Electric Mobility Integration in Energy Communities: Trending Topics and Future Research Directions

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***Abstract*—The urgent need to reduce carbon emissions resulting in decentralized renewable energy systems also encourages the establishment of energy communities where residential and/or commercial consumers can actively participate in the generation, consumption, or provision of flexibility of electric energy. The integration of electric mobility within these energy communities is of particular interest as its increasing load will impact grid stability and therefore the power grid's and components' sizing and operation. With this work, we provide a holistic overview of research activities on the integration of electric vehicles in energy communities that supports researchers and practitioners with the identification of relevant topics and research gaps. We identify seven research clusters by hierarchical clustering analysis. Relevant topics include smart charging, vehicle-to-x, and considerations of uncertainty. Future research should focus on open-source models and the synthesis of the knowledge base from the extensive body of literature.**

I. Introduction

The growing dissemination of distributed energy resources encourages the establishment of energy communities where residential and/or commercial consumers can actively participate in the generation, consumption, or provision of flexibility of electric energy. Generally spoken, consumers acquire ownership of renewable energy installations and become prosumers [1]. In this case, they can share the energy they produce to reduce overall expenditures. One of these installations is electric mobility, i.e., electric cars and charging stations, used by the prosumers in the energy community. The integration of electric mobility within energy communities, driven by the need to reduce carbon emissions, is of particular interest as its increasing load will impact grid stability and, therefore, the power grid's and components' stability, operation, and sizing [2]. There is numerous academic literature concerning the integration of electric mobility in energy communities covering multiple research perspectives. For example, there is research focusing on the economic evaluation [3], presenting real-world examples [4], estimating electric vehicle (EV) demand [5], or examining optimal strategies [6]. In addition, there are extensively reviewed examinations on EV (e.g., [7]) or energy communities (e.g., [8]). However, to the best of our knowledge, a structured review and synthesis of academic knowledge on energy communities focusing on electric mobility integration is limited to one short article with only 20 reviewed works [9]. This is somewhat surprising since electric mobility can play an important role in reducing greenhouse gas emissions and cost savings for prosumers. With this work, we want to close this gap and provide a holistic overview and synthesis that supports researchers and practitioners in identifying relevant topics and research gaps. This can foster the widespread of electric mobility and serve as an ignition of the chances and challenges associated with energy communities. In doing so, we chose a software-enhanced research design with a python based text mining tool. Text mining has the advantage of finding helpful information from documents and identify patterns and trends [10]. Therefore it is a suitable tool for our research procedure, that will answer the following research questions:

1. What are trending topics in electric mobility research concerning its integration in energy communities?
2. What research gaps can be identified, and how can they be approached?

The rest of the paper is structured as follows: After the theoretical background on energy communities and electric mobility (Section II), we present our research design and methodology in Section III. Section IV encompasses descriptions of the identified topics and a graphical representation of the research clusters. Afterward, research gaps and future research directions are identified (Section V), limitations are stated (Section VI), and concluding remarks are given (Section VII).

II. Theoretical Background

The principle of energy communities has been a topic of research since the 70s and has gained more attention in recent years [11]. The focus on energy communities is driven by the climate crisis, technological change, and the urgent need to reduce greenhouse gas emissions resulting in the current transformation of the energy sector [11]. In their Clean Energy Package (CEP), the EU even sees energy communities as a key element for consumer participation in a renewed sustainable EU energy system and directly promotes the opportunity for citizens to join energy communities [12]. The definition of energy communities is an important aspect of this paper due to the chosen text mining approach. There are many different names or definitions of the principle, all with a slightly different concept of an energy community. [11] examine the existing different concepts of energy communities pointing out 17 different definitions. On the basis