

Information and Communication Technologies in Energy Management

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Abstract. The information and communication technologies ICTs is spreading all over the world and they are affecting the global systems in many livelihood sectors. ICTs have a wide positive impact on huge economical and developmental factors, from increasing productivity to controlling and monitoring to the systems. The purpose of this article is to analyze ICT models for energy supply management. The importance of energy supply in the developing countries is deniable, as well as possibilities that were brought by ICT for their management. Using the comparative analysis method, the article will illustrate the difference between using the old energy management models to the ICT energy management systems focusing on the results after implementation.

Keywords: ICTs, Efficiency, Energy Management, Sustainable Development, Innovation

1. Introduction

Modern countries and cities are developed and managed basically taking into consideration the importance for sustainable development, several initiatives have highlighted how ICT can be used to achieve cities' powering targets by using effectively and efficiently the scarce sources of energy. Range of researchers (Bernadette & Michael, 2016; Christian, Shahrazed, & Ahmad,

2016; Deju & Peter, 2016; Stefano, Giorgio, & Marco, 2017) states that the efficient resource utilization in power generation applications is a critical energy management challenge in meeting the world's energy sustainability goals. Improving energy outputs, energy efficiencies, and reducing environmental impact of major traditional power generation systems is the optimal goal that the developing countries are focusing on in our recent century in the energy management sector. In this article, the consequences of the electrical problems in developing countries will be discussed. Information and communication technology models will be analyzed in order to reach an efficient and effective solutions in developing countries. The ICT methods of implementation will be the milestone in having a clear vision in trying to implement the correct methods for improving the energy sectors in the developing countries including Lebanon. The assumption that lack of innovation and broad vision on using the information and communication technologies are key factors in most developing countries facing resources challenges related to energy management (Stéphane, Olivier, Julien, & Mouchira, 2016; Bin & Venkata, 2017). The energy management system production is based mainly on producing highly intense methods of energy we find in nature, such as fossil fuels, rivers, waterfalls and energy coalitions (Meera & Akinlab, 2017). The old energy systems word wide are becoming dysfunctional because highly concentrated forms of energy are in short supply and playing critical roles in the ecosystem. The main objective of this article is to analyze the impact of ICT implementation in the energy management sector, in order to create a solid comparative analysis between the old and the new, ICT controlled, systems. Conducting analysis of the results after the implementation of ICT will help in determining the effectiveness and efficiency factors of the new energy management models. Also a comparative analysis method will be used to compare between the old energy management systems and the new ICT based energy management systems.

2. Literature Review

The scientific literature of information and communication technologies has taken the interest of researchers, defined ICT as a typically general-purpose technology, which is pervasive and will spread with a time lag. It facilitates and induces firms to introduce more efficient organizational forms (Bitzer & Gebretsadik, 2015; Aftab, Muhammad, Muhammad, Saad, & Alagan, 2015; Donald J. Leu, Kinzer, & Coiro, 2004; Timmer & Van Ark, 2005). Information and communication technologies at the long run will enhance the growth of the productivity throughout the economy, in addition to major restructurings of business systems and processes around ICT capital. ICT is also defined as: Web logs (blogs), word processors, video editors, World Wide Web browsers, Web editors, e-mail, spreadsheets, presentation software, instant messaging and plug-ins for Web resources, list servers, bulletin boards, avatars, virtual worlds, and many others (Alam & Salahuddin, 2015). Information and Communication Technologies (ICTs) have a wide array of effects on key global systems such as energy and economic systems (Alam & Salahuddin, 2015).

The importance of ICT in the energy management systems is enhancing and upgrading of the current energy systems used by the developing countries around the world. What makes ICT positively affecting the energy management system theoretically is the acceptance of innovation by the governments, and the mutual trust between the citizens and the new energy management systems that are going to take place during the next decade. Indeed, while inventions can be defined as the creation and establishment of something new, innovations are inventions that become economically successful and helpful in the development of the energy management sector (Stefano, Giorgio, & Marco, 2017). Furthermore, promoting a purposive collaboration among firms and other players in the innovation ecosystem is likely to improve the research and development productivity (Ili & Albers, 2010) which will lead to scientific results affecting positively the energy management system. Developments in the energy management systems are becoming more profitable and real-time

operational actions in distribution networks are becoming realistic and possible (Nijhuis, Gibescu, & Cobben, 2015). Implementing ICTs into the energy management process will give and added value to the system, as the ICT's will be monitoring, assessing and evaluating the outcomes of the process. Real time monitoring is expected to be the corner stone in the implementation of the new energy management systems, as it will provide the quick response for any dysfunctional element or process during the operations.

