International Journal of Economics, Commerce and Management
United Kingdom Vol. III, Issue 11, November 2015
http://ijecm.co.uk/ ISSN 2348 0386

EFFECT OF SMART TECHNOLOGY ON PERFORMANCE OF ENERGY SECTOR IN KENYA

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Abstract

Smart Technology has been touted to help utilities in better system management, but within the Energy sector in Kenya there has been slow uptake of smart technology with partial implementation of three smart systems: Supervisory Control And Data Acquisition (SCADA) for monitoring and controlling power generation and transmission, Automatic Meter Reading (AMR) for metering Industrial and large Commercial customers and Mobile technology is used for payment and notifications. The survey instrument was designed to study the effect of Smart Technology on Performance of the Energy sector, targeting 132 management staff handling the Smart Technology within the sector. The data was analysed using Statistical Package for Social Sciences (SPSS) which provided descriptive and inferential statistics. Inferential analysis confirmed that each of the three Smart Technologies used in the sector had a positive effect on the Performance of the Energy Sector, leading to the conclusion that Smart Technology has a positive effect on the Performance of the Energy Sector. It is therefore recommended that the Energy sector fully adopts Smart Technology in management of power generation, transmission, distribution, commercial services and customer service processes for improved performance.

Keywords: Smart Technology, Performance of the Energy Sector, AMR, SCADA and Mobile Technology

INTRODUCTION

Most of the Power utilities in the developing world, suffer in general, from the serious challenges of revenue management and network management. This state of affairs coupled with inadequate network facilities to match the customer demand and needs, resulting with consequential system overloads and under-voltages manifesting in higher power system losses, impact negatively on their bottom-line as well as the customer satisfaction. With these challenges gaining a substantial proportion with time, utilities are increasingly resorting to loss reduction and revenue management programs in their multi-facet least cost approach to overcome these daunting challenges. Consequently, researches have been done and technology has been developed that would assist utilities out of these difficulties. Some of these technologies include: System automation, Prepayment Systems, Automatic Meter Reading (AMR) systems, Advanced Metering Infrastructure (AMI) and Billing Systems (Ndenderu, 2012).

Non-technical losses (meter failure, meter tampering or fraud, un-metered or illegal connections or data tampering in billing) represent approximately 20-30% of revenue losses for utilities across the continent, and in some cases this reaches 50%. Additionally, power utilities' inefficient billing systems are one of the main reasons behind non-technical losses. They often rely on outdated and manual modes of billing and payment collection (post and in-person office payments), and face a culture of non-payment fostered by social and political impediments to disconnecting services (ADB report, 2013).

Smart technology mainly saves utility providers the expense of periodic trips to each physical location to read a meter, collect revenue or inspect an installation. Another advantage is that billing can be based on near real-time consumption rather than on estimates based on past or predicted consumption. This timely information coupled with analysis can help utility, providers and customers' better control the production and use of electric energy, gas usage, or water consumption. Smart technologies include switch gears, auto changeovers, handheld sets, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line communication (PLC) (Ndenderu, 2012). Due to relative advantages in terms of accessibility, convenience and speed Mobile technology are used utilities, credit card companies, insurers, auto lenders and more. In addition they have the ability to offer customers multiple mobile interactions: receiving invoices, reminders, demands and transact payment (Fiserv, 2003).

The deployment of smart solutions provides energy providers with improved management of connections, remote monitoring and more efficient billing processes, thereby reducing losses and recovering costs needed to ensure reliable services and connect more customers. Mobile technology and mobile network operators can provide a range of smart solutions for energy services, from basic connectivity, and machine-to-machine communication, to platforms for mobile payments and data management services (Smertnik et Al, 2014). Smart technology being an interactive technology allows different part of utility systems to communicate system status and performance with a control centre. This enables data collection, system operations, isolation and restoration to be performed remotely. In the electricity sector system the technology is useful in generation management, grid operation and metering solutions.

The smart metering has come up strongly as an enabler of smart grids. Across the United States of America (US), electric utilities are deploying smart meters (technically termed Advanced Metering Infrastructure or AMI) to their residential customers as the basic building block of the Smart Grid. In a few areas of the US states, such as California and Texas, smart meters are almost fully deployed. As of June 2010, approximately 20 million smart meters had been deployed in the U.S. and it is likely that the number will rise to approximately 65 million meters by the end of the year 2015 (IEE, 2010). This would represent approximately 50 percent of all U.S. households. By the end of this decade, smart meters may be deployed to almost all U.S. households.

