A Decision Support System for Brewery Production Planning at Feldschlösschen

Markus Mickein <markus.mickein@uni-hamburg.de>**, Matthes Koch, Knut Haase**

Introduction

Feldschlösschen, the largest brewery and beverage distributor in Switzerland, was founded in 1876 and accounts for 40% of the Swiss beer market with an annual revenue of over 900 million CHF (£747m). Feldschlösschen has been a part of the Carlsberg Group since 2000. Its portfolio includes many regional brands but also international brands such as Carlsberg. This study was based on the traditional brewery in Rheinfelden with an annual production volume of 1.8 million hectolitres.

The production schedule contains 220 finished products, 100 semi-finished products, 13 production resources, 8 storage resources, 3 main production levels, and a planning horizon of 52 weeks. The brewery production process is subject to restrictive dependencies, such as lead times for fermentation and maturation, a short shelf life of finished beer and divergent production structures. Moreover, the changing demand of different customer groups for various packaging volumes, variants of beer (particularly craft beers such as India Pale Ale) and specific brands, enlarges the manufactured product portfolio of the brewery but increases production complexity.

The aim of the study was to improve production planning processes with the aid of a Decision Support System (DSS), which would better integrate the actions of the departments involved and also provide more transparency of the planning process. The work was carried out by a team from Hamburg University, working closely with company planners and managers.

▲ Fig 1. Brewhouse of the Feldschlösschen Brewery.

The Production Processes

Beer manufacturing requires integrated planning of several multilevel sub-processes: brewing, fermentation, maturation, filtration, and bottle/can filling. Fig 2 shows the production process from the base beer to the finished beer.

Beer production starts with brewing the wort (unfermented beer) in the brew house. After adding yeast, the fermentation begins, which is followed by maturation. These processes last up to three weeks. Next, filtration removes the yeast and other undesired particles, producing several types of semi-finished beer. The semi-finished beer is stored in buffer tanks until further processing. Finally, the beer is transferred to bottles, cans, or kegs. The finished beer is stored in the warehouse until delivery to customers.

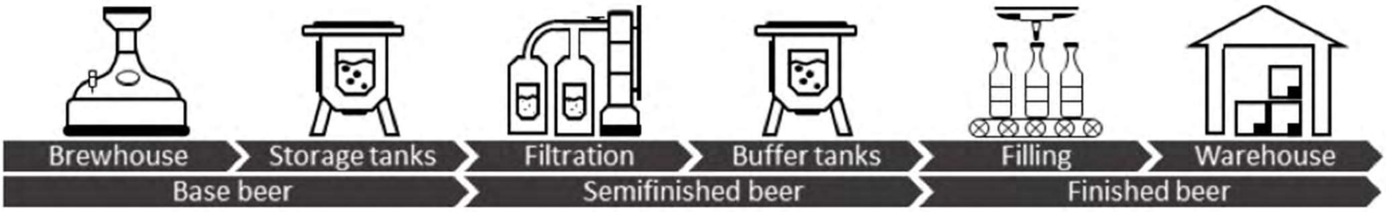
In addition to the general brewing process, producing alcohol free beer and mixed beers requires additional production stages. Corresponding sub-processes increase the planning complexity due to additional equipment and ingredients.

The Decision Support System

Production planning at a brewery can be regarded as a general multilevel bill of materials problem, also known as the multi-level capacitated lot-sizing problem (MLCLSP), and this is modelled at the core of the DSS. Thus this new DSS develops production schedules for the entire production system to support tactical and strategic planning by scenario analysis or "what if" queries.

Fig 3 illustrates the structure of the DSS, which consists of a **user interface (UI)** and **visualization tool** embedded in a **cloud-based optimization framework**. The UI includes data collection and validation. A virtual machine in the cloud runs the calculation, generates planning reports, and stores optimization results. Finally, customized dashboards visualize the optimization results.