Connecting the whole systems and processes together under one platform controlled and monitored by the ICTs will give the real sustainable value for the energy management core. The integration of the inputs, analysis, outputs, assessments and evaluations of the sustainable management systems can maintain the durability and longevity of the system performance efficiently and effectively. There are many developments which have an impact on the requirements of the energy management systems. The introduction of electric vehicles, energy storage, demand response, ICT and power electronics within the distribution network, photovoltaic, as well as changes in the household load are the main developments of the energy systems as well as the ICT driven energy transition (Nijhuis, Gibescu, & Cobben, 2015).

Energy is critical in supporting people's daily life and continued human development. Although great successes have been achieved, more than 2 billion people are still lacking of sufficient energy supply throughout the world (Favrat & Jochem, 2005; Asif & Muneer, 2007; Nfah, Ngundam, & Tchinda, 2007).

Management of renewable energy resources is crucial for many urban communities throughout the world. The rising fossil fuel prices, increasing environmental- and health-impact concerns, shrinking energy reserves, and varying legislation, geographic, economic and political conditions are having significant effects on renewable energy management practices (Cai & Huang, 2009).

The evolution of energy management systems towards higher phase of renewable energy generates tough and hard encounters in designing,

implementing, controlling and maintaining the processes and the systems. Environmental assessments of system structures and the decisions made during design, implementation and operation are usually based on complex data, models and decision procedures and therefore involve innovative applications of information and communication technologies (Hilty, 2015). Many effects of the energy transition from the old energy systems to the new ICT governed systems will be faced such as technical, social, regulatory and economic effects are expected to be raised during the transition phase. The implementations of the ICT models in the renewable energy management can be hard to apply, but the expected results to be achieved can pay off the hard implementation process. The ICT industry is totally aware of the potential benefits of renewable energy sources in making the future management systems reliable and sustainable. The extraordinary growth in the information and communication technology has made the process of innovation and creation of electrical energy management possible, easy and applicable.

3. ICT in Energy Sector of Developing Countries

Developing countries are facing the lack of innovation and creation in the renewable energy management sector. There is a huge possibility for implementing the information and communication technologies in the developing countries, because the current system of energy management is old and suffering from any improvements. A positive or negative environmental impact of ICT can occur at different system levels, depending on how far the causal chains of ICT applications are followed and what time horizon is assumed (Hilty, 2015). By accepting the idea of applying new systems to the developing countries, this will improve the daily life of these countries, governments should start with themselves in accepting applying new and modern technological systems. The implementation of the ICTs should be enforced on an international level and to provide a truly global dimension to the large number of local and regional efforts to transfer the technological innovations, to encourage digital

opportunity, and to place ICTs at the service of development for all sectors related to development of the developing countries (Martinez, 2003).

The innovation in the energy management system brings influence in the two essential components of quality and durability, which in other terms can be translated into efficiency and sustainability. The issue of sustainability is easier to manage with ICTs, which may result in monetary savings in addition to governmental and citizen's trust in development processes and systems. Scientists agreed that however it is also true that if care is not taken to ensure that ICT provision and use is tailored to the specific needs of the groups that really need them, there is a danger that existing isolation and relegation will be reinforced and increase (Manas, 2015; Ali El Haj, Bahadiri, & Harbaji, 2011). There is a huge interrelation then between information and communication technologies and the development of the renewable energy management sector in the developing countries, the action agenda for sustainable development outlines a shared framework for sustainable development through the following interconnected priority challenges that must be addressed at global, regional, national, and local scales (Umberto Pisano, 2010). The stakeholders should believe in applying the information and communication technologies in the energy management systems because it is the only sustainable way to control, monitor and evaluate the systems to perform at the highest levels specially that we are living in the era of technological evolution.

