A PESTEL-Analysis of ICT-Requirements on Decentral Smart Energy Management

Masterarbeit

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vorgelegt von

Name: Gerlach Vorname: Jana

[redacted] [redacted]

Prüfer: Prof. Dr. M. H. Breitner

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1 Introduction

One of the most fundamental challenges our society is facing the climate change. In order to mitigate its impact, climate protection goals have been established with the target to reduce greenhouse gas emissions. According to these goals, greenhouse gas emissions have to be reduced by 40 percent until 2030 and by 80 to 90 percent until 2050. Both, with reference to the year 1990. When considering the current greenhouse gas emissions of approximately 900 million tonnes CO_2 equivalent and the climate protection goals which require greenhouse gas emissions of approximately 550 million tonnes CO_2 equivalent in 2030 and 55 tonnes in 2050, it can be assumed that the climate protection goals cannot be achieved. Particularly, if the trend continues as it is today. Thus, there is a large gap between the climate targets and the real development of the trend. Areas with the greatest need for action are the energy sector and the building sector (Agentur für Erneuerbare Energien, 2018a), (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2019).

Consequently, there is a huge demand for action in order to reduce the emissions of greenhouse gases by raising energy efficiency, introducing and integrating renewable energies, as well as reducing and phasing out the usage of fossil fuels. In consideration of achieving the climate protection goals, Germany has enacted a large number of political and legal framework conditions (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2019). These include the so-called "energy transition" and the "heat transition". The aim here is to make energy supply more decentralized, shifting away from central coal-fired power plants and moving in the direction of renewable energies. Besides decarbonization and decentralization, one more objective is the digitalization of the energy sector (Bundesregierung, 2019). In particular, the increasingly fluctuating nature of the electricity pattern, caused by renewable energies, can lead to instabilities and imbalances within the energy grid. To balance these instabilities and supply disparities, smart energy management, combined with information and communication technology provides an intelligent way to compensate energy shortages and excesses (Aichele, 2018, pp. 699-702).
In this context, the issue emerges of how a digitalized and primarily decentralized energy system can be structured and designed. A possible solution could be that energy, produced by renewable energy plants in smart homes and/or smart quarters can be used either at home or distributed to other households and consumers in the smart quarter (Erbstößer and Müller, 2017, pp. 9-12), (Aichele, 2018, pp. 699-702).

The digitalization of the energy sector is a major challenge for practitioners as well as academics. Therefore, the shift in paradigm requires far-reaching calls, not only for individual issues, but also for these to be embedded and linked to the whole system and its periphery.
The overall purpose of this thesis is to develop and create ICT-requirements for a decentralized smart energy management by using a PESTEL-Analysis in order to get a

broad insight as well as reflecting several factors. Therefore, the research question is as followed:

What are the requirements of Information and Communication Technology for Smart Energy Management with regard to the Decentralization of the Energy Sector as well as the Macro-environmental Framework?

This thesis will provide an understanding of the subject-specific terminology in order to comprehend what the decentralization and digitalization of the energy supplying system actually implies. Therefore, this thesis is divided into ten chapters. On the introduction to the theme follows the second chapter with the explanation of the theoretical background. In this chapter, general terms, like smart home, smart quarter, ICT and smart grid are defined according to their utilization and purpose for the whole system and field of application. Subsequently, in the third chapter, a presentation of the research method follows which is of considerable relevance for the further processing of the thesis. The approach of a PESTEL-Analysis as well as a SWOT-Analysis will be explained. After the explanation of the research methodology, the PESTEL-Analysis follows in the fourth chapter and will occupy a significant fraction of the main part. In order to derive the ICT-requirements of the decentralized energy system from a macroeconomic perspective, political, economical, social, technological, ecological and legal factors are considered and discussed individually. In the fifth chapter follows a SWOT-Analysis, based on the results obtained before. Hence, this analysis consists of a discussion in a reflective and evaluative way, in which opportunities and threats, as well as strengths and weaknesses are being examined. Subsequent to the SWOT-Analysis, the results are discussed, at first separated, according to the individual PESTEL-factors and afterwards together, considering all factors and aspects. Furthermore, this chapter also compares the relationships between the individual factors and the sub-factors. The aim is to find out which factors influence the energy system and its further digitalized and decentralized development to the greatest extent and which factors make a major contribution to the system. The following chapters give implications and recommendations regarding the ICT-requirements for smart energy management by additionally considering the micro and macro-environmental framework. The ninth chapter gives a limitation of the thesis. The tenth and final chapter summarizes the results in a conclusion and presents an outlook to the future.

