Towards Predictive Energy Management in Information Systems: A Research Proposal

David Heim[1], Gregor Friedrich-Baasner[1], Anna Fuchs[1], and Axel Winkelmann[1]

[1] University of Wuerzburg, Chair of Business Information Systems, Wuerzburg, Germany
{david.heim,gregor.friedrich-baasner,
a.fuchs,axel.winkelmann}@uni-wuerzburg.de

Abstract. The progressive energy transition, driven by the growing number of renewable energies, the increasing social importance of sustainable actions, as well as new technologies, causes major challenges for enterprises and power supply companies (PSCs). While the electricity price fluctuations will continue to increase in the future, the installation of smart meters and smart meter gateways is aimed to ensure grid stability. They provide the basis for communication between companies and PSCs. In order to make companies energy consumption predictable even before the energy is needed, an automated data exchange between an energy management system (EnMS) and enterprise resource planning (ERP) system is essential. Therefore, we address this problem by following five research steps to develop a prototype for predictive energy management in information systems.

Keywords: Energy transition, predictive energy management, information systems, demand-side management

1 Motivation and Current Developments

A predictive energy management system provides the foundation for a secure, eco-friendly and economical operation of the energy system. In the future, the produced amount of electricity should be consumed in order to exploit renewable energies and to avoid the current problem of buffer storage. The German Federal Government's goal is to cover 35 % of its electricity requirements by 2020 and 80 % by 2050 from renewable energies [1-3]. This leads to increased volatility on the electricity market [4], [5]. The far-reaching transition, driven by the liberalization of the energy market, the growing number of renewable supply, as well as increasing socially importance of sustainable actions and the change of paradigm (consumption must adapt to production) in the energy industry to decentralized feed-in causes major challenges in terms of information processing and business models [3], [6].

The resulting growing complexity of internal processes, increased customer requirements and rapidly changing economic conditions can be counteracted by the use of adequate information and communication systems [4]. Nowadays, ERP systems are an important component of companies' IT infrastructure. When implemented successfully, they support business processes by linking all areas of a

14th International Conference on Wirtschaftsinformatik,
February 24-27, 2019, Siegen, Germany

company and enable the integrated management of all enterprise resources [7]. This includes also production-relevant data such as orders, production planning and machine occupancy.

On the other hand, companies are increasingly using EnMS, which are tools used to control and monitor organizations energy flows. The ISO 50001 standard, published in June 2011, is the first international standard for EnMS and supports organizations in all industries in implementing such systems [8]. The main objective of such systems is to increase energy efficiency in order to achieve energy savings, thus optimizing energy consumption and saving costs [9]. With regard to production-relevant data, an EnMS provides information about the energy consumption of machines and production lines as well as their load profiles [10].

By combining the data from both systems, it is possible to calculate a predicted progression over time [4]. Based on this information, PSCs can use them to predict energy demand more precisely and, if necessary, to take appropriate countermeasures. Furthermore, companies can benefit from this development and optimize their production costs. At the same time, the enormous increase in electricity costs means that variable electricity rates can gain even more importance for companies [11], [12]. Significant cost savings potential can be generated even when production processes are postponed within the day. Due to Singhal and Swarup [13] energy prices can be highly volatile to systems conditions. While the magnitude of electricity price fluctuations will continue to increase in the future [14], companies can generate sustainable competitive advantages through intelligent production planning. Price fluctuations result in particular from the availability of renewable energies that cannot be planned precisely and are therefore dependent on external factors. Changes with regard to price fluctuations can be observed in particular in countries that are already increasingly relying on renewable energies [15-17]. An oversupply of electricity on the short-term energy market can result in negative prices. The number of hours during which negative electricity prices occur have increased significantly since 2010 [18]. Current research projects in the field of energy management, such as TechPlan[1], SynEnergie[2], FOREnergy[3], and PHI-Factory[4] underline the relevance of our research topic, but do not consider our approach in this way. An initial overview of the literature shows, that there are several publications on ERP-Systems and EnMS [4], [19-21]. However, the combination of both systems is currently not considered [22], [23].

2 Research Approach

The goal of our approach is to develop a prototype that allows an automated data exchange between ERP systems and EnMS. This should enable companies, to link their energy consumption with the current amount of available energy and the prices on the energy market. By aggregating this information across many companies, PSCs can more accurately predict demand and react if the amount of energy is not available at the moment. The aim of a bidirectional data exchange between companies and PSCs is to ensure grid stability and create incentive models for energy consumption.

This can be achieved, for example, by creating price incentives to shift the production of the companies to periods when demand of energy is lower.

In order to adequately address this problem, we divided our research approach into five steps, as shown in figure 1. The first step, we are working on, is to create an initial overview of current research projects, as mentioned in chapter 1, as well as several publications on ERP systems and EnMS. An exact breakdown of the scientific literature with the help of a structured literature review according to Webster & Watson [24] will be our second step. The focus of the review is on the differentiation between ERP systems and EnMS, as well as their functions. The literature and technology overview will represent our knowledge base as a basis for our iterative adjustments during the development of the prototype.

