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EFFECTS OF ICT'S ON ENERGY MANAGEMENT SYSTEMS*

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Abstract. The modern world is facing hedge amount of challenges in the area of energy management. Information and Communication technologies are on of most important tools for managing, monitoring and improving the energy consumption efficiency if they are implemented and used for that. Not all countries dealing with this issues successfully and effectively. Therefore scientific and practical solutions based on regions specifics are necessary. This article aims to analyze the peculiarities of Middle East countries in ICT usage in energy management sector. After conducting the researches, it can be stated that the positive influences of the ICTs' in managing the energy management sector are valid, valuable and giving progressive results. The research results are presented further in the article and the peculiarities of the factors and the tools that are used to improve efficiency and sustainability of in the energy management sector in Middle East countries.

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1. Literature Review

The energy crisis observed to be one of the major emerging issues due to its rising on demand as well as on reducing supply. The reason behind the energy crisis is the limited availability of oil resources along with the restricted supply due to the geographical barriers along with political conflicts (Williams & Alhajji, 2003; McKillop, 2008; Vegeera et al. 2018). The growing concern of energy crisis is also due to its over-consumption, rising population of the world, poor infrastructure for its efficient & effective management, and unexplored renewable energy options. It also includes a delay in commissioning of power plants and excessive wastage of energy by the consumers in certain regions.

The modern world faced with enormous environmental problems and challenges that no individual, governments, nor companies would want to wish away (Hannan, Al Mamun, Hussain, Basri, & Begum, 2015, Dudin et al. 2019). The energy consumption of the society has created harmful and deep-rooted consequences to the environment that if not tamed, threatens to destroy the ecosystem. Energy consumption, therefore, should be managed efficiently so that it does not cause additional challenges to the already imbalanced environment. The biggest challenge of the current generation, consequently, would be the efficient management of energy consumption systems (Adamczewski, 2016; Rogalev et al. 2018). When the warning was sounded about the possible consequences of depleted energy reservoirs, different governments and stakeholders in the energy sector committed to finding innovative and sustainable ways that could meet the spiraling energy demands (Cullen-Knox, Eccleston, Haward, Lester, & Vince, 2017; Strielkowski 2017; Abbas 2018; Tvaronavičienė 2018; Tvaronavičienė et al. 2018; Masood, et al. 2019). The ICT sector, in its reaction to this proposal, offered to put in place innovative ways that could help end the energy consumption menace and to also open new avenues by designing newer methods that would consume less energy (Trentesaux, Borangiu, & Thomas, 2016). Currently, most companies and governments have realized that the ICT sector could help them to some extent in the management of their energy policies for the future. Therefore, the role that ICT could play in the energy sector management cannot be wished away and, consequently, any individual, company, or government that would want to manage its energy sector efficiently should incorporate the ICT systems available to them. Consequently, the ICT sector has effects that are more beneficial in the energy management sector than the disadvantages of incorporating ICT in energy management systems.

The purpose of this article was to evaluate the factors and the tools that are used in order to improve efficiency and sustainability of in the energy management sector I Middle East countries. For the research literature review and Multi Criteria Decision Analysis in row with descriptive analysis of results were employed.

2. Literature Review

One of the major causes of the energy crisis is its increasing demand in the global context. Contextually, the increasing demand has also been due to the rising population throughout the world (Coyle & Simmons, 2014). The underdeveloped nations such as Lebanon face financial issues with reduced cash flow. Hence, this, in turn, affects the supply of supply of energy (Qasim & Kotan, 2013). The growing concern for the environment protection from the use of fossil fuel has resulted in the restriction in its consumption (Festus & Ogoegbunam,

2015). Climate change in the global context has also led to the growing concern for environmental protection (Pathak, 2014). In addition, the poor infrastructure has also been the reason for the global energy crisis, which increases the production cost as well as complexity associated with it (Coyle & Simmons, 2014). Moreover, the wastage of energy has been a common phenomenon in both urban and rural areas, which, in turn, causes its crisis at the time of requirement (Pathak, 2014). In Lebanon, the energy distribution system is poor due to the lack of proper infrastructure. Hence, due to this particular reason, the country faces a crisis in both rural and remote areas (Qasim & Kotan, 2013). During wars, especially evident from World War II, there have been severe international political conflicts, which resulted in an energy crisis in some nations (Coyle & Simmons, 2014). Natural calamities also affect the supply chain process, especially in the case of oil pipeline burst due to which energy cannot be distributed to the destination. The heavy taxes on oil and automobiles causes energy crisis to a certain extent (Coyle & Simmons, 2014).

