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Research paper

Digital Energy Hub for Optimizing Energy Usage: A Review

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Abstract

Energy usage as it relates to its security and management is an important aspect that all organizations having a vested stake in power production should be concerned with in these coming years. In this respect, harnessing the knowledge so that it may benefit various sectors, from the power producer right down to the customers, can be achieved by way of the digital energy hub, as proposed in this paper. We first put into context the workings and functions of such a digital platform, and then proceed to outline how it could benefit the many parties involved. Lastly, we take into account the challenges that needs to be addressed for its successful implementation, in which information security and privacy is a top priority amongst other issues.

***Keywords**: Knowledge management, Energy security, Energy management, Information security, Power grids, Information privacy*

1. Introduction

One of the essential areas for the energy players for competitiveness is to optimize energy usage. As defined by the International Energy Agency (IEA): “long-term energy security and management mainly deals with timely investments to supply energy in line with economic developments and short-term energy security and management focuses on the ability of the energy system to react promptly to sudden changes within the supply-demand balance” [1]. IEA has stated that a failure in managing energy would lead to negative economic and social impacts ranging from either the physical unavailability of energy, or prices that are not competitive or overly volatile. On that note, knowledge in optimizing energy usage is essential for energy sectors and must be shared among the key players around the world. This justification is supported by [2], in which they indicated that knowledge or digital hubs are necessary technologies for businesses to analyze the conversion, management and storage of renewable energy within the residential home, smart communities and smart cities. Hence, digital hubs should feature largely under the scope of the energy and utility players when it comes to managing the operations and equilibrium of their power systems, particularly when the grid is experiencing heavy load periods and there is a surge in electrical power demand from its users [3].
The rest of this paper is organized as follows. Section ‘Method’ outlines the steps taken in the systematic review of the literature on digital energy hubs, the results of which is presented in the subsequent section. Section ‘Literature Review’ presents a thorough review of the digital energy hub, covering the technology, criteria for its successful implementation and its benefits in context. Section ‘Discussion’ looks at several issues, mainly security and privacy that might be of concern for this digital platform. Finally, the paper is concluded in the section ‘Conclusion’.

2. 2.Method

2.1. Selection criteria

Abstracts, published between the year 2003 and 2016, were selected for retrieval of paper if they were judged to include information about or containing the following terms: knowledge management, knowledge management success, smart grid, interconnected power system, electricity markets, home energy management, energy cost, energy reliability and smart metering. The abstracts for these studies (n = 17) were selected independently by two researchers. From here, they were further inspected and the decision for its inclusion and exclusion were mediated between three researchers through several discussions.

3. Results

Most studies focused on the knowledge or digital hub deals in the domain of knowledge management and covers amongst other things the technology, its benefits to an organization and its end-users as well as critical success factors for its implementation.

Table 1. Common attributes among the reviewed literature

Topics	Reference	Review/Comments
Knowledge Management (KM) Technologies and Applications	[4]	KM is referred as an approach that simplifies the process of acquiring, transferring, sharing, distributing, developing, and understanding of an individual or organizational knowledge
	[5]	The emergence of Information and Technology (IT) and network infrastructure have simplified users to obtain significant knowledge from different channels and mediums through virtual technology
	[7]	Within an organization, the distribution and retrieval of information relies a lot on knowledge-based systems
	[8]	Platforms hosted on the internet are ideal digital environments in the continuous development of knowledge, its transfer, and ultimately embeds knowledge sharing practices within organizations
	[9]	IT Infrastructure such as network structure, high-end computers, integrated databases and standardization of hardware and software are key success factors in building a KM system
Success Factors for KM Implementation	[9]	A platform that is easy and efficient to use, will ensure the utilization to be high, and knowledge sharing activities could be influenced positively
	[11]	Lack of integration of the IT platform, network infrastructure, training, and documentation have been identified as the major barriers to knowledge sharing
	[12]	Digital hubs stimulate knowledge sharing activities which enables collaborative decision, organizational learning and memory, eventually affecting its performance and innovation
	[13]	Digital hubs should allow users to easily collaborate and socialize; providing a user-friendly interface and offer an assessment of platforms
End-user Experience and Benefits	[14]	Digital hubs can serve utility customers by providing information on outages, allowing customers to report problems, manage their accounts, and provide feedback and suggestions
	[15]	Smartphone capabilities that is integrated with digital hubs enhances multichannel experiences to improve customer access to the utility services
	[16]	Features commonly available on normal websites, such as applying for an electricity connection and paying the bills are being added to the mobile experience and can be integrated with the digital hubs
	[17]	Customers can receive periodic information on important events, decisions, and documentation that are related to the utility sectors
	[18]	Customers will have access to a centralized hub that displays the activity of the electricity market in an easy-to-interpret and interactive graphical presentation