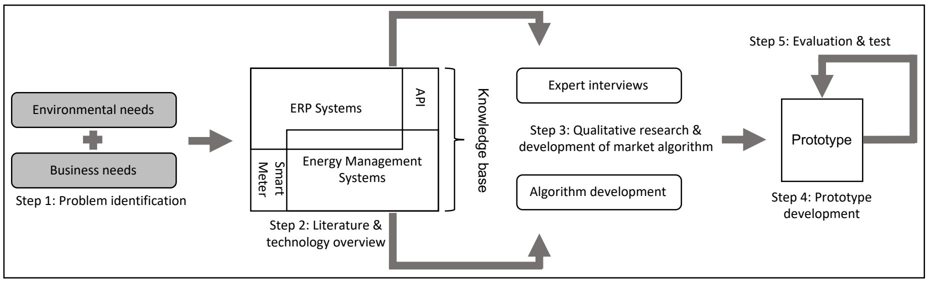

Figure 1. Research Approach

In order to adequately consider current issues and practical experiences, the requirements of companies for such a prototype have to be analyzed in the third step. To determine these, qualitative interviews with experts from different industries and company sizes are suitable [16]. Additionally, a matching algorithm should be developed, which can connect the data from the ERP system with the data from EnMS.

In the fourth step, this algorithm will be implemented into the existing infrastructures of the companies. To ensure a bidirectional data exchange between ERP systems and EnMS, the prototype contains standardized API's. This is required to enable the prototype to interact with both systems. The evaluation and test of the prototype will be an iterative process. In this case the evaluation is followed by further surveys through experts. The method of delphi studies is selected to gain these insights [25]. Ultimately, this project is intended to lead to a constantly improving tool, with a deep learning algorithm, that supports companies in their digitization.

3 Conclusion and Expected Contribution

Our research will provide the PSCs with more reliable data for their energy planning. However, the main condition, and therefore also a limitation, is that an ERP must be available at the company. At the same time, it aims to support companies in optimizing costs and enables new business models to be developed in the long term.

These new business areas are, for example, in the previously unknown topic of the energy broker. Furthermore, new services can also be created in the areas of billing, procurement and consulting [6]. Precisely, the supply fluctuations will arise from the increase in renewable energies, we assume that electricity price fluctuations will increase in line with market equilibria [15-17]. This offers both, companies and PSCs the opportunity to achieve competitive advantages through elaborated strategic action. However, these advantages can only be achieved on a reliable data basis. In our point of view, this is only possible on the basis of existing systems (ERP systems and EnMS) and the combination as well as the expansion of those. The ERP system already provides all necessary production data and the EnMS provides the corresponding energy data. By linking them, it is possible to adequately predict the required energy consumption. The linking of these systems leads to a better basis for decision-making and thus to greater insights. On the other hand, PSCs can use historical and weather data to calculate the amount of energy available and react to bottlenecks at an early stage. In this context, new technologies, like the smart meter can also be used in a meaningful way and contribute to the general objective of the energy turnaround. Here, smart meters and smart meter gateways provide the platform for the transmission of electricity prices as well as the respective demand levels. In addition, the solution to be developed will be established in familiar ecosystems, so that no transaction costs will arise for companies. One thing remains certain despite the change: Energy is the backbone of new innovations and will become an immanently important asset over the coming decades. In order to handle our planet carefully and to support the change in the energy industry, we saw ourselves induced to this research approach and have the noble goals to contribute to it. In our opinion, no major new system solution is required. Information systems have the necessary functions and the corresponding data foundation. The main objective here is to exploit the advantages of these mature systems by means of an adequate connection. This allows the potential of the systems to be expanded and enhanced. This research project is intended to test and evaluate this thought-provoking impulse.

References

1. Goebel, C., Jacobsen, H.-A., Razo, V., Doblander, C., Rivera, J., Ilg, J., Flath, C., Schmeck, H., Weinhardt, C., Pathmaperuma, D., Appelrath, H.-J., Sonnenschein, M., Lehnhoff, S., Kramer, O., Staake, T., Fleisch, E., Neumann, D., Strüker, J., Erek, K., Zarnekow, R., Ziekow, H., Lässig, J.: Energy Informatics. Current and Future Research Directions. Bus. Inf. Syst. Eng. 6, 25–31 (2013)
2. Gerpott, T.J., Paukert, M.: Determinants of Willingness to Pay for Smart Meters: An Empirical Analysis of Household Customers in Germany. Energy Policy. 61, 483–495 (2013)
3. Jagstaidt, U.C.C., Kossahl, J., Kolbe, L.M.: Smart Metering Information Management. Wirtschaftsinformatik. 53, 313–317 (2011)
4. Feuerriegel, S., Bodenbenner, P., Neumann, D.: Is More Information Better Than Less? Understanding the Impact of Demand Response Mechanisms in Energy Markets. In: Proc. 21st European Conference on Information Systems, pp. 1–12. (2013)