Energy security and efficiency assurance is highly important for economic growth as well as development along with its sustainability in the long run. It leads to industrial growth, which in, turn, increases employment and the purchasing power of the people. It significantly contributes to reducing the inflation rate as well as poverty among people (Stošić-Mihajlović & Trajković, 2018). Moreover, energy security and efficiency assurance is crucial for saving the planet, as it reduces pollution and carbon footprint along with the lowering of the possibility of climate change (Volyand, Woodman, Hook, Reece, & Fagan, 2010). Energy security along with efficiency assurance leads to the welfare of the society, as it promotes industrialization and establishes modern societies. It also ensures the development of a clean and healthy environment for the people (Bokor, 2013). Besides, energy security and efficiency assurance leads to a reduction in the operational costs of the respective companies (Mechtenberg, 2009).

2.1. Combining Environmental Effects and ICT

To the energy consumers, a reduction in the expenditures they incur in terms of costs would be a welcome idea. On the contrary, businesses and associated companies would look at the idea of cutting energy consumption expenses in a variety of ways (Higón, Gholami, & Shirazi, 2017). For instance, they would be willing to cut on their energy consumption if it would lead to an improvement in their production and rationalization of their procedures. Moreover, they would not consider cutting their energy consumption if the effect would affect the quality of their services, lead to customer dissatisfaction, or lead them into loss-making ventures. Currently, ICT has enabled a reduction in the consumption of energy by gathering and offering services that manage information in simpler ways than before (Kramers, Höjer, Lövehagen, & Wangel, 2014). The development and emergence of devices that are handled, stored, dematerialized, and transmitted like computers, computer programs, and networks have brought a new road to the cutting down of energy consumption.

Information and Communication Technologies that include the internet and GSM transmission have been at the forefront in helping different sectors cut down on their energy consumption (Ahmed, Naeem, & Iqbal, 2017). These inventions came with the advantages such as high speeds of transmitting data, the security of the information that they convey, and their ease of use. These advantages would justify these developments in the ICT sector as beneficial to different companies and individuals alike. People would not use these services if they were complicated, and the security of the information they transmit was questionable. Even though broadband systems provide their clients with a variety of internet-based energy saving options, the internet could not be the only ray that would address energy efficiency. Telecommunications operators also have the advantage of using GPRS in their data management system for companies and individuals that do not have access to the internet.

In the present context, ICT plays a crucial role in all aspects, thereby contributing to the betterment of the life of people (Sharma, Gandhar, Sharma, & Seema, 2011). ICT largely supports in enhancing the knowledge of the people throughout the world regarding various aspects. Thus, people by using this gained knowledge can

contribute to own betterment in several fields (Luić & Glumac, 2009). ICT in the modern day context is mainly used in learning. It involves the presence of various technologies, which can be used for learning. Apart from the improved learning scope from the use of ICT, it also plays a role in enhancing problem-solving and decision-making skills. Thus, ICT can be used for effective problem solving along with decision making of the various issues related to people. This also implies the issue energy crisis can be solved as well as effective decisions can be taken for the energy security and efficiency assurance (Sharma, Gandhar, Sharma, & Seema, 2011).

The role of ICT in using Emerging Learning Technologies (ELT) such as blogs, podcast, and wikis among others supports in enhancing one's knowledge (Sharma, Gandhar, Sharma, & Seema, 2011). The role of ICT in improving business practices through improved communication and coordination with all the stakeholders. Additionally, it supports in the effective decision making and problem solving of the business by successfully using and analyzing the available information (Luić & Glumac, 2009). The online buying and selling of goods and the conducting electronic business activities have been feasible through the development of ICT. This helps in enhancing the business efficiency along with reducing cost. Thus, it offers similar scope to the energy producing and dealing companies to lower the cost and enhance efficiency (Luić & Glumac, 2009). Moreover, ICT plays the role of conducting e-governance, which, in turn, ensures the effective implementation of the policies. Thus, the government can effectively implement energy security and efficiency assurance policies (Luić & Glumac, 2009).