4. 4.Literature Review

4.1. Digital energy hub

In the field of knowledge management, knowledge or digital hubs are vital when it comes to the understanding of knowledge that can be harnessed from any individual or organization. On the outset of achieving this goal, the digital hub acts as a platform that simplifies the task of obtaining, delivering, sharing, disseminating and developing of said knowledge [4]. In recent years, employees are able to acquire important knowledge through various digital mediums and channels, aided with the rise of social media, big data analytics and mobile technology [5]. A multitude of mediums and channels means many different outlets in the acquiring and sharing of this knowledge. Previous scholars, such as [6] and [4] have indicated that the digital hub was designed and suited to ease the burden of the task, enabling effective allocation of resources any particular task, while also improving decision making and problem solving by key personnel.

The digital hub's role in an organization is to determine how information is distributed and accessed organization-wide [7]. This technology employs robust computers and network technology to cater for a wide-range exchange of data and knowledge, which eventually supports new businesses and globalization in general [8]. Other scholars, such as [9] stress how the technology provides major features, which includes searching and retrieving functions. By adding the extensive capabilities of semantic web and data mining, we can further push the quality of this digital platform. The digital hub serves as a digital environment that continuously helps to cultivate new information while spreading the current existing knowledge. This helps in embedding knowledge management practices across all sectors that relate to power technology. In practice, this platform should simplify connectivity and encourage social collaboration among staff that will enhance knowledge transfer and acquisition within the organization [9]. Additionally, a digital hub acts as a storehouse for saving documents in an accountable, reliable and organized manner, serving as a common platform for all energy players. Moreover, it can be seen also as a platform for storing explicit knowledge which can be readily searched and extracted as needed for reference in the future. As an energy player, supporting the sharing of knowledge among employees will eventually lead to the formation of a digital hub, where any personnel can offer their expertise in a virtual fashion to their organization, which in turn can be easily accessed by the entire team.

4.2. Optimizing Energy Management

A digital energy hub will provide several benefits and business values for the management of the energy players. Technical personnel, within and outside of the organization, could employ the digital hub as an information portal, allowing them to retrieve an immediate overview, for instance, of current loads as well as supplying them with tailored technical information vital for the administering of the grid. In practice, this platform should ideally publish various technical information which includes electrical power loads, electricity generation, frequencies, transferable capacities, legal contracts and documents, the exchanges from one system to another as well as an observation of the local energy markets. This digital hub will act as the centralized single entry point which eases the publishing of information, allowing for the personalization of management and rights, and will be immediately integrated with internal information systems functions such as search, classification, security and accessibility [10]. Internal staff, in particular those at the management level can benefit from the ability to pull real-time information, allowing them to administer the organization in an efficient and timely manner. Having a single unified and centralized access to the information regarding the grid's performance, management would be better equipped at analyzing and controlling this myriad of knowledge from all the different information systems. It is worth noting that the lack of integration of the various systems, network infrastructure and documentation had been identified as major barriers to knowledge management and collaboration among the internal staff [11]. Additionally according to [11], usability issues in the digital hubs can affect its adoption by potential end users; frustrated users would very quickly abandon the technology rather than persevere to use it. Hence, issues related to the intuitiveness and ease of use of the platform needs to be looked into. Otherwise neglected, it might result in lower adoption, hindering knowledge management activities within the organization [9].

As a matter of fact, these digital platforms should support knowledge management activities in terms of cross-functional decision making plus organization-wide learning and memory which would eventually impact operational performance, creativity and innovation [12]. These platforms should also allow businesses to be on their toes, constantly shifting and diversifying their operations as it looks into the future. Such an objective can only be achieved if the digital platform enables the business to forecast and anticipate forthcoming trends in the energy markets. [13] had stated that knowledge-based technologies, in particular digital hubs, must encourage the staff and management to easily collaborate and socialize; on top of being equipped with an intuitive and easy to use interface. Significant features that should be common for a digital hub include having a fair amount of knowledge artifacts and archives readily present, a substantial amount of actively participating users already existing in the system, as well as more features that enhances user participation on these platforms [13]. Other scholars, such as [9] also stress that the effectiveness of a digital platform is in its ability to provide major elements, such as queries and visualization, and the aforementioned capabilities of semantic web and data warehousing which would support decision making and analysis of future trends for their long-term survival.

4.3. Optimizing Customer Usage

Normally, millions of people around the world tune-in to their mainstream media (such as the television, radio and newspaper), social media or even official websites to get information about power outages and finding out when their electricity would be restored [14]. These customers would rely on the information from these sources without having to call or query a customer service representative from their respective energy provider company. Alternatively, digital hubs can also be employed innovatively to serve these same customers by providing information on outages, while also allowing customers to report problems, manage their accounts, and provide feedback and suggestions from time to time. One of the most compelling reasons for utilities to build their own digital hubs is what the industry is calling 'demand response' [14]. As mentioned by [14], when customers see how much of power they are consuming, and how much it actually costs, they can trace the expense back to behaviors, and understand how to impact the numbers. Consequently, the customers will benefit from lower bills and it will also manage their future spending in energy consumption and utilization.