The **User Interface** is a desktop application for Microsoft Windows, designed for Feldschlösschen, and enables production planners to prepare data scenarios and initiate calculations: production data (i.e., product, resource, and demand data) specifies the input data of a production scenario. The UI validates the data and reports errors, enables data collection and input from the Enterprise Resource Planning (ERP) system and various spreadsheets. Users can manually adjust existing data and add new data from different sources and each data category can include several data scenarios.



▲ Fig 2. Beer manufacturing process.

The **Visualization Tool** displays the optimization results (i.e., lot sizes, inventories, and capacities) for the computed production scenarios in interpretable dashboards. These derived Key Performance Indicators (KPIs) for each resource within the multilevel production system, support decision making and the comparison of different scenarios by planners and managers.

The **Cloud-Based Optimization** is carried out on virtual machines because of the computing power required to ensure rapid calculation times and to enable multiple simultaneous uses of the DSS. In the cloud, a virtual machine hosts an SQL database and executes the mathematical program using the optimization software GAMS. An adaptable fix-and-relax-and-optimize heuristic is used to achieve good solutions in a reasonable time. The optimization model and solution approach are implemented in GAMS and solved by CPLEX. Further details of the optimisation are provided in Reference 1.

▲ Fig 3. Structure of the Decision Support System.

Some assumptions that are not critical to the outcome have been made in the mathematical model, including, for example, that demand is satisfied in each period and that raw and packaging materials are available at any time, in any quantity. The model formulation accounts for set-up times and losses but assumes set-up times to be sequence-independent. Each product has a fixed allocation to one production line and one storage facility. Multiple identical tanks are aggregated into tank groups. In addition, an initial and final inventory is assumed so as to ensure production capability at the beginning of, and beyond, the planning horizon. Unexpected demand is handled by including a dynamic safety stock, which depends on future demand and a product-dependent risk factor.

Implementation

Local planners and managers were involved in the project from the very start, so as to ensure that they could understand the principles of the new DSS but also and more importantly, so that they could input their expert knowledge, particularly about how the brewing process is represented in the DSS. Initial results were discussed at inter-divisional meetings and input parameters adjusted if necessary. Results from the DSS could be seen to be an improvement compared to the previous system, which aided acceptance.

Local staff were able to advise on the balance between the level of simplification of the process, as represented in the DSS, versus solution quality and accepted longer computing times so as to achieve better solutions. Thus critical processes are modelled in more detail. The jointly devised and easy to use UI also aided local acceptance and encouraged full use of the DSS. Experience has shown that visualization and validation encourage planners use the new planning system.

The authors continue to work with Feldschlösschen to improve the DSS. For example, a software extension to further improve operational planning level decisions is under development. Also training sessions and workshops for local planners and managers continue to be held, so as to exploit the DSS's potential.

Impact

Feldschlösschen applies the DSS to support decision making related to top management issues, such as beer variety strategies, investment decisions, and capacity development. The DSS quantifies the effect on the production process of strategic decisions such as changes in the product portfolio. Additionally, the efficiency of investments in new equipment on the remaining production system can be evaluated. The new DSS has been shown to reduce operating costs by around 5% whilst reducing planning effort by as much as 40%.

Endorsement

"The software supports strategic and tactical planning decisions in standardized reports. The most significant value added is the analysis of the interactions between production stages as the consequence of decisions. This enables us to better quantify investment requirements and evaluate future strategies. It reduces investment costs by identifying actual need and realizes operational cost savings by analysing strategic scenarios in a holistic manner. Furthermore, it improves decision communication to the relevant departments." (Head of Supply Chain Planning & Product Change Management, Feldschlösschen Supply Company AG)

Reference

Markus Mickein, Matthes Koch, Knut Haase (2021) A Decision Support System for Brewery Production Planning at Feldschlösschen. INFORMS Journal of Applied Analytics 52(2):158-172. https://doi.org/10.1287/inte.2021.1101

Acknowledgement: The editors are grateful to Michael Gorman, the editor of INFORMS' Journal of Applied Analytics, for permission to run this abbreviated article in IFORS News.