FLEXIBILITY MANAGEMENT FOR INDUSTRIAL ENERGY SYSTEMS

Isabella BIANCHINI[1], Kerim TOROLSAN[2], Alexander SAUER[3]

Introduction

Demand-side flexibility [1] presents added benefits for the energy grid. For instance, reduction of generation capacity requirements, higher security of supply and widened competition for the provision of balancing services [2]. Through demand-side flexibility, consumers can also benefit from reduced energy supply costs and a higher grid reliability [3]. Due to the large consumption levels of the industrial sector [4], the inherent flexibility of industrial facilities poses a significant contribution to extend the demand-side capabilities of the grid. If we look from the industrial consumer's point of view, it is fundamental to first, identify and characterize the energy flexibility measures for local industrial processes and secondly, to evaluate for which market segments or tariff schemes the flexibility can be offered in a demand response market. Finally, it is important to assess the economic benefits of flexibility. With regard to the first step, the German research project SynErgie [3] described the flexibility of industrial processes through *energy flexibility measures (EFM)*. The description through EFM offers a simple and effective way to compare the identified flexibility potentials executable in an industrial production site [5]. As for the second step, a deep knowledge of the energy market and tariff structure is required. Currently, consumer awareness regarding the opportunities provided by demand response actions has yet to be fully established [1]. In literature, a methodic classification for market segments or tariff schemes has been carried out describing where the commercialization of energy flexibility is possible [6]. In [6] so-called *market options* are characterized in order to support flexible industrial consumers. A general potential for costs reduction or profit increase was also evaluated, showing that the highest potential can be ascribed to the reduction of network charges and the day-ahead market (DAM) [6]. Finally, quantitative assessments for different market options and their possible combinations have to be carried out. For this, a decision model for the cost-optimized utilization of the EFM must be designed. This would allow exploring how the consumer can benefit from the means of EFM through a specific market option or multiple market options and identifying the most profitable market combination. In literature, decision models or energy management systems for industrial flexibility have been proposed in [7–9]. However, they mostly lack a generic definition of the industrial flexibility requiring specific modelling of each energy flexibility measure and concentrate the assessment on only one configuration of energy markets and tariffs.

Method

In this paper, a decision model for the cost-optimized utilization of EFM in multiple market options is designed. Here, EFM activation is simulated that modifies the electricity consumption profile measured at the consumer's connection point to the public grid. The aim is to decide in the current situation whether it is the optimal time to activate the EFM for maximum energy cost reduction. The cost reduction is achieved reducing the network charges and/or purchasing the electricity on the DAM [6].The decision model is based on a mixed integer linear programming (MILP) optimization problem with a time interval of 15 minutes. The system complexity is due to the multiplicity of market options and EFM, which impose constraints regarding the maximum load at the connection point of the facility and on the EFM activation. Using the definition of EFM, the designed decision model is applicable to different facilities in industrial environment. With the simulation results, the costs for the energy purchase and the EFM activation are calculated and the corresponding optimized load profile is defined. Results are compared to a set of

[1] Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Nobelstrasse 12, D-70569 Stuttgart, +49 (0)711 970-1959, isabella.bianchini@ipa.fraunhofer.de, www.ipa.fhg.de
[2] University of Stuttgart Institute for Energy Efficiency in Production EEP, Nobelstrasse 12, D-70569 Stuttgart, etk89466@stud.uni-stuttgart.de, www.eep.uni-stuttgart.de
[3] University of Stuttgart Institute for Energy Efficiency in Production EEP, Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Nobelstrasse 12, D-70569 Stuttgart, +49 (0)711 970-3600, alexander.sauer@eep.uni-stuttgart.de, alexander.sauer@ipa.fraunhofer.de, www.eep.uni-stuttgart.de, www.ipa.fhg.de

reference scenarios, evaluating the benefits of the EFM implementation and assessing the most profitable market options combination.

