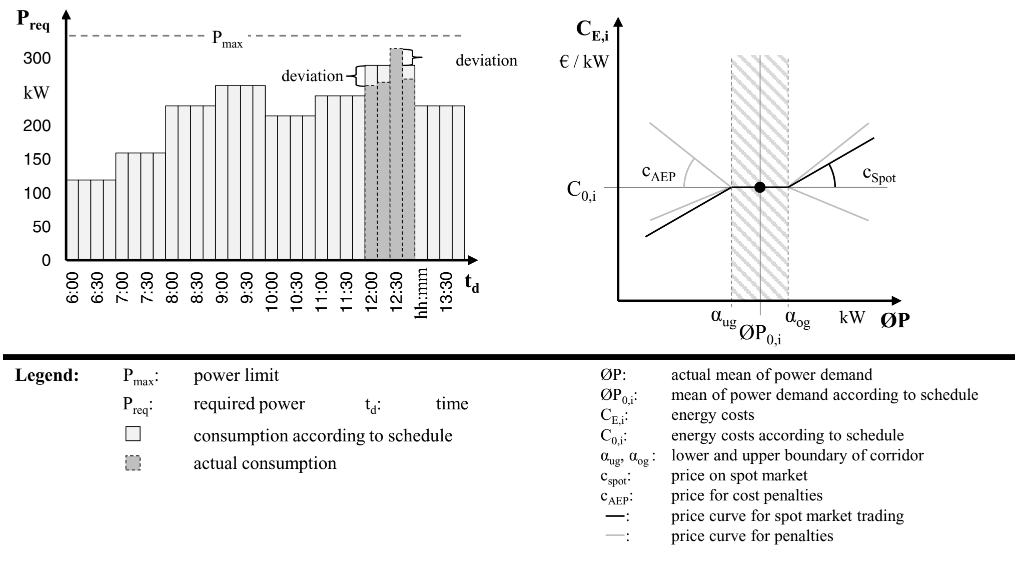

Figure 1. Example of an energy schedule for one shift (left) and diagram of costs associated with the schedule (right)

3. Encompassing framework for an energy-oriented production control

In order to describe the tasks and the functional interrelations of production control Lödding has proposed the model shown in Figure 2. The tasks "order release", "sequencing" and "capacity control" on the left side of the diagram are all part of production control. In contrast, "order generation", which is depicted on the right side, is typically part of production planning since it defines planned values as targets for the manufacturing process [6].