10 Conclusions and Outlook

The overall purpose of this thesis is to develop and create ICT-requirements for a decentralized smart energy management by using a PESTEL-Analysis in order to get a broad insight as well as reflecting several factors, by answering the research question: What are the requirements of Information and Communication Technology for Smart Energy Management with regard to the Decentralization of the Energy Sector as well as the Macro-environmental Framework?

In this context, the objective for every smart prosumer household is primarily to supply themselves with energy. Here, the smart energy management system is of crucial relevance, as it efficiently distributes and manages energy in an intelligent manner. However, the objective is by no means to be autonomous, but rather to save energy consumption. Through the use of ICT, the respective smart devices in the house can be connected to the energy resources, the energy storage and perhaps, even to the electric car by distributing the energy according to its requirements. It is particularly important that the energy is stored for the night in order to ensure that as less external energy as possible is consumed during the night. In addition, all devices should be able to communicate with each other, so interoperability is essential, as well as a fast internet connection in order to manage and monitor processes and current meter readings in real time. Furthermore, in the area of demand side management, power-intensive devices should be limited in their function of being permanently operable. This means that in case of insufficient energy in the in-house power cycle or in the smart grid, no additional energy is consumed. However, this function should only be used if the stability of the energy supply is limited. It would also be conceivable to have a separate storage facility in these devices in order to be able to continue running autonomously without having to consume energy from the grid. Both proposals would contribute to the stability of the grid and would also be favorable in terms of user acceptance.

With regard to energetic smart quarters, their classification should be dynamic, as the number of prosumers, pure producers and pure consumers can constantly change. It needs to be considered that a local authority is responsible for the quarter planning and not a company with a profit-oriented business model. In addition, data, transmitted to companies for further use should be anonymized in order to do justice to the EGDPR and user acceptance on the other hand. In these smart quarters, there should be a central energy distribution and management platform or center which cooperates with the peer-to-peer energy trading platform. Hereby, the focus is mainly on the blockchain technology, which can provide an automated impact during the transaction. Moreover, all processes should be monitored by a governmental authority.

Furthermore, it is important to customize the security countermeasures to the increasingly digital and decentralized energy supply. Therefore, every member should know

what to do in case of an attack or power failure and also in general, to be able to protect themselves most adequately against cyber-attacks.

With regard to the macro-environmental framework, which is an essential part for the further development and enhancement of the digital and decentral energy system, the economic, technological and social aspects in particular, are of essential importance. The changing structure of the energy market is particularly significant in this context. On the one hand, existing energy companies are challenged to change their business models and on the other hand, new companies and start-ups were introduced to the energy market with low barriers. On the social level, user acceptance plays an relevant role. This is influenced by many aspects, such as income, age, gender, but also technological affinity and environmental awareness are crucial for the adoption of smart energy management systems.

The factors with the highest influence on the entire system are the political and the environmental factors. These determine the direction and set the framework conditions. In the first instance, these include laws such as the EEG, the EEWärmeG, the MAP and the Act on the Digitization of the Energy Transition, as well as many other laws. Furthermore, it also includes the goal of reducing Germany's dependency on energy imports from other countries which are dominating the oil reserve as well as the uncertainties and adverse effects on health and the environment.

Looking into the future, it will be important that the sustainable produced electricity can indeed be shared with other local consumers.

For many people, the realization that fossil fuel reserves will be exhausted in a foreseeable future is very surreal and inconceivable. Nevertheless, the challenge for the future will be, to find active and attractive solutions for a time after fossil fuels, as well as reducing the effects of climate change and to decrease health and environmental impacts. ICT and technology in general can provide an intelligent solution for linking sectors and distributing electricity efficiently and in line with energy requirements.

In order to be able to further expand the development of a decentralized energy system with local smart quarters, however, there is still a need for strict rules from legislation. For example, on interoperability and additionally, more governmental support. Political conditions provide the framework and lead the way.

After all, without the connection with the human being, even the most full or semi-automatic technology cannot be used in a purposeful way and no technology acceptance or even a repurchasing interest can be formed, if human and machine interactions are not in the focus.