2.2 Application of Energy Management Systems

The best way to manage energy would be the control and reduction of energy consumption by all the economic players of the world. Application of an efficient and effective energy management system would be the appropriate way to reduce and control this (Houghton, Miller, & Foth, 2014). Energy management systems could be used to help in the analysis and maximization of consumption rates. These systems would help in controlling equipment that consumes energy, follow up on real-time consumption, and in data recovery of any faults that may have been detected in the energy consumption trends of any given individual or company. The ICT sector has enabled the development and installation of these management systems that have been of benefit to several consumers around the globe (Klimova et al., 2016). Companies and individuals have had the benefit of monitoring and managing their energy consumption and have the added advantage of controlling their consumption through the use of these systems. Even though these systems could be easily found in offices, there have been other management systems that also enable people in residential places to control energy consumption, for example, in lighting and heating devices (Zhou & Yang, 2016). Although improvements can be made to the energy management systems to make them better, the length that the ICT sector has gone to make energy management simpler and easy cannot be underrated. The development of such systems has enabled most businesses to cut or control their energy expenses. Such cuts and controls on energy consumption have the net effect of reducing the emission of greenhouse gases to the environment and also improving the efficient management of energy systems thanks to ICT based automation.

3. Research Methodology

The above-mentioned background information motivated in conducting research to identify and assess the way ICT can be used in energy security as well as efficiency. In this regard, the rationale behind conducting this research has been to identify and evaluate the positive effects of implementing ICT for reducing the technical problems, lowering the cost, maintaining energy management security, and assuring efficiency. Further motivation has been gained from the fact that this study attempted to determine and evaluate the ways through which the energy problems in the underprivileged nations can be mitigated.

A research was conducted with experts in the energy management field from Lebanon, United Arab Emirates and Jordan. The aim of the research was to evaluate the factors and the tools that are used to improve efficiency and

sustainability of in the energy management sector. Using the Multi Criteria Decision Analysis (MCDA), the tools and the factors were evaluated and a descriptive analysis explaining the results were discussed.

Table 1. Demographic data of the experts

Demographics	Percentage
Location of Experts	
Lebanon	33%
UAE	50%
Jordan	17%
Gender of the Experts	
Male	67%
Female	33%
Age of Experts	
Between 36-50	50%
Between 51-65	50%
Educational degree of Experts	
Masters degree	83%
PHD	17%

Data was collected from six experts in the field of energy management during spring 2019. Demographic characteristics of experts are presented in table 1. Cronbach Alpha to test for internal consistency was used, results are presented in table 2. Cronbach Alpha for the four criteria and three indicators was analyzed. Cronbach alpha is used to measure internal consistency and when cronbach alpha possesses a value greater than 0.8 then the internal consistency is excellent and items within each factors are closely related and are well combined as a group. As for the criteria; tools and external factors had an excellent consistency while systems and processes had a good consistency. As for the indicators; management and productivity had an excellent consistency while efficiency had a good consistency.

Table 2. Cronbach Alpha to test for internal consistency

Indicators	Internal consistency
Criteria 1: ICT tools in energy management sector	0.81
Criteria 2: Management systems in ICT	0.78
Criteria 3: Management processes in ICT	0.76
Criteria 4: External factors in ICT	0.83
Indicator 1: Management	0.87
Indicator 2: Efficiency	0.70
Indicator 3: Productivity	0.82

4. Discussion and results

The third world countries (like some countries in Middle East) have been facing major issues of an energy crisis due to a lack of effective infrastructure along with insufficient fund. However, this issue can be resolved by the application of ICT. The use of ICT in the third world countries would facilitate in gaining along with assessing information, which, in turn, contribute to conducting innovation in the energy sector. This, in turn, leads to an increased generation of energy as well as its efficient distribution throughout the nation. The wastage of energy has been a common issue in the underdeveloped, which can be addressed by the implementation of ICT. In addition, ICT involves tracking of the energy performance and identifying, wherein there is wastage of energy. The immediate addressing of the issue leads to the cost saving of the energy sector. This is extremely crucial from

the perspective of a third world nation. The use of ICT in the energy sector in the third world nations leads to the improvement of the infrastructure, which has been the major issue prevailing in these countries. The infrastructural development contributes to the increased energy. In the third world nations, ICT can also be used to aware people regarding the importance of saving energy and the ways it can be conducted by consumers.