Statement of the problem

In the Energy sector, the aspect of delivery of reliability power to customers and efficient management of the sector which can lead to reduced cost of electricity still remains a challenge to managers of the sector mainly because the sector still uses traditional ways of managing most its processes instead of employing appropriate technologies for efficient management of the sector. Smart Technology has been touted to help utilities in better system management; in the revenue protection through minimizing risk of power theft, guarantee of supply quality by timely restoration of supply, accurate consumption measurement, load management and minimizing cost. The technology has the ability to monitor and control generation and transmission of power, can be used for operation and restoration of supply, accurately collect meter readings and other operational data without site visits utility's personnel.

The technology has been adopted in many parts of the world where by utilities are operating smart grid and smart meters leading to efficient and cost effective management of the utilities processes. However in Kenya the technology has been implementation partially through 1) AMR metering has been implemented for 5,000 Industrial and Commercial customers leaving out over 3.5 Million Small and Medium customers (Ordinary customers) on conventional metering, 2) SCADA used for monitoring and controlling power generation and transmission systems leaving out the expansive Distribution network being management manually which is labour intensive, expensive and inefficient and 3) Mobile technology through mobile payment and query services. This has denied the sector the opportunity to reap full benefits from the technology. The slow intake of the technology can be attributed to lack of understanding by all stakeholders of the benefits of the technology.

Objective of the Study

This study aims to determine Effect of Smart Technology on Energy Sector Performance in Kenya.

Research Hypothesis

H01 Smart Technology has no significant influence on the Performance of the Energy Sector in Kenya.

Justification of the Study

There is a belief within utility circles that sectorial performance is enhanced by the use of smart technology. Available statistics on the energy sector, however does not confirm this view. This study aims to provide an insight into the performance of the sector and the extent to which this is affected by smart technology in commercial management, revenues assurance, customer satisfaction, outage and cost management. Operational personnel will then be able to argue strongly for or against the above mentioned belief, based on the findings of the study.

KP and other organisations will on the other hand gain knowledge on whether there's need to strengthen their use of technology or look elsewhere for performance solutions. Similarly, if implementation smart technology is found to affect organisational performance significantly. Sectorial stakeholders including shareholders, creditors, bankers, management, staff, and prospective investors among others, will also find this study useful, since it will help them in gauging the performance of organisations. Lastly, the findings of this study will help fill a gap in the field of technology by adding onto the existing knowledge on how technology impacts organisational performance. It will also open up the area for further academic research.

THEORETICAL REVIEW

Technological Determinism Theory (Technology-Led Theory)

The technological determinist theory is a technology-led theory of social change. This theory views technology as the prime mover in history. In economics, this is known as a technology push theory rather than a demand-pull theory. According to technological determinists, particular technical developments, communications technologies or technology in general are the sole or prime precursor which causes changes in society (Chandler, D. 1995), and technology is seen as the fundamental condition underlying the pattern of social organization. Technological determinists interpret technology in general and communications technologies in particular as the basis of society in the past, present and even the future. They say that technologies such as writing or print or television or the computer changed society. In its most extreme form, the entire form of society is seen as being determined by technology: new technologies transform society at every level, including institutions, social interaction and individuals. At the least a wide range of social and cultural phenomena are seen as shaped by technology. 'Human factors' and social arrangements are seen as secondary.

Deterministic perspectives have been common amongst commentators on communication technologies. Theorists who have argued that changes in communication technologies have had an important cultural impact have tended either to regard such changes as limited to social and institutional practices or, far more radically, have argued that such changes have also had profound psychological consequences, transforming the nature of human consciousness. This radical claim of psychic change is dubbed by Michael Heim 'the transformation theory' (Heim, 1987). For instance, Christopher Evans declared that the computer would transform 'world society at all levels' (Robins & Frank 1989). Smart metering platform will transform commercial cycle management at all levels, with more emphasis on quality control more than field work. The technologies bring in customer participation and say in their consumption and billing. Smart grid on the other hand brings reliance on the technology for remote system monitoring, operation and fault finding rather than the traditional line patrols, thus transforming the network management in the sector. Availabilities of smart technologies in the market has greatly influenced the energy sector, many utilities are adopting the technology mainly due to its availability and the pressure for efficient management of utilities.