5. Strbac, G.: Demand Side Management: Benefits and Challenges. Energy Policy. 36, 4419–4426 (2008)
6. Doleski, O.D.: Geschäftsmodell – Methode zur Realisierung von Geschäftsideen für Utility 4.0. Springer-Verlag, Heidelberg (2016)
7. Becker, J., Kugeler, M., Rosemann, M.: Process Management A Guide for the Design of Business Processes. Springer-Verlag, Berlin (2014)
8. International Organization for Standardization: ISO 50001 Energy Management, https://www.iso.org/iso-50001-energy-management.html (Accessed: 31.10.2018)
9. Sequeira, H., Carreira, P., Goldschmidt, T., Vorst, P.: Energy Cloud: Real-Time Cloud-Native Energy Management System to Monitor and Analyze Energy Consumption in Multiple Industrial Sites. In: 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing, pp. 529–534. (2014)
10. Schellong, W.: Analyse und Optimierung von Energieverbundsystemen. Springer-Verlag, Heidelberg (2016)
11. Grandel, M.: Das „Smart Metering Dilemma“ – Strategische Überlegungen zum flächendeckenden Einsatz von Smart Metering. In: Servatius H.-G., Schneidewind U., Rohlfing D. (eds.) Smart Energy. pp. 221–231. Springer-Verlag, Heidelberg (2012)
12. Kunz, C., Müller, A., Saßning, D.: “Smart Grids” für die Stromversorgung der Zukunft. Optimale Verknüpfung von Stromerzeugern, -speichern und -verbrauchern. Renews Spez. 58 (2012)
13. Singhal, D., Swarup, K.S.: Electricity Price Forecasting Using Artificial Neural Networks. Int. J. Electr. Power Energy Syst. 33, 550–555 (2011)
14. Benini, M., Marracci, M., Pelacchi, P., Venturini, A.: Day-ahead Market Price Volatility Analysis in Deregulated Electricity Markets. In: IEEE Power Engineering Society Summer Meeting, pp. 1354–1359. IEEE Press, New York (2002)
15. Romanchenko, D., Odenberger, M., Göransson, L., Johnsson, F.: Impact of Electricity Price Fluctuations on the Operation of District Heating Systems: A Case Study of District Heating in Göteborg, Sweden. Appl. Energy. 204, 16–30 (2017)
16. Zareipour, H., Bhattacharya, K., Cañizares, C.A.: Electricity Market Price Volatility: The Case of Ontario. Energy Policy. 35, 4739–4748 (2007)
17. Lund, H., Münster, E.: Management of Surplus Electricity-production from a Fluctuating Renewable-energy Source. Appl. Energy. 76, 65–74 (2003)
18. Statista: Anzahl der Stunden mit negativen Strompreisen in Deutschland in den Jahren 2008 bis 2017, https://de.statista.com/statistik/daten/studie/618751/umfrage/anzahl-der-stunden-mit-negativen-strompreisen-in-deutschland/ (Accessed: 31.10.2018)
19. Curry, E., Hasan, S., O’Riain, S.: Enterprise Energy Management Using a Linked Dataspace for Energy Intelligence. In: Sustainable Internet and ICT for Sustainability (SustainIT), pp. 1–6. (2012)
20. Bunse, K., Vodicka, M., Schönsleben, P., Brülhart, M., Ernst, F.O.: Integrating Energy Efficiency Performance in Production Management – Gap Analysis Between Industrial Needs and Scientific Literature. J. Clean. Prod. 19, 667–679 (2011)
21. Vikhorev, K., Greenough, R., Brown, N.: An Advanced Energy Management Framework to Promote Energy Awareness. J. Clean. Prod. 43, 103–112 (2013)
22. Goldhahn, L., Bock, D., Eckardt, R., Weber, H.: Energetische Planungsalgorithmen für ERP-Systeme (EnPlan): Entwicklung Energetischer Planungsalgorithmen und deren Nutzbarmachung für den Einsatz in ERP-Systemen Metallverarbeitender KMU. ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetr. 107, 603–607 (2012)

23. Karnouskos, S., Colombo, A.W., Martinez Lastra, J.L., Popescu, C.: Towards the Energy Efficient Future Factory. In: 2009 7th IEEE International Conference on Industrial Informatics, pp. 367–371. IEEE Press, New York (2009)
24. Webster, J., Watson, R.T.: Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Q. 26, xiii–xxiii (2002)
25. Skinner, R., Nelson, R.R., Chin, W.W., Land, L.: The Delphi Method Research Strategy in studies of information systems. Commun. Assoc. Inf. Syst. 37, 31–63 (2015)

[1] TechPlan (http://www.techplan-erp.de/): TechPlan is a research project to improve the energy efficiency of SMEs in the metal industry. This should be achieved through energetic and technological planning of production processes.

[2] SynEnergie (https://www.fim-rc.de/forschung/forschungsprojekte/laufend/synergie/): The reserach project "SynEnergie" deals with synchronized and energy-adaptive production technologies for a flexible alignment of industrial processes and the fluctuating energy consumption.

[3] FOREnergy (http://forenergy.de/): The aim of the FOREnergy research project is the evaluation of concepts and solutions for an energy-flexible factory.

[4] PHI-Factory (http://phi-factory.de/): The goal of this research project is the development of technical and organisational solutions that enable industrial companies to save energy costs and support power grid stability at the same time.