Descriptive statistics of the four criteria's of ICT in energy management sector is conducted and frequency and percentages are reported in the table 3. Results showed that the six experts are in either medium or high agreement with all the indicators of the four criteria. Experts were asked to rate each criteria and their sub-categories on a scale of 1 to 10. Due to conformity of experts to the above indicators; rating of below 7 were considered to be low agreement, rating of 7 and 8 were considered medium agreement and rating of 9 and 10 were considered to be in high agreement.

Table 3. Descriptive statistics of the four criteria's of ICT in energy management sector

Variable	Medium	High
Criteria 1: ICT tools in energy management sector		
Efficiency of using laptops in energy management sector for data management and technical reporting	33%	67%
Availability of smart devices in the hand of the users in energy management sector for energy usage and billing	67%	33%
Usage of online applications in energy management sector for energy usage and billing	67%	33%
Availability of website for people to report technical or human errors happening in energy management sector	17%	83%
Availability of computer hardware for Information and communication technology solutions in energy management sector	67%	33%
Coverage of internet to report technical problems on the spot in energy management sector	17%	83%
Criteria 2: Management systems in ICT		
Importance of information systems in energy generating activities	17%	83%
Importance of information systems in energy storage activities	67%	33%
Importance of information systems in hiring qualified people	83%	17%
Importance of information systems in evaluating the human resources	50%	50%
Importance of information systems in cloud storage management	67%	33%
Importance of information systems in collecting fees online	50%	50%
Importance of information systems in reporting on technical problems	33%	67%
Criteria 3: Management processes in ICT		
Importance of current processes used in the energy management sector in decision making	83%	17%
Impact of current systems used in the energy management sector in strategies	33%	67%
Influence of problem solving strategies used in the energy management on processes	33%	67%
Influence of project planning used in the energy management on strategies	33%	67%
Influence of project controlling used in the energy management on strategies	-	100%
Influence of impact analysis used in the energy management on strategies	33%	67%
Criteria 4: External factors in ICT		
Importance of infrastructure on upgrading the energy management sector	67%	33%
Importance of government policies on energy management sector	33%	67%
Acceptance of people on implementing new systems in the energy management sector	17%	83%
Importance of natural resources on implementation within the energy management sector	-	100%
Importance of human resources on implementation within the energy management sector	17%	83%
Importance of technological resources on implementation within the energy management sector	-	100%
Importance of governmental regulations in the development of the energy management sector	33%	67%
Effect of economy in development within the energy management sector	17%	83%
Availability of the infrastructure in the implementation of new technologies within the energy management sector	67%	33%

The three indicators that ICT have effect on in the energy management sector is conducted and frequency and percentages are reported in the table 4. Results showed that the six experts are in either medium or high agreement with all the indicators that ICT have effect on in the energy management sector. Experts were asked to rate indicator on a scale of 1 to 10. Due to conformity of experts to the above indicators; rating of below 7 were considered to be low agreement, rating of 7 and 8 were considered medium agreement and rating of 9 and 10 were considered to be in high agreement.

Table 4. Descriptive statistics of the three indicators that ICT have effect on in the energy management sector

Variable	Medium	High
Indicator 1: Management		
Importance of operations in implementing ICT in energy management sector	33%	67%
Importance of cost reduction in energy management sector	17%	83%
Importance of improvements in energy management sector to the public	33%	67%
Importance of natural resources availability in energy management sector	33%	67%
Importance of human resources in energy management sector	50%	50%
Importance of time management in energy management sector	83%	17%
Importance of property management in energy management sector	33%	67%
Indicator 2: Efficiency		
Importance of action plan in applying ICT in energy management sector	50%	50%
Importance of sustainability in applying ICT in energy management sector	17%	83%
Importance of growth rate in applying ICT in energy management sector	33%	67%
Importance of performance in applying ICT in energy management sector	67%	33%
Importance of measurements in applying ICT in energy management sector	17%	83%
Importance of energy resources in applying ICT in energy management sector	67%	33%
Indicator 3: Productivity		
Importance of framework in upgrading the energy management sector	17%	83%
Importance of quality in energy management sector	33%	67%
Importance of waste reduction in energy management sector	33%	67%
Importance of productivity in decreasing the cost in energy management sector	50%	50%
Importance of safety in energy management sector	33%	67%
Importance of assessment tools in energy management sector	33%	67%

Average of the four criteria of the ICT was assessed. Experts were asked to rate in general the importance of ICT tools in the energy management sector, importance of management systems in ICT, importance of processes in ICT and importance of external factors in ICT. The results are presented in rtable 5. 33% agreed that tools are important while 67% considered the tools as extremely important as one of the ICT in the energy management sector. As for the management of systems in ICT; 50% rated the management system as important and 50% rated it as extremely important. 67% rated the importance of management processes in ICT as very important and 33% rated it as important. Half of the experts agreed that external factors in ICT are important and the rest considered it as very important element.