Actor-Network Theory (ANT)

ANT proposes a ‘socio-technical’ approach that encompasses the holistic interconnectedness between the social and material, or the human and the actor (Lukie, 2009). Both the human and the technology are seen as equal and incapable of separation. To separate them, as both determinist approaches mentioned above do, is claimed to be flawed. ANT also focuses on the associations, or agency, or actions between humans and technology. In essence, that is focusing on how the different combinations, or medium of forces, organize and influence each other (Munro, 2009). It looks at how newly created associations can create new actions between humans and the actors, and in doing so, measures the actions that take place as the key change in power regardless of whatever intention was behind them. This power of association is measured in both its ability to give and take power away. By placing emphasis on power within the rearrangement of actors, ANT also shows how power is most effective in its silent form. This basically translates to how, both human and non-human actors, in their groupings, change different power structures around them. For example, (Latour, 1992) technology is made by humans, substitutes for the actions of humans, and shapes human action. Smart technologies made by man have been and are able to carry out some activities in utilities previous carried by human. They are being developed to take a central role in grid management and commercial cycle management. The newly created association lead to structural change and creates new actions between humans and the technology, and in doing so, measures the actions that take place as the key change in locus of control, whereby some critical tasks previous carried by human are transferred to the technology.

EMPIRICAL REVIEW

Implementation of Smart Technology in Kenya

In Kenya, smart technology has been partially implemented in generation, transmission, metering, customer queries and payments. In generation, Supervisory Control And Data Acquisition (SCADA) system controls and monitor power flow between Kenya Power (KP), Kenya Electricity Generation company (Kengen) and the Independent Power Producers (IPPs). The KPs national control centre monitors power output in terms of Megawatts, voltage levels, frequency and status are monitored and decisions additional or reduction of generation are made remotely through the SCADA system which part *smart* technology (Fichtner, 2006). The technology is also used in monitoring and operation of all primary substation such 220KV/66KV, 132/33KV substations and transmission lines. However the technology is yet to be implemented on the secondary substation and distribution lines.

Supervisory control and data acquisition (SCADA) is a term applied to automated techniques and systems used in managing, monitoring and documenting the operations of a technical process. SCADA systems are utilized to assist in the operation of all energy infrastructures (electric power, oil, and natural gas), as well as in water, waste water and factory floor automation systems. SCADA provides the ability to monitor operational parameters at remote facilities and to adjust physical controls at those facilities in a timely manner, in most cases without the need for on-site personnel (Fisher, 2010). The energy infrastructure utilizes SCADA systems to operate key infrastructure components such as: generating stations, the electric grid, petroleum production platforms, pipeline systems, petroleum refineries, compressor stations, and storage facilities through the use of automation.

In metering, AMR metering technology was implemented in 2008 for Large and Industrial customers. This was following a study on loss reduction in KP by the International Consultant from Manitoba Hydro, it was recommended that since KP had already adopted modern technologies such as converting all the metering from conventional electronic meters, it go a step further and change the meters for large consumers to AMR (Mutua, 2007). This was expected to improve billing by improving data reliability and accuracy. The technology was also aimed at combating losses in the Large Industrial and Commercial Customers by communicating exceptional occurrences in the supply through alarms through e-mails and SMS. The resultant of this undertaking was to be improvement in billing accuracy, elimination of estimated meter reading and reduction labour costs. Employee safety was expected to improve, customer complaint to reduce, improved management of closed / disconnected accounts.

In Mobile technology, an agreement signed been KP and Safaricom for use of Mobile money for payment of power bills in April 2009 (Mwangi, 2011). A similar agreement was signed soon after between Airtel and KP. The use of the technology has now been expanded and is currently being used for sending bills; reminders for payment due date, advertising and passing service status information to their customers based mobile technology.

The study focused on the smart technologies already in use, in the energy sector in Kenya which are: a) AMR metering technology in commercial cycle management b) SCADA system in power generation and transmission and c) Mobile technology in customer service.

