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Procedure for generating a basis for PPC systems to schedule the production considering energy demand and available renewable energy

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Abstract

Production planning and controlling (PPC) plays an important role in modern production enterprises. Current production management systems consider resources such as material, labour and production capacity and their respective costs, but neglect the role of energy and possibilities for cost savings. To develop sustainable production (in terms of economic and environmental aspects), the system must be extended; energy aspects, such as energy demand and available renewable energy, must be included in planning and monitoring the production. The paper presents a procedure for generating a basis for PPC systems to schedule the production related to energy demands and available renewable energy, for evaluating the planning errors and for indicating problems in the production based on the energy plan.

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Keywords: Production Planning and Control System; PPC; Energy planning; Renewable Energy; Direct consumption of renewable energies

1. Introduction

A production facility serves to transform raw materials into products, usually with the goal of achieving a designated output (in terms of quantity and quality) at minimum costs (see Figure 1, Part A). With the aid of planning systems, raw-material inputs, outputs of products, by-products and waste are planned related to a determined output of products (including services).

In general, current production management systems consider resources such as material, labour and production capacity at its respective costs, but neglect the role of energy (electrical and thermal energy) and its possibilities for cost savings. Though energy management systems have been pushed in the last years by legislation and financial incentives [1], the integration into operational production management is pending. To develop sustainable production (in terms of economic and environmental aspects), the **managed system must be extended; energy aspects must be included in the planning** (see Figure 1, Part B). In times of climate change, because of high greenhouse gas (GHG) concentration, increasing consumption of energy and rising energy costs (despite declining prices in the energy market), it is necessary to look at the production factor energy with respect to **sourcing** and **consumption**.

Production companies need to consider not only the costs of energy but its sustainable generation as well. Therefore, even for smaller production companies, energy sourcing is becoming more complex because of increasing sourcing criteria. Next to the energy prices of different energy forms, taxes and levies apply (depending on a country's legislation), investment costs and sustainability criteria must be considered when energy sourcing decisions are made. What is the best option for sourcing energy: sourcing from an energy provider and/or (partial) self-generation by own renewable energy (RE) sources? For companies wishing to self-supply, the design of their energy plants is important (see [2] for more information on this). In the case of (partial) self-supply, the fluctuating nature of energy is an issue to be handled. In which way and to what extent are energy forecasting and energy demand planning necessary?

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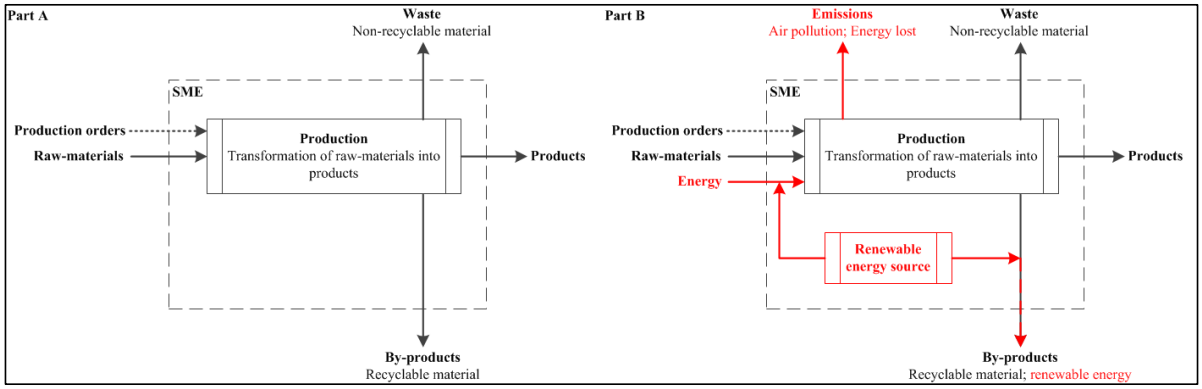

Fig. 1: Transformation of raw-materials into products without (Part A) and with (Part B) consideration of energy consumption

While operational production planning is already a complex task, the following questions need to be answered for the integration of energy aspects: Which aspects of energy planning need to be considered? And how does it change traditional production planning and controlling (PPC)? For production companies, energy consumption can be split into two categories: First, in basic demand to achieve operational capability; second, in production-related energy demand (see Figure 2) to transform material (input) into products (output). For the latter, energy planning in the sense of scheduling the daily energy demand respectively its causation, the production, is vital. When the energy demand is known, e.g. in the form of a 24 h day-ahead plan, it can be matched to the availability of self-generated RE to optimize costs and minimize environmental impacts, e.g. GHG emissions. Under this aspect, the PPC system should balance the daily energy demand and energy supply from RE sources and grid. For this, demand planning data, supply forecasting and planning data, including estimated error and balancing possibilities on both sides, need to be available. For the supply side, energy availability from fluctuating RE sources such as wind and sun need to be forecasted, while non-fluctuating RE such as geothermal or biomass can be planned.

An enterprise can benefit from using self-generated RE energies, as mentioned, to reduce energy costs and avoid GHG emissions by avoiding regular energies (fossil fuels). The drawback is, for maximizing the effect, additional know-how and planning capability are needed: energy planning needs to be done and must be joined with production planning. Though this is a drawback, the prerequisite for energy planning, energy monitoring, can be used as a benefit, e.g. with continuous monitoring of planned energy versus actual energy demand, the status of the machines can be monitored. Deviation signals can indicate problems, and counteractions can be taken immediately.

The paper presents a four-step procedure for generating a basis for PPC to schedule the production related to energy demands and available RE. The presented prototypic procedure is based on the following assumptions:

- The stability of the grid for energy supply in times of low RE production is guaranteed.
- The design of thermal and electrical RE sources is fixed, and the RE generation is only related to weather conditions.
- The absolute input and output of required material and energy related to the daily production program (production orders) is fixed.
- The enterprise is able to install and operate RE generation plants and manage its own energy demand (for more information, see [3])

After this introduction, a short overview is given of related work. Section 3 presents first, the methodology used to develop the procedure; and second, a detailed description of each step of the procedure is given. Section 4 contains the conclusion and future work, followed by the references.

2. Related Work

The scheduling of energy demands and RE production is the topic of several papers (for an overview, see [4]). In general, these papers investigate how energy planning can be used to achieve significant benefits on the market [5, 6] and/or minimize environmental impacts [7, 8]. Previous studies have analysed the deviation of expected and actual energy demand under the objectives of meeting production requirements while minimizing the overall operating and environmental costs through producing. The papers have also been focused on evaluating the deviations of forecast RE generation and take this into account to optimize the energy planning [7, 9–11]. The review [12] presents an overview of existing research about smart grid technologies and applications of the smart grid. The growth of networking through the smart grid in households and industry offers new opportunities for monitoring the distributed energy generation and energy demands by utilizing historical energy generation and consumption data. The basis for this monitoring and a key function of the smart grid is the accurate energy demand and RE generation forecast.