Deutsches Biomasseforschungszentrum
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DBFZ

Model-based Process Optimization of Biogas Plant Operation

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Motivation

In the course of the German *Energiewende*, the share of renewables in energy supply is growing. In order to compensate residual load rises, associated with fluctuating sources such as photovoltaics and wind power, appropriately equipped biogas plants can be flexibly operated to dynamically react to peak electricity demands. However, this kind of operation requires bigger storage volumes and induces oscillations in the gasholder. In order to fully leverage a biogas plant's potential, model-based process optimization minimizes these oscillations through targeted feeding modulation, while taking biological process stability into account.

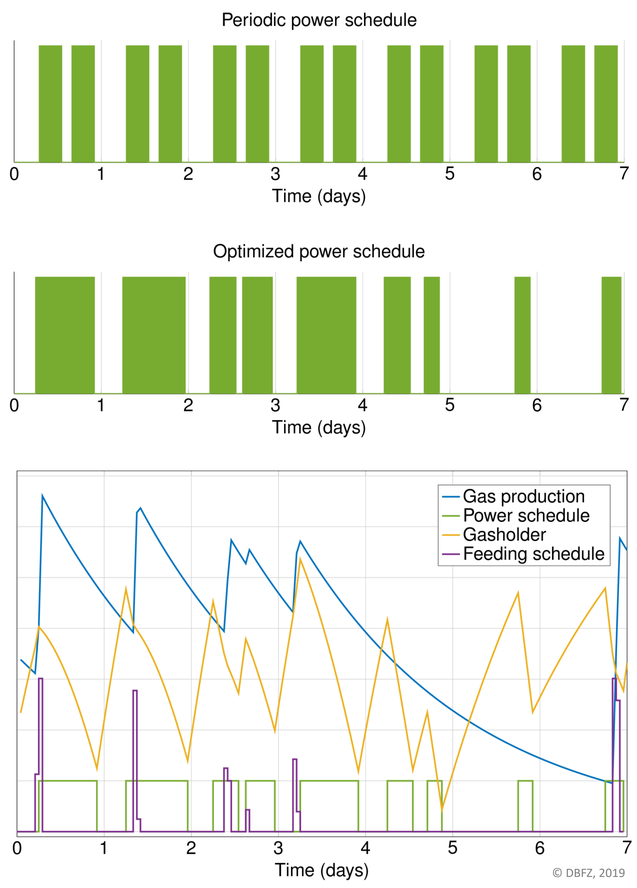

Fig. 2: Exemplary results of power and feeding schedule optimization.

Materials and methods

Based on previous work [1], a comprehensive plant model is applied for simulation and process optimization (Figure 1). Thus, numerous influencing factors and sub-processes, such as EPEX and substrate prices, meteorological data for calculation of available gas storage volume, or biochemical process indicators and intermediates are regarded in the overall plant model. The fermenter is simulated by mass-based Anaerobic Digestion Model No. 1 (ADM1) or its reduced stages (ADM1-R1 to ADM1-R4) [2]. As optimization routine, *fmincon* from Matlab Optimization Toolbox is employed for nonlinear, and CBC (Coin-OR Branch and Cut) from OPTI toolbox for mixed-integer linear optimization.