Smart Technology on Performance of the Energy Sector

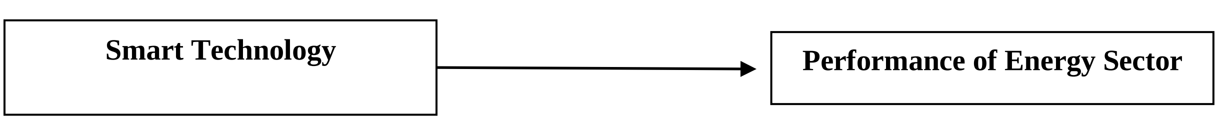
Infrastructure utilities around the world are facing far-reaching changes. State-owned, vertically integrated, monopoly electricity utilities are all being restructured to improve performance. Private sector participation is frequently on the agenda, including the introduction of Independent Power Producers (IPPs). New regulatory regimes are being put in place and reformed utilities need to deliver expanded and affordable services for the poor, while underpinning and supporting economic growth. Leaders and managers in these sectors face complex new challenges (UCT, 2015). Jerry Jackson observes that Smart grid technology is touted to be utilities 21st century business model in delivering increased system efficiency and reliability, enhanced and participatory customer energy use management and other benefits. However, utility investments required to implement comprehensive smart grid initiative are substantial and smart grid hardware and software technologies are just evolving. Many utilities are concerned whether the smart grid investments will pay back over time or mistake in making near time smart grid investment decisions may increase cost and limit benefits (Jackson, 2011).

Smart technology is an important tool for loss reduction in that energy theft, a major source of non-technical losses, can occur anywhere, though there is a higher incidence in areas of concentrated populations with low levels of income, such as suburban slums and areas where violence is an everyday part of life. In some of these areas, utilities find it difficult to operate safely due to the presence of armed individuals who pose a threat to the inspection teams. In addition to the dangers energy theft poses, it costs the energy industry billions of dollars each year (Wright &Pritchard, 2006). Smart meters provide a way of measuring this site-specific information, allowing utility companies to introduce different prices for consumption based on the time of day and the season (Sinopoli, 2010). Utility companies propose that from a consumer perspective, smart metering offers potential benefits to householders. These include, a) an end to estimated bills, which are a major source of complaints for many customers b) a tool to help consumers better manage their energy purchases - stating that smart meters with a display outside their homes could provide up-to-date information on electricity consumption and in doing so help people to manage their energy use and reduce their energy bills. Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise if power from other jurisdictions or more costly generation is brought online.

Conceptual Framework

AMR technology enables an organization to bill its customers accurately and timely manner thereby assuring it of increased electricity sales. AMR enables an organization to notice and take corrective action on system over load, it also detects malfunctioning or tampering of the metering installation thus reduction of both technical and commercial losses. SCADA enables organizations to manage power outage and therefore maintaining continuous intake of power supply leading to increased billing, improved revenues and customer satisfaction. AMR and SCADA enable the organizations to reduce cost of labour and transport through remote controlled operations, thereby enhancing cost management. Mobile technology enable customers get their bills and pay away from the utility banking hall leading improvement of revenue flows and reduction of human resource requirement.

Figure 1: Conceptual framework



METHODOLOGY

Research Design

This research study applied was a descriptive research approach in describing and bringing out the elements of the different variables being studied (Zikmund, 2003). The function of research design was to provide for the collection of relevant evidence with minimal expenditure of effort, time and money. Research design is the scheme, outline or plan that was used to generate answers to research problems (Orodho, 2003). The researcher prepared a research design after formulating the research problem in clear terms and stating the conceptual structure within which research will be conducted. The preparation of such a design facilitates research to be as efficient as possible yielding maximum information.

Study Population

The study will cover a target population of 132 Supervisory staff of the departments using Smart Technology in Kenya Power and Kenya Electricity Generation Company in the energy sector in Kenya.

Study Instrument

Data was collected by use of the well-structured self-administrated questionnaires method. Questionnaires are appropriate tools for data collection where respondents are in different physical location as it was scenario in this at study.

Reliability of the Instrument

The reliability of instruments was established through a pilot study and the questionnaires from the respondents were verified and checked for reliability. As defined by Walliman (2001), reliability was assessed using the test–retest reliability method, by including similar items on the measure, and tested a diverse sample of individuals. Cronbach Alpha value for reliability of 0.857 was obtained which is above 0.7. Appropriate modifications were made on the questionnaire after pre-testing for the purpose of achieving the objectives of the study.

