# MODEL FOR UBIQUITOUS APPLICATION ENABLEMENT PLATFORMS (AEPs) FOR SMART BUILDINGS

**Nicodemus Aketch Ishmael**

PhD Student, Business Information Systems, Jaramogi Oginga Odinga University of Science & Technology, Kenya

**Dr. Solomon Ogara**

Jaramogi Oginga Odinga University of Science & Technology, Kenya

**Dr. George Raburu**

Jaramogi Oginga Odinga University of Science & Technology, Kenya



**Received:** 22nd January 2016

**Accepted:** 29th January 2016

Full Length Research

**Available Online at:** http://www.iajournals.org/articles/phdse_v1_i1_1_12.pdf

**Citation:** Ishmael, N. A., Ogara, S. & Raburu, G. (2015). Model for ubiquitous application enablement platforms (AEPs) for smart buildings. *International Academic Journals PhD Serial Edition, 1* (1), 1-12

## ABSTRACT

The purpose of this study is to develop a model for ubiquitous application enablement platforms (AEPs) for smart buildings. The specific objectives being to determine whether financing affects application of AEP's for smart buildings, to investigate whether functionality affects application of AEP's for smart buildings, to determine whether comfort and safety concern of buildings affects application of AEP's for smart buildings and to investigate whether architectural value affects application of AEP's for smart buildings. The study will seek to contribute to the widening debate about how the transformation of buildings in cities responds to the changing smart technologies and climate change. The current study will be a descriptive research which involves developing research questions based on existing theory, and then designing a research methodology to test the research questions based on research objectives. The target population will be National Construction Authority of Kenya staff and registered contractors. The research data will be collected using self administered email questionnaires as the main research instrument of the study. The questionnaire will contain different sections such that each section will address specific research objectives. Collected data will be coded and analyzed using statistical package for social sciences (SPSS) in order to draw out conclusions and recommendations based on the research objectives and findings of the study. The final results will be presented using appropriate descriptive statistics (percentages, means and frequency distribution) and displayed using tables and pie charts.

***Key Words:*** *model, application enablement platforms, AEPs, smart buildings*

## INTRODUCTION

Everywhere, our knowledge is incomplete and problems are waiting to be solved. We address the void in our knowledge and those unresolved problems by asking relevant questions and seeking answers to them. The role of research is to provide a method for obtaining those answers by inquiringly studying the evidence within the parameters of the scientific method (Leedy, Newby and Ertmer, 1997). There is a serious need for developing an optimized solution of sustainability and intelligence in buildings that will help the agenda of living in a healthy, comfortable, technologically advanced world. Energy security is one of the main concerns of the future in the world today. The rapidly growing world energy use has already raised concerns over supply difficulties, exhaustion of energy resources and heavy negative environmental impacts (ozone layer depletion, global warming, climate change, etc.). The global contribution from buildings towards energy consumption, both residential and commercial, has steadily increased reaching figures between 20% and 40% in developed countries, and has exceeded the other major sectors such as industrial and transportation, creating immense energy and climatic change crisis (Guo, 2010).

As the world population rises, so does the energy consumed by world's buildings. The main aim of this study is to approach the world energy crisis by developing a Model for Application Enablement Platforms for smart buildings that will in turn help conserve energy so that the world can be assured of continued existence. The study looks at diverse effects of climate change and how a Smart Building can mitigate the negative effects of climate change (Morgan and King, 2007).

Energy efficiency is the most sustainable source of energy, and smart building technologies bring a new sophistication to energy management that can elevate efficiency to the appeal of alternative energy like solar and wind that so often dominate the conversation. Energy efficiency is about eliminating the waste in how we operate our buildings, but the nuts and bolts of engineering improvements often push the topic off the public palette for energy policy debate. Smart building technologies can bring new viability to energy efficiency priorities by leveraging leading edge information technology to deliver a combination of energy and cost savings that resonate with a broad spectrum of stakeholders from the c-suite to operators to sustainability advocates. Buildings are an intrinsic part of our lives. Buildings are a cornerstone of human development. They also represent a large and growing share of energy use and emissions globally. Policy and innovative investment can help us make buildings more efficient and comfortable.