Results

The decision model is tested on an energy flexible industrial facility characterized by an electrical storage system, a flexible ventilation system, and unidirectional charging stations for electrical vehicles (EV). Simulations consider an exemplary load profile of an industrial facility and historic energy prices. Results show that the utilization of energy flexibility allows an energy costs reduction in every market option combination up to 3,5%, assessing the positive effect of demand response for industrial companies. In addition, the consideration of alternative market options further reduces the overall facility energy costs.

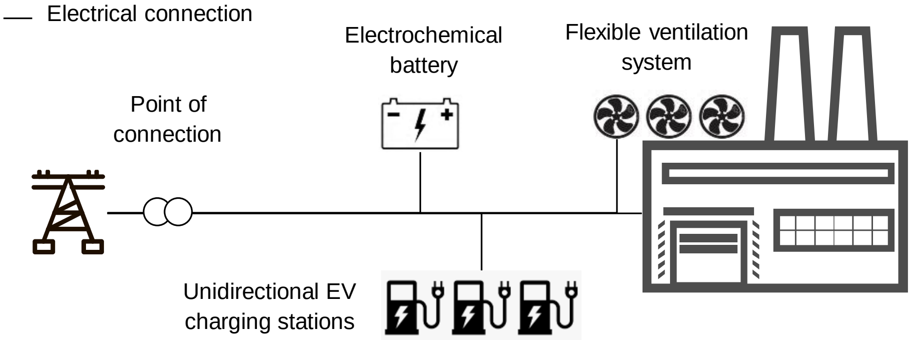

Figure 1: The case study for the decision model considers an industrial facility including an electrochemical battery, EV charging stations and a flexible ventilation system.

References

[1] European Smart Grids Task Force Expert - Group 3, "Final Report: Demand Side Flexibility: Perceived barriers and proposed recommendations," 2019. Accessed: Jun. 17 2021. [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf

[2] N. O'Connell, P. Pinson, H. Madsen, and M. O'Malley, "Benefits and challenges of electrical demand response: A critical review," Renewable and Sustainable Energy Reviews, vol. 39, pp. 686–699, 2014, doi: 10.1016/j.rser.2014.07.098.

[3] Sauer, E. Abele, and H. U. Buhl, Eds., "Energieflexibilität in der deutschen Industrie.: Ergebnisse aus dem Kopernikus-Projekt - Synchronisierte und energieadaptive Produktionstechnik zur flexiblen Ausrichtung von Industrieprozessen auf eine fluktuierende Energieversorgung (SynErgie).," Fraunhofer IPA, Stuttgart, ISBN: 978-3-8396-1479-2, 2019.

[4] Bundesverband der Energie- und Wasserwirtschaft e.V. (BDEW), Die Energieversorgung 2020 – Jahresbericht –. [Online]. Available: www.bdew.de

[5] A: J. Tristan, F. Heuberger, and A. Sauer, "A Methodology to Systematically Identify and Characterize Energy Flexibility Measures in Industrial Systems," Energies, no. 13, pp. 1–35, 2020, doi: 10.3390/en13225887.

[6] Bianchini, F. Zimmermann, K. Torolsan, and A. Sauer, "Market Options for Energy-flexible Industrial Consumers," International Conference on Power, Energy and Electrical Engineering (PEEE 2021), 2021. (Preview).

[7] F. Angizeh, M. Parvania, M. Fotuhi-Firuzabad, and A. Rajabi-Ghahnavieh, "Flexibility Scheduling for Large Customers," IEEE Trans. Smart Grid, vol. 10, no. 1, pp. 371–379, 2019, doi: 10.1109/TSG.2017.2739482.

[8] X. Zhang and G. Hug, "Bidding strategy in energy and spinning reserve markets for aluminum smelters' demand response," in 2015 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT 2015): Washington, DC, USA, 18 - 20 February 2015, Washington, DC, USA, 2015, pp. 1–5. Accessed: Nov. 4 2021.

[9] Marcel Bohringer, Tim Ploser, Jutta Hanson, Timm Weitzel, Christoph Glock, and Nils Roloff, 2019 54th International Universities Power Engineering Conference (UPEC): Proceedings : 3rd-6th September 2019, Bucharest, Romania. Piscataway, NJ: IEEE, 2019. Accessed: Nov. 4 2021.