Table 1: Reliability Test

Independent Variable	**No of elements**	**Cronbach Alpha**
Automatic Meter Reading (AMR)	12	.866
Supervisory Control And Data Acquisition(SCADA)	8	.747
Mobile Technology Services	8	.759
Total	**47**	**.857**

Data Processing and Analysis

The study was to assess the Effect of Smart Technology in the Performance of the Energy Sector. The data collected was both quantitative and quantitative. The data collected from the filled questionnaires was checked for completeness. The Statistical Package for Social Sciences (SPSS) was employed both descriptive and inferential statistical analysis.

ANALYSIS AND FINDINGS

Descriptive Findings and Discussions

In this section, the descriptive statistics for study variables are discussed. The study was guided by effect of AMR, SCADA and mobile technology as the independent variables and Performance of the Energy Sector as the dependent variable.

Effect of AMR, SCADA and Mobile Technology on the Performance of the Energy Sector

The study intended to know the effect of the Smart Technologies already in use in the sector; AMR, SCADA and Mobile Technology on the Performance of the Energy Sector in areas of Electricity sales management, outage management, power loss management, cost management and customer satisfaction. These statements were ranked on a 5 point Likert scale ranging from “5- most applied” to “1-least applied”. Table below presents these findings. Respondents agreed that AMR has an effect on the Performance of the Energy Sector (mean = 4.0068). The respondents also agreed that SCADA has an effect on the Performance of the Energy Sector (mean= 4.0198). The respondent further agreed that mobile technology has an effect on the performance of the Energy sector (mean= 3.8055). The standard deviations were .91189, .52807 and .68229 respectively. These data were not far from zero hence the data were also very close to the mean of respective indicators. The study revealed all the Smart Technologies in the Sector have a positive effect in the Performance of the Energy Sector.

Table 2: Mean and Standard Deviation of Smart Technology on the Performance of the Energy Sector

	N	Minimum	Maximum	Mean	Std. Deviation
AMR	73	1	5	4.0068	.91189
SCADA	73	1	5	3.806	.52807
Mobile Technology	73	1	5	4.0196	.68223

Inferential Analysis Results

Inferential analysis is used to determine whether there is a relationship between an intervention and an outcome, as well as the strength of that relationship. It uses statistical test to see if a pattern observed is just due to chance or is due to the program or intervention effects.

AMR and Performance of the Energy Sector

As shown in Table 3, AMR has R-value of .256 indicating a significant positive relationship between AMR and Performance the Energy Sector. This is satisfactory to the first objective of the study: to determine the influence of AMR in the Performance of the Energy Sector. The p values (.029) are below .05 thus leads to rejection of null hypothesis that there is no significant relationship between AMR and Performance of the Energy Sector, at 5% level of significance. Therefore implementation of AMR is positively correlated to the Performance of the Energy Sector. This agrees with Mutua 2007 that active monitoring of energy distribution assets mitigates power system losses, increases billing accuracy, reduces cost and increases efficiency of doing businesses with the emergence of AMR metering (Mutua, 2007).

Table 3: Influence of AMR on Performance of the Energy Sector

		AMR
Performance of the Energy sector	Pearson Correlation	.256*
	Sig. (2-tailed)	.029
	N	73

SCADA and Performance of the Energy Sector

As shown in the Table 4 SCADA has R-value of .308 indicating a positive relationship between SCADA technology and Performance of the Energy Sector. This is a satisfactory to the second objective of the study; to determine the influence of SCADA on Performance of the Energy Sector. The p-values .008 are below .05 thus led to rejection of the null hypothesis that SCADA does not influence the performance of the energy sector, at 5% level of significance. Therefore SCADA technology is positively correlated the Performance of the Energy Sector.

This agrees with the observation of Fisher 2010 who observed that SCADA provides the ability to monitor operational parameters at remote facilities and to adjust physical controls at those facilities in a timely manner, thus positive influencing the performance of the energy sector (Fisher, 2010).