A smart building, which is also commonly termed as, integrated building, intelligent building, automated building, high performance building or advanced building, is a building that is designed for longevity. Older buildings are frequently torn down and replaced by new constructions, which seems like a waste but most often it is more efficient and less expensive to build a new building that can offer the rich amenities that we need in today's buildings. However, an old building can be retrofitted with new smart building technologies to become a smart building. A smart building is designed to leverage the systems in the building. They all need cabling, lighting and HVAC (Heating Ventilation and Air Conditioning) control systems. Lighting represents almost 20% of all the electricity produced (IEA, 2013), International Energy Agency. This requires that we promote improved lighting system management by ensuring that building codes promote the use of natural light. Some need internet, access, security, wireless and more. By designing a smart building, for example, the access control system can assist the security system in detecting trespasses, the fire alarm in determining occupancy, and also assist the HVAC and lighting in conserving energy. In addition, a smart building can provide alarms and alerts that assist the facility personnel in proactively managing the building, formulating trends on the health of the building, and ongoing commissioning of systems. Because a smart building is designed with open systems, it is easier to introduce innovative, new technologies and utilize a variety of different manufacturers and vendor equipment. Building owners can keep abreast of trends in demand response, curtailment and smart grids. It enables the building owner to utilize new revenue models, new technologies and provide occupants with additional amenities. This is a simplistic overview and not exhaustive of the full capabilities in the hands of the right designer and engineer.

These next generation energy management solutions utilize information technology and building automation to bring unprecedented coordination to building operations. The kind of integrated energy management of a smart building redefines a facility – these technologies allow building systems to respond in real time to external signals or internal policies. This means that buildings can elevate from simply operating optimally without energy waste, but in a future vision, even become resources that interact with the grid responding to demand response or price signals of grid stress and shedding load by changing how equipment operates such as dimming lights or raising the temperature by a degree or two. This kind of dynamic operations of the smart building can push efficiency over the threshold to meet the 50% goal outlined by the current USA President.

The field of Intelligent Buildings, Intelligent Homes and Building Management Systems (BMS) encompasses an enormous variety of technologies, across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls. The function of Building Management Systems is central to 'Intelligent Buildings' concepts; its purpose is to control, monitor and optimize building services, e.g., lighting; heating; security, CCTV and alarm systems; access control; audio-visual and entertainment systems; ventilation, filtration and climate control, etc.; even time & attendance control and reporting (notably staff movement and availability). The potential within these concepts and the surrounding technology is vast, and our lives are changing from the effects of Intelligent Buildings developments on our living and working environments. The impact on facilities planning and facilities management is also potentially immense. Any facilities managers considering premises development or site relocation should also consider the opportunities presented by Intelligent Buildings' technologies and concepts.

The first buildings ever constructed were primitive shelters made from stones, sticks, animal skins and other natural materials. While they hardly resembled the steel and glass that make up a modern city skyline, these early structures had the same purpose - to provide a comfortable space for the people inside. Buildings today are complex concatenations of structures, systems and technology. Over time, each of the components inside a building has been developed and improved, allowing modern-day building owners to select lighting, security, heating, ventilation and air conditioning systems independently, as if they were putting together a home entertainment-system.

At the most fundamental level, smart buildings deliver useful building services that make occupants productive (e.g. illumination, thermal comfort, air quality, physical security, sanitation, and many more) at the lowest cost and environmental impact over the building lifecycle. Reaching this vision requires adding intelligence from the beginning of design phase through to the end of the building's useful life. Smart buildings use information technology during operation to connect a variety of subsystems, which typically operate independently, so that these systems can share information to optimize total building performance. Smart buildings look beyond the building equipment within their four walls. They are connected and responsive to the smart power grid, and they interact with building operators and occupants to empower them with new levels of visibility and actionable information.

