More than a Trending Term? - A Taxonomy and Archetype Analysis of AI-enhanced Services in the Energy Sector

Masterarbeit

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1 Introduction

This master's thesis deals with the topic ‘More than a Trending Term? - A Taxonomy and Archetype Analysis of AI-enhanced Services in the Energy Sector’. The collaboration took place with the Institute for Information Systems Research at Leibniz Universität Hannover.

Artificial Intelligence (AI) is becoming a trending term in many fields, and AI-enhanced services are being used in more and more areas. The topic of AI is present in research, business and society and is gradually permeating almost all areas of life. It has become an indispensable part of the increasingly digital world. AI is also repeatedly present in the media in connection with the energy sector (Deutsche Energie-Agentur (dena) 2020: 6, 11). The energy sector is currently undergoing a fundamental transformation. This is being intensified by the fight against climate change. In the course of this, the EU, for example, has set a target of reducing greenhouse gas emissions by 80%-95% by 2050 compared to 1990 levels (Europäische Energie- und Klimaziele 2019). In order to make this transformation successful, renewable energies, for example, are increasingly being used and expanded (Statistisches Bundesamt (Destatis) 2021). Among other things, this will lead to a decentralization of electricity generation and a significantly more volatile electricity grid (Bundesministerium für Wirtschaft und Energie 2016: 28). In addition, the quality and quantity of data in the energy sector are increasing significantly, which must be managed quickly and efficiently to ensure the stability of the system (Heinemann et al. 2021: 12). In particular, the topics of decarbonization, decentralization and digitalization are in the foreground (Wolf et al. 2019: 4). Due to the growing complexity in the energy sector, there is an increasing search for new, integrated solutions. AI is seen as a hopeful tool for achieving the goals of a CO_2-free energy system, while at the same time increasing or at least maintaining economic, ecological and social requirements (Deutsche Energie-Agentur (dena) 2020: 6).

So, the question arises as to how much is behind the bearer of hope and trending term AI-enhanced service in relation to the energy sector. In the course of this thesis, areas will be identified in which AI-enhanced services are already being used in the energy sector. Due to the growing number of AI-enhanced services in the energy sector and the so far low number of publications in science related to this, a research demand has been identified. In order to examine this more closely, two research questions are posed, which are to be explored in this thesis. These are as follows:

> *RQ1* What does a taxonomy of AI-enhanced services in the energy sector look like?

RQ2 Which archetypes can be identified with the help of an archetype analysis based on the taxonomy of AI-enhanced services in the energy sector?

As there is currently no taxonomy in this area, the aim of this thesis is first to create a taxonomy of AI-enhanced services in the energy sector with the help of the above-mentioned research questions. Subsequently, archetypes are to be identified based on this taxonomy.

The thesis is structured as explained below. Chapter 2 begins by describing the current status in the energy sector. Then AI terms, methods and capabilities are explained and finally applications of AI in the energy sector are presented. Chapter 3 presents the methodological approach of taxonomy development according to Kundisch et al. (2021) which is based on Nickerson et al. (2013). In addition, a literature review according to vom Brocke et al. (2015: 205-224) and Webster and Watson (2002: xiii-xxiii) is conducted to identify relevant papers for taxonomy development. The taxonomy of AI-enhanced services in the energy sector is then developed in five iterations in chapter 4 and the final taxonomy is presented. Building on the taxonomy, chapter 5 identifies archetypes using the k-means algorithm. In chapter 6, the taxonomy is evaluated with the help of a survey of the companies offering the AI-enhanced services. Chapter 7 gives an overview of the availability of open-source AI-enhanced services in the energy sector. Finally, the results of the thesis are discussed, limitations and implications are pointed out and a summary with an outlook for further research is given.

10 Conclusion & Outlook

In the course of this master's thesis, AI-enhanced services in the energy sector were examined. For this purpose, trends in the energy sector were first identified in the chapter theoretical background. For example, in the focus of decarbonization, more and more attention is being paid to renewable energies, resulting in the electricity grid being much more volatile. In addition, electricity generation is becoming decentralized due to an increasing number of market participants. Digitization is also a major trend and the quality and quantity of available data are increasing. This change in the energy sector requires new solutions for the complexity that arises. These solutions are to be created with the help of AI. Based on the first research question, existing AI-enhanced services were investigated and a taxonomy was developed according to the taxonomy development process of Kundisch et al. (2021).

> *RQ1* What does a taxonomy of AI-enhanced services in the energy sector look like?

Five iterations of taxonomy development were carried out. The first iteration followed the conceptual-to-empirical approach. Nine dimensions and 49 characteristics were identified from literature sources. The literature was previously found in a literature review according to vom Brocke et al. (2015: 205-224). Subsequently, four further iterations were carried out according to the empirical-to-conceptual approach. During the iterations, 100 AI-enhanced services listed on Crunchbase were examined. After the fifth iteration, all ending conditions were met. The final taxonomy consists of 14 dimensions and 79 characteristics.

Building on the taxonomy, an archetype analysis was carried out as part of the second research question.

> *RQ2* Which archetypes can be identified with the help of an archetype analysis based on the taxonomy of AI-enhanced services in the energy sector?

Five archetypes were identified and named based on the formative characteristics. The five archetypes are ‘Demand response and grid management’, 'Asset & grid maintenance’, 'Building energy management', ‘Energy generation optimization' and 'Energy market platform & trading'. The archetypes contain a significantly different number of services. For example, the archetype 'Building energy management' contains 39 services in contrast to the archetype ‘Energy generation optimization' which contains only 11 services.

Based on the results, the companies offering the services were asked for an evaluation. Some suggestions for possible extensions or improvements were made. In addition, the feedback helped to prove that the taxonomy is useful. Among other

possibilities, the most frequently mentioned was the use for competitor analysis. Through the evaluation, the taxonomy development process was successfully completed.

A benchmarking exercise was then carried out, looking at open-source AI-enhanced services in the energy sector. It was observed that there are very few open-source services to be found. However, there are many small projects, for example, on GitHub. As the use of AI and the number of open-source AI increases, it is likely that more open-source services will be available for the energy sector in the future.

Future research could expand the taxonomy in some areas. On the one hand, the features mentioned in the evaluation could be included in the taxonomy as dimensions or characteristics. In addition, other sources for services besides Crunchbase could be searched. Furthermore, the taxonomy should be repeated at regular intervals to ensure that the characteristics and services are up to date. Evaluations by other groups, such as researchers, could also bring new knowledge. In addition, it would be interesting to see which AI-enhanced services and in which areas are successful on the market in the long term. Another approach would be to carry out the taxonomy from the service provider’s view in order to obtain a new perspective.