Table 4: Influence of SCADA in performance of the Energy Sector

		SCADA
Performance of the Energy sector	Pearson Correlation	.308*
	Sig. (2-tailed)	.008
	N	73

Mobile Technology and Performance of the Energy Sector

As shown in the Table 5 Mobile Technology has R-value of .090 indicating a positive relationship between Mobile Technology and Performance of the Energy Sector. This is a satisfactory to the third objective of the study; to determine the influence of Mobile Technology on Performance of the Energy Sector. The p-values .048 are below .05 thus led to rejection of the null hypothesis that Mobile does not influence the Performance of the Energy Sector, at 5% level of significance. Therefore Mobile Technology is positively correlated the Performance of the Energy Sector. This agrees with Fiserv (2012) who observed the Mobile Technology gives billers, including utilities the ability to offer customers multiple mobile interactions and thereby improving customer satisfaction.

Table 5: Influence of Mobile Technology in Performance of the Energy Sector

		Mobile Technology
Performance of the Energy sector	Pearson Correlation	.090*
	Sig. (2-tailed)	.048
	N	73

*. Correlation is significant at the 0.05 level (2-tailed).

Hypothesis Testing

The hypotheses of the study were tested using Chi-Square which was calculated using the SPSS software. The findings were then interpreted thereby forming the basis for acceptance or rejection of null hypotheses. The results were as shown in the Table 6 below;

The first hypothesis of the study was; H_{01}: There is no significant relationship between AMR on Performance of the Energy Sector. Based on the findings as shown in Table 6, the p-value .000 <0.05 hence the null hypothesis was rejected and concluded that there was significant relationship between AMR and Performance of the Energy Sector.

The second hypothesis of the study was H_{02}: SCADA does not significantly performance of the energy sector. The p-value on this hypothesis was .038, which is less than 0.05. This led to rejection of the null hypothesis and concludes that SCADA influences the Performance of the Energy Sector in Kenya.

Consequently, the third hypothesis of the study was H_{03}: Mobile Technology does not significantly influence on Performance of the Energy Sector in Kenya. According to the findings in table 6, the results yielded a p-value, .034, <0.05 hence the null hypothesis was rejected and concluded that Mobile technology has a significant influence on Performance of the Energy Sector.

Table 6: Test Statistics

	AMR	SCADA	Mobile Technology
Chi-Square	380.690[a]	270.532[b]	203.022[c]
Df	3	3	3
Asymp. Sig.	.000	.038	.034

a) 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.0.

b) 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 5.8.

c) 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 6.8.

CONCLUSIONS

Having set out to evaluate the Effect of Smart Technology on the Performance of the Energy Sector, the researcher made the following conclusion in line with the objectives of the study. It was clear from most of the respondents that the three independent variables identified for analysis; AMR, SCADA and Mobile technology had a positive effect in the Performance of the Energy sector leading to the conclusion that Smart Technology has positive effect on the Performance of the Energy Sector in Kenya.

RECOMMENDATIONS

Smart technology having a key role in the Performance of the Energy Sector, its full adoption and implementation is a necessity for improvement of the Performance of the Energy Sector. Based on this critical importance of smart technology, the researcher therefore proposed the following recommendations;

(i) The sector should review its technical and operational standards to facilitate adoption and implementation of Smart technologies in the entire grid management to include generation, transmission and distribution system.

(ii) The sector should invest in the most efficient and effective metering solution since metering is the interface between the customer and the utility and plays a critical role in the determination of sales volumes, losses through under billing and operational cost.
(iii) The sector should include Mobile Technology in its processes because the mobile has become part and parcel of people lives. Mobile technology services should be expanded to include service requests like application of power supply, accounts closure and account opening to enable customer get these service without having to visit the utilities banking halls.

LIMITATIONS OF THE STUDY

The main challenge and constraint that the researcher encountered included: limited availability of information and literature due to the little attention given on research on the effect of Smart Technology of the Energy Sector. The problem of limited availability of literature when developing the background research was overcome by conducting extensive and detailed research from various sources such as journals, websites, organizations business cases and face-to-face interactions.

SUGGESTIONS FOR FURTHER STUDIES

Based on the outcome of the study it was evident that not all the technologies that influence the performance of the energy sector were explained by the three variables. The researcher proposes therefore that a further research incorporating other technologies and other factors like organization structure or even cost of implementation of a smart technology among others so as to clearly shed more light on the matter. The researcher further recommends that similar or related studies should be conducted in other sectors including water sector or even petroleum sector among others.

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