Enabled by technology, this smart building connects the structure itself to the functions it exists to fulfill: connecting building systems, connecting people and technology, connecting to the bottom line, connecting to the global environment, connecting to the smart power grid and connecting to an intelligent future. But building owners today are beginning to look outside the four walls and consider the impact of their building on the electrical grid, the mission of their organization, and the global environment. To meet these objectives, it is not enough for a building to simply contain the systems that provide comfort, light and safety. Buildings of the future must connect the various pieces in an integrated, dynamic and functional way. This vision is a building that seamlessly fulfills its mission while minimizing energy cost, supporting a robust electric grid and mitigating environmental impact.

Putting man on the moon was one of the greatest technological challenges of the 20th century. In the 21st century, we face an even greater test – tackling climate change. In contrast to the space race, the solutions required today must encompass us all. Climate change is a reality we have to live with. The frequency of climate phenomena like drought and flooding has shortened. As soon as we come out of one climate related disaster, do we enter into another. Climate manifests itself in different ways e.g. floods, droughts, tropical storms and typhoons. Climate controls our lives and hence must be taken seriously.

A significant proportion of total worldwide energy is consumed by buildings. For example, buildings in the US account for over 40 percent of total energy consumption and greenhouse gas emission (E-Business Engineering, 2009). Green house gas emission, global warming and ozone layer depletion are some of the dangers that need immediate attention to stem climate change.

Most experts agree that over the next few decades, the world will undergo potentially dangerous changes in climate, which will have a significant impact on almost every aspect of our environment, economies and societies. However, some of the disasters aren't even caused by extreme events, for example; in 2009, a climate non-extreme event in Zimbabwe caused a cholera outbreak that affected 90,000 people and resulted in 4,000 deaths. The vulnerability of the community and the exposure to climate risk made the outbreak severe (The Institute for Climate Change and Adaptation (ICCA) – University of Nairobi, May 2012).

The enormity of global warming can be daunting and dispiriting. Nations ought to team up, for one nation's effort to reduce global warming is not possible, each of which is challenging but feasible and, in some combination, could reduce greenhouse gas emissions to safer levels, thus saving the world from imminent disaster. The climates disasters aren't country bound but are global. Some examples of disasters from which we can draw lessons include; the heat waves in Europe and India; hurricane Katrina in the USA; localized flash floods in Nairobi as a result of rapid growth, settlements near rivers and blocked drainages; sea level rise in tropical small islands; and droughts in west Africa that are coupled with high populations, variable rainfall and ecosystem degradation (Stadler, Siddiqui, Marnay & Lai, 2011). While climate change is a global issue, we believe that solutions for reducing building energy use are fundamentally local. They must be relevant and adapted to each region's social, economic and legislative context as well as climate zone. Evidently the challenges and issues related to the use of energy in buildings are significantly different. For instance, in Europe and in the U.S, the emphasis is put on existing buildings and deep retrofitting, whereas in China and in India, the focus is on new construction. There is need to readjust development to incorporate climate change, as the costs related to climate change impacts are rising and it is estimated that it will be at about 3% of the National GDP by 2030 (Institute for Climate Change and Adaptation (ICCA) – University of Nairobi, May 2012).

International concern about climate change has led to the Kyoto Protocol, negotiated in 1997, which contains legally binding emission targets for industrialized countries to be achieved during the commitment period 2008-2012. Construction industry everywhere faces problems and challenges, the general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues in the sector where incidence, incapacity and negligence of the parties concerned results in poor building construction and associated challenges (Marnay, Venkataramanan, Stadler, Siddiqui, Firestone & Chandran, 2008).