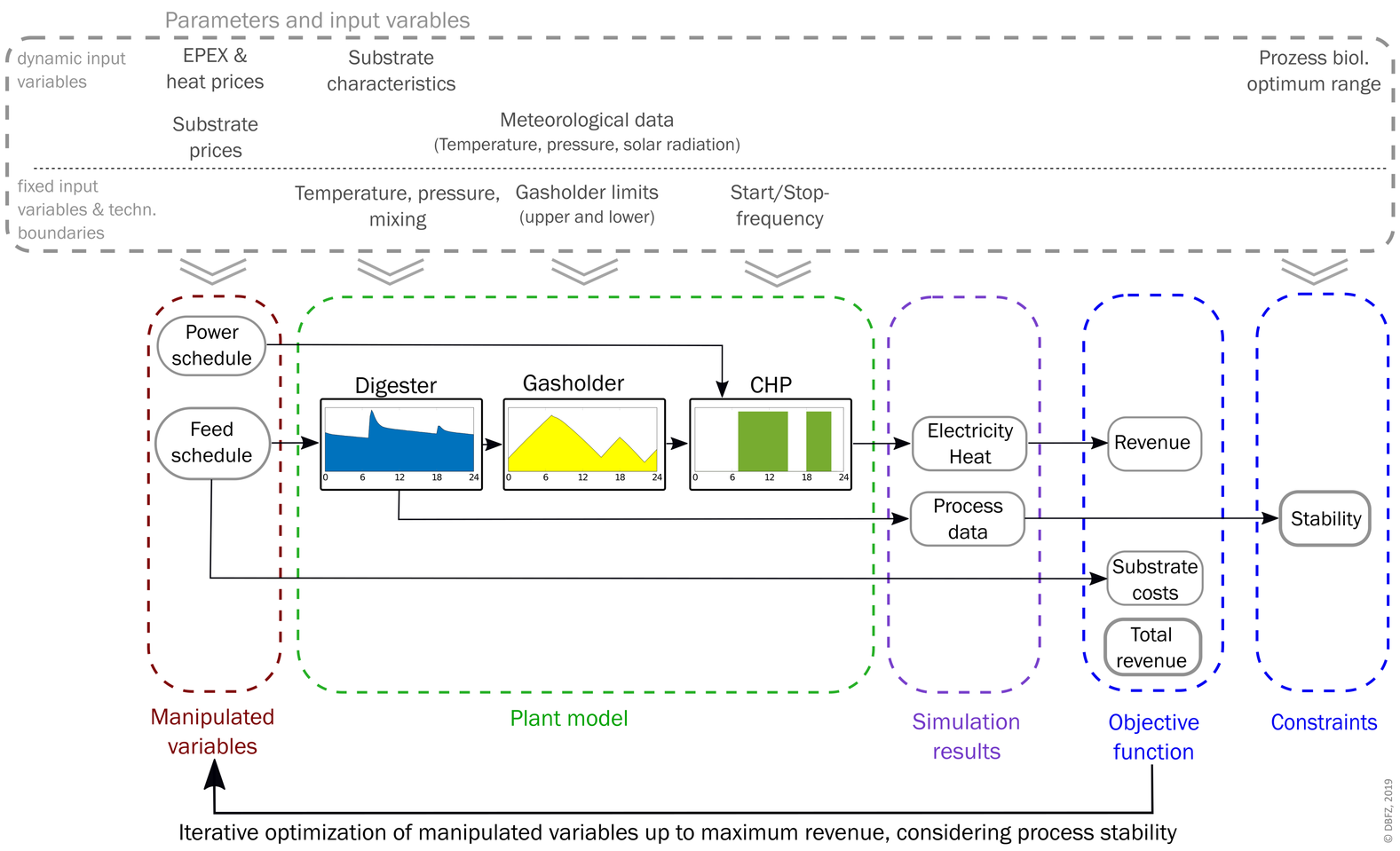

Fig. 1: Schema of Model-Based Process Optimization.

Process Optimization Approach

The overall objective is to maximize total revenue, while ensuring resource efficiency and biological process stability. Since this problem is hard to tackle in its entirety, it is split into two suboptimizations, whose results are neatly interchanged. As a first step, the economically optimal power schedule is sought at a given gas production per hour and gasholder constraints (see Fig. 2). As a second step, feeding optimization aims at minimizing oscillations in the gas holder at a given power schedule (see Fig. 2).

→Next step: Experimental validation at DBFZ Research Biogas Plant (FBGA)

[1] E. Mauky, S. Weinrich et al., Demand-driven biogas production by flexible feeding in full-scale: Process stability and flexibility potentials, Anaerobe (2017) 86–95.

[2] S. Weinrich, Praxisnahe Modellierung von Biogasanlagen: Systematische Vereinfachung des Anaerobic Digestion Model No. 1 (ADM1), Universität Rostock, 2017.

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