The energy problems in the developing countries are severe and extensive. Lack of access to sufficient and sustainable supplies of energy affects as much as 90% of the population of many developing countries (Barnes & Floor, 2006). Some 2 billion people are without electricity; a similar number remain dependent on fuels such as animal dung, crop residues, wood, and charcoal to cook their daily meals (Barnes & Floor, 2006). The theoretic problem of creating a sustainable and innovative energy management system is that most of the developing countries are controlled by corrupted governments. The old energy management system can maintain the continuity of corruption as

financial waste and the suspicious deals between the contractors and the governmental sector will keep on going. Implementing the information and communication technologies in the energy management systems can eliminate a lot of the problems occurring in the developing countries. The below table will show the difference between in how the ICT will give an impact in the energy management sector.

Table 1. Comparison for the energy management situation before and after implementing the ICTs, (Created by the Authors)

| Energy Management Situation | |
|---|--|
| Before Implementing ICT | After Implementing ICT |
| High CO2 emissions during energy production | Has the ability to expressively reduce the CO2 emission during energy production |
| Inefficient resource enhancement | Enhance resource efficiency |
| High bill cost | Controlled bill cost |
| A lot of technical problems | Few or no technical problems at all |
| Reactive to technical problems | Proactive to technical problem if found |

Energy management situation before ICT is totally different of energy management after using ICT. Incorporating energy efficiency into the design of network protocols and architectures represents a relevant issue in networking research. Currently, very few works address energy efficiency as a fundamental feature of network protocols (Usman, Kliazovich, & Castoldi, 2015). To address the energy sustainability of ICT and capture the full potential of ICT in resource efficiency, a multidisciplinary ICT-energy management system needs to be brought together including electronic hardware and software in order to control, evaluate and perform the appropriate interpretation (Peacock, Chaney, & Goldbach, 2017; Khakimova, Kusatayeva, & Shamshimova, 2017). A number of authors have investigated the relation between the degree of development of a country and its energy use. Most studies have found strong correlations between energy use and living standards at lower energy use levels in the “developing countries”, and decoupling at higher levels in the “developed countries” (Arto, Pérez, Lago, Bueno, & Bermejo, 2016).

The model of energy management system that is currently used in the

developing countries is based on using the old methodology in generating power, transmitting power from the power plants to the end users and finally the in dealing and fixing the technical problems that usually occurs. There are two things that the old system used in the developing countries is facing. The first issue is the widespread inefficient production and use of traditional energy sources, such as fuel-wood and agricultural residues, which pose economic, environmental, and health threats. The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which pose important issues of economics, equity, and quality of life (Barnes & Floor, 2006). These problems are affecting the management style of the energy, as they are completely based on the bad management behavior where efficiency and effectiveness are not taken into consideration. Bad management habit affects the energy resources as they are not well maintained, governments and ministries of energy are responsible for the waste of money and resources. Governments are paying huge amount of money on using the old energy production facilities, which in other hand not producing the sufficient amount of energy. This loop of loss is costing the developing countries a respectful amount of money paid on old energy systems while if these amounts were used in a systematic and efficient ways the developing countries can be in a very different advanced place regarding the energy management.

4. Advantages of New Models of Energy Sector Management

The rapid use and expansion of information and communication technologies have a number of economic consequences ranging from increasing productivity, boosting economic growth to reducing corruption (Alam & Salahuddin, 2015). From this point of view, we can say that the interpretation of the ICTs in the energy management systems will definitely lead to positive results in the developing countries. The rapid expansion of ICT usage is believed to improve