Table 5. Average of the four criteria’s of ICT in energy management sector

Variable	Medium	High
1: ICT tools in energy management sector	33%	67%
2: Management systems in ICT	50%	50%
3: Management processes in ICT	33%	67%
4: External factors in ICT	50%	50%

In order to prioritize the criteria and sub-criteria, six experts were consulted. Questionnaire was developed by following the methodology proposed by AHP. Tools, systems, processes and external factors sub-criteria were assessed with respect to the four criteria of the ICT. Each expert was given the same weight, thus the process of aggregation of all the judgments was performed using the geometric mean. The comparison matrix of the four criteria is represented in table 6.

The implementation of ICT largely impacts and benefits with respect to energy management security and efficiency assurance. It significantly supports in reducing the technical issues in the energy management. In this context, it can be analyzed that ICT supports in improved communication between the stakeholders of energy producing companies. This, in turn, assists in addressing the quality issues. It further supports in conducting research as well as witnessing innovation for increasing the energy efficiency.

Table 6. Pairwise comparison of the criteria

Criteria	Tools	System	Processes	External factors
Tools	1	1.958	1.125	0.638
System	0.8839	1	0.811	1.543
Processes	0.7985	0.8140	1	0.957
External factors	0.8844	0.9140	0.8073	1

The use of ICT in the energy sector has also led to the reduction of the cost of energy management security and efficiency assurance. This has been apparent from the fact that ICT significantly contributes to the energy sector by increasing productivity as well as rationalizing the process. This, in turn, directly contributes to the reduction of the operational cost of the company. However, ICT further ensures that the reduction of cost does not affect the quality of the product or service, customer satisfaction, and revenue collection.

The use of ICT is also helpful in finding new sources of energy through extensive research and employment of varied related technologies. Thus, it can help in overcoming the global challenges related to the energy crisis. It can also be evaluated that ICT can be effectively utilized for improving the infrastructure for efficient production, management, and distribution of energy all over the world. The energy sector has also been facing the issue of excessive wastage, which, in turn, causes the crisis to a certain extent. In this regard, the use of ICT is extensively effective, as it leads to the identification of the areas, which generates wastage.

Conclusion

Based on the overall discussion, it is apparent that ICT significantly contribute to energy security as well as efficiency assurance. It supports in overcoming the technical issues in energy management along with, maintaining efficient, and effective energy supply and reduction of the cost. It mainly involves the use of cloud and internet technology, radio frequency, GPRS, various software, and hardware along with the computerized processing of several related information. Thus, it largely helps the underdeveloped countries in mitigating the issue of the energy crisis. The improved communication through the integration of ICT assists in immediately addressing the supply chain issues of the energy sector. It also assists in reducing wastages, thereby contributing towards reducing the involved costs along with the greater maintenance of higher efficiency and energy security. ICT also supports in conducting of innovation that supports in the identification of new efficient energy at reduced cost. Moreover, ICT assists in improving the infrastructure in the energy supply process. This, in turn, ensures that energy is available at all places in the region. The integration of ICT also helps in promoting the use of renewable energy throughout the world. It ensures the protection of the environment along with the maintenance of people’s health, as it involves reduced carbon emission.

This paper examined the effects that the ICT sector has on the energy management systems and the possible positive impacts that ICT played in the reduction of energy consumption; thereby reducing the emission of gases into the atmosphere. It has been established that the initially feared effects of an explosively growing ICT industry have not been seen in effect, but rather the ICT industry has had more benefit in the energy management systems than its disadvantages. At the same time, the ICT sector continues to grow as well as the energy consumption, however, the role of controlling, monitoring and developing the energy sector will have a positive effect on the energy consumption.

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