In fact, it has been reported that customers tend to prefer one single media or platform for handling their routine tasks, either through a telephone, website, or perhaps using a mobile application, as their primary mode of interaction with the energy industries [14]. But the trend is changing with more and more customers opting to engage via a combination of channels. Using 'smart' mobile capabilities that is integrated with digital hubs enhances multichannel experiences to improve customer access to their services [15]. Features commonly available on normal websites, such as applying for an electricity connection, paying the bills or submitting a complaint or feedback, are quickly being added to the mobile experience and can be integrated with the digital hubs [16]. The future for the digital energy hub strategy is to be built completely on customer experiences and features an integrated content management platform for optimizing the customer usage [14].

Direct access to real-time information is beneficial at the customer end. Related to this are the mutual documents about power generation, distribution and transmission of electricity as well as information regarding energy laws, policies and the energy market that would be useful reference to the customers [17]. By connecting to the digital hub, customers are able to obtain information on the organization's functions and structure, not to mention periodic activities that may be of concern to them. According to [17], customers could have the privilege to receive regular information on key events, decisions, and documentation that are related to the energy sectors. The digital hub also contributes to further develop the electricity market by way of making public the current prices offered by the individual energy providers. All of the traded quantities of energy can be published on the hub, along with the energy prices and other analysis from market activities [18]. In turn, this brings about the fruition of a competitive electricity market which leads to the lowering of prices and value-added services to the customers, improving their daily lives. On that note, customers will surely benefit from having access to a centralized hub that displays the activity of the electricity market in an easy-to-interpret and interactive graphical presentation. When market players compare this information with the data from the consolidated technological systems, they have the opportunity to make informed decisions both in technological and economical terms for their market participation. Additionally, making the information on the electricity market presented by the digital hub public guarantees equal access of information to all market participants, and as a result helps to keep electricity costs lower for the benefit of the business and their customers.

5. Discussion

5.1. Security and privacy issues

The emergence of the digital knowledge hub that helps to optimize energy efficiency will certainly improve the quality of life and offer many benefits to the communities around it. Nevertheless, security remains a major concern in the context of the digital world. For instance, the new knowledge hub would pool data on energy consumption mostly from the customer's smart meter installed in their private respective premises, which in of itself presents a myriad of security and privacy issues that needs to be highlighted. It is feared that failure to recognize these issues would affect the successful implementation of the digital knowledge hub. According to [19], the digital hub should have the ability to share its resources to a large audience and is accessible to a diverse range of users who are interested in the content available on it. In regards to using the digital hub for the purpose of gaining information related to energy optimization, most of the data will come from the Advance Metering Infrastructure (AMI) built into the smart meter installed at the customer's premises. These smart meters will supply a huge amount of data which not only contains the energy consumption behavioral pattern but also customer sensitive information like the smart meter's Internet Protocol (IP) address and location [20]. An attacker might be able to exploit this sensitive information to carry out a malicious attack on the customer's premise, the surrounding neighborhood or even worst against the entire smart grid itself. Hence, it is important to implement access controls on the digital hub, ensuring different levels of division in terms of data access based on data sensitivity. Scholars including [21] had noted that many end users are concerned about how their daily energy usage patterns are being monitored through the smart meter and how it is eventually shared to external parties without their mutual permission.

5.1. Accuracy issues

Validity of information garnered from the knowledge hub is another issue that needs to be highlighted. As stated earlier, most of the consumer's behavioral data on the digital hub comes from the AMI in the smart meter. [22] had stated that since the nature of the smart meter is similar to a Personal Computer (PC), it will also characteristically inherit the same vulnerabilities of the latter. For example, an attacker planning to penetrate the AMI environment can physically connect a device directly to the smart meter if it is not physically well-protected. Worse still, the smart meter can be tampered with, which in turn leads to false data being generated by the smart meter. Another scenario might see an attacker physically replacing the actual smart meter installed by the energy provider with a replicated device that supplies false information to the AMI central controller. In all cases, false data would be introduced into the digital energy hub's data bank, which would in turn relay wrong information to its users.

6. Conclusion and Future work

Further work can certainly be explored from what is presented in this paper, with the objective of developing a new framework that takes into account the security and privacy issues stated earlier. A comparative study on fully deployed digital energy hubs that tracks energy consumption could be conducted, while at the same time reviewing the highlighted concerns and how they impact the successful implementation of the hub and the stakeholders in general.

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