

SYNTHETIC LOAD PROFILE GENERATION FOR PRODUCTION CHAINS IN ENERGY INTENSIVE INDUSTRIAL SUBSECTORS

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Introduction

The industrial landscape is accountable for 37% of the overall primary energy demand in Austria [1]. Therefore, the industry undoubtedly has to take part in the energy transition [2]. The development of comprehensive energy system models may help to overcome these challenges and align the industrial sector with the European net zero greenhouse gas emission goals. The dynamic character of simulation models allows to get hold of fast changing trends and technologies, evaluate their impacts on the physical energy system and support the strategic decision making for the energy transition. Due to increasing volatility of the energy system, various models incorporate analysis of future grid demands and for energy suppliers [3]. Here, the calculation of timely resolved behaviour of energy consumption and generation of industrial consumers in terms of load profiles (LP) play a key factor.

Our overall goal is to develop such methodologies to correctly and dynamically depict the energy consumption patterns of all relevant industrial subsectors by generating synthetic LPs and to integrate these models into a digitalised version of the future energy system in Austria by creating a software environment called *Ganymed*.

Methodology

Throughout an extensive literature research, we found that such models were developed for the residential sector as bottom-up approaches for various sizes of consumer groups [4]. In the sector of mobility, LP generation methods mostly utilise measured profiles of real charging stations and determine the effects on the power grid [5]. However, we found only a few evidences that LP generation models were developed for the industrial sector. We assume, that this is due to its heterogeneous production structures and demands as well as strict corporate data security policies, which makes detailed energy system and consumer analysis difficult.

To nevertheless reach our goal, this study aims to cover the most energy intensive subsectors first: Iron & Steel, Pulp & Paper, Non-Metallic Minerals and Chemical & Petrochemical. We found that these subsectors utilise only a limited range of production processes and chains compared to other subsectors like Machinery or Food & Beverages [6]. Due to this fact, a bottom-up methodology of depicting these production chains and generating corresponding LPs is our chosen approach. In a first step, the energy intensive subsectors and their main production processes are identified. We used a standardised research approach to correctly depict their characteristics e.g. runtime, energy consumption and generation, unit sizes etc. Therefore, processes can be operated continuously or batch-wise. Furthermore, characteristic serial and parallel subproduction chains are identified.

Next, a methodology for modelling the timely behaviour of these production processes and for generating synthetic LPs is developed. We utilise the methodology of discrete-event simulation as the underlying bottom-up concept combined with stochastic methods of Gaussian distribution. In overall, discrete-event simulation depicts the timely interaction of active components (e.g. tonnes of steel) with resources (e.g. industrial processes) [7]. This simulation method is improved and adapted extensively throughout this study to adequately cover the timely behaviour and patterns of industrial processes and production chains as we integrated all researched processes into the developed methodology. For example, the mentioned interactions with processes generate singular demand patterns as active components are passed through the production chains during simulation. Continuously and batch-

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operated processes act differently according to their operating time. We also implemented the option of integrating auxiliary material streams besides the main active component stream of products. Furthermore, the development of dynamic system boundaries allows to generate load profiles starting from single processes to the whole plant border.

Figure 1 shows the application of auxiliary materials streams (Flow of natural gas), integrated system boundaries as well as the three energy carriers as target values.

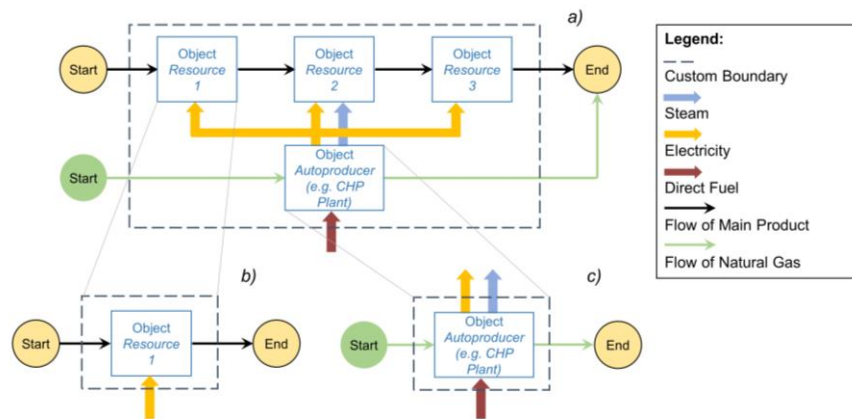


Figure 1: Application of Developed Methodology

The methodology is furthermore embedded into a software environment with a developed graphic user interface (GUI). This allows a dynamic creation of a user defined production chain by moving and aligning processes, system boundaries, energy and material streams via drag-and-drop.

Results

We apply and validate the developed methodology via various case studies. For example, studies modelling the primary steel production route of Austrian steel mills or integrated pulp & paper production mills are conducted. The results are then compared to real measured LPs for a timeframe of one week. We found that the resulting, synthetic LPs exhibit good approximations to the measured ones regarding their mean absolute percentage error and daily fluctuation. However, for now, this method is only applicable for facilities, where 24h/7 production takes place. Reductions in the production capacity due to non-operating times off-shift or unforeseen process downtimes are not taken into account yet. This, however, can be solved by improving the stochastic methods and integrating more extensive data basis into the methodology. Consequently, *Ganymed* can be deemed as a suitable software for generating energy consumption and generation behaviour of processes and production chains of energy intensive industries.

References

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