productivity and energy efficiency (Varoudakis, Sharma, & Mitra, 2016; Matos, 2016). Nevertheless, the rapid expansion of ICT use in the developing countries is likely to have significant energy impacts as ICT products and services cannot be operated without electricity. The connection between the ICTs and energy is an overlapped correlation, one depends on other. ICTs hardware and software cannot work without electricity, on the other hand, energy management systems in the developing countries must depend completely on ICTs to have the appropriate improvements in the sector. ICT tools allow exchange of information: websites, social networks, and project management tools such as wiki, podcasting and information retrieval tools. (Davidavičienė & Raudeliūnienė, 2010). While these tools allow the exchange of information, the ICTs can have a huge impact on the energy management systems by exchanging information between the developing countries and the developed countries. Without the exchange of information, ICTs cannot be effective and efficient. Many of the technical and implementation problems can be solved once the data is shared between the developing countries and the developed countries. The positive relationship between ICT use and electricity consumption suggest that developing countries can easily achieve energy efficiency gains from ICT expansion (Heddeghem, Lannoo, & Demeester, 2014). If the energy efficiency gains from ICT use could be achieved, it is likely to further promote the expansion of the ICT use in the region as this will reduce the cost of using ICT products and services which is further expected to play an important role in reducing digital divide both within and between the developing countries (Alam & Salahuddin, 2015; Heddeghem, Lannoo, & Demeester, 2014). Governments of developing countries need to come up with an energy management policy that motivates investment to create pioneering behaviors in generating ICT products, networks and data collection centers which consume a very high level of electricity among ICT products and service. The data collection centers that overdo the requirement of certain level of electricity consumption may be monitored and regulated through appropriate means. By implementing ICTs in

the energy management systems, it will be easier for the governments to:

- Find innovative solutions for issues other than energy management related problems
- Create systems that monitor the energy productions and consumptions
- Monitor and control the efficiency of energy management systems
- Insure the sustainability of the implemented energy management systems
- Reduce the cost of energy production
- Insure that the energy produced by the renewable energy systems can be sufficient to cover the needs of the citizens.

The ICT controlled energy management systems can improve the lives of the developing countries if it is used effectively and efficiently. The ICT can also have an economical positive impact on these countries as the waste of money spent on the old energy management solutions will be eliminated. Developing countries must rely on ICTs in order to achieve successful results in the energy management sector which will also affect confidently the countries in other livelihood related sectors.

In the past 10 years we have seen exceptional improvements in the consumption of energy resources. An exceptional growth in the renewables energy market, in forms of investment, building new capability and high growth rates in developing countries have made a change in the setting for the energy sector. We have seen the growth of alternative resources and improvements in the information and communication technologies evolution for all forms of energy resources. The developed countries now are going in the path of using sustainable renewable energy management systems, they are focusing on hydro-power, wind, solar, bio-energy, waste-to-energy management systems in order to produce energy. Solar and wind energies are universal and environmental friendly, and due to their powerful characteristics, they can generate continuous power (Bouchebbat & Gherbi, 2017). The new energy management systems that

are currently used in the developed countries are saving a lot on the citizens, this could not happen if the governments didn't see that there is a need to sustain the current energy resources that they have. Implementing ICT's in the new energy systems would help in many factors that can effectively and efficiently sustain the new energy generation systems in addition to monitor, control and evaluate the old energy management systems used in the developing countries.

5. Conclusions

The information and communication technologies are evolving widely in our world, the effect of the ICTs is observed clearly in the development of the sectors that it was controlled and monitored by it. Implementing the ICTs in the energy management system will definitely push the sector to a higher and more professional level of service providing. Developing countries nowadays are facing a huge challenge in the energy management sector, especially is that the money paid on this sector is not paid in the correct place of development. Governments should give the opportunity for ICTs to be implemented in the energy management sector in order to give positive results in terms of sustainability and development. The economic growth is linked to the development of the energy management sector in the developing countries. Innovation, ICT systems, modern rules and regulations should be adapted by the governments in order to enhance the economical and the social situations in the developing countries. In my opinion, there must be a great coordination between the governments in order to accept the positive impact of implementing the ICT's on the environmental level, this will surely save the planet and give more hope for sustaining the current energy resources to be used elsewhere other than producing electricity. ICT implementation in the energy management sector is one of the most needed steps in the developing countries. Implementing ICTs into the energy management systems in the developing countries might face huge challenges. The role of the governments after accepting the idea is to educate their citizens about the positive impact of the implementation. The

developed countries are a good example of the level of development that they reached. Huge portion of the high level of development is that the governments are helping the local communities to come up with innovative solution to whatever problem they have. The developing countries should take the high level of development in the developed countries and try to implement it. The results of implementing the ICT are promising, governments should adapt these new systems in order to reach a higher level of sustainable development.

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