Scientists predict that left unchecked, emissions of $CO_2$ and other greenhouse gases from human activities will raise global temperatures by 2.5ºF to 10ºF this century. The effects will be profound, and may include rising sea levels, more frequent floods and droughts, and increased spread of infectious diseases. To address the threat of climate change, greenhouse gas emissions must be slowed, stopped, and reversed. Meeting the challenge will require dramatic advances in technologies and a shift in how the world economy generates and uses energy. Smart building is one of the best strategies for meeting the challenge of climate change because the technology to make substantial reductions in energy and CO2 emissions already exists (Cano & Ermoliev, 2014). The average LEED (Leadership in Energy and Environmental Design) certified building uses 32% less electricity and saves 350 metric tons of CO2 emissions annually. Modest investments in energy-saving and other climate-friendly technologies can yield buildings and communities that are environmentally responsible, profitable and healthier places to live and work, and that contribute to reducing CO2 emissions. Smart buildings provide abundant opportunities for saving energy and mitigating CO2 emissions, smart building can reduce CO2 emissions while improving the bottom line through energy and other savings.

Climate change is real, and it is already happening. ICTs are becoming ubiquitous throughout the society. Given the momentous gains that ICT has achieved in the few decades it has been in existence, it's only imperative that ICT professionals urgently search for a concrete solution to counter global warming disaster that is waiting to wipe out the entire earth. Most of the global changes on earth have been analyzed and a number of indirect measures of climate such as ice cores, tree rings, glacier lengths, pollen remains and ocean sediments and by studying changes in Earth's orbit around the sun indicate that all is not well worldwide. One of the applications of ICT is in smart technologies associated with smart buildings.

Modern buildings contain complex mechanical devices, sophisticated control systems and a suite of features to improve the safety; comfort and productivity of occupants, many of these systems involve machine-to-machine communications (Marnay et al., 2008). A number of legacy buildings have been retrofitted with Smart building technologies and performed exceptionally well. A significant proportion of total worldwide energy is consumed by buildings which are estimated to over 40 percent of total energy consumption and greenhouse gas emission (Cano & Ermoliev, 2014). Therefore buildings offer the most cost-effective mitigation potential, and the reason why the sector has become a focus for climate change policy-makers. Yet as this report highlights, our current building energy policies are not on-track to deliver the sector's CO2 mitigation or energy savings potential. Instead there is an increasing emissions gap between where we are headed and where we need to be in order to ensure the building sector plays its part in achieving less than global warming (Cano & Ermoliev, 2014), and that's the research gap that is targeted by this study.

Recognising that the risks posed by climate change are legitimate but highly unpredictable, the Government of Kenya published its National Climate Change Response Strategy (NCCRS) in 2010 to investigate vulnerability in the country and potential future responses. The NCCRS concluded that “the evidence of climate change in Kenya is unmistakable”: in many areas, rainfall has become irregular and unpredictable; extreme and harsh weather is now the norm; and some regions experience frequent droughts during the long rainy season while others experience severe floods during the short rains. In response to this energy and climatic crisis, recent developments in building technologies in the USA, Europe and Japan reflect the trend towards more smart and energy-efficient buildings (Morgan & King, 2007)

## STATEMENT OF THE PROBLEM

A smart building is an intelligent space that optimizes efficiency, comfort, safety for people, and asset performance within the building. This is achieved through the use of building management systems (BMSs) which work to balance the performance of multiple building automation systems (BASs) to enable central control and achieve higher levels of efficiency. However, the scalability of these systems becomes a challenge when higher levels of efficiency are required, as is in the case of adequate energy efficiency that can help stem climate change. Application Enablement Platform (AEP) then becomes extremely necessary as a form of PaaS (Platform as a Service) that is meant to enable a developer to rapidly implement an IoT application or service without worrying about the scale-out or scale up factor. Whereas climate change has received attention from scholars in various fields, including environmental, property, international, and human rights law, not many studies have been undertaken yet in analyzing how Application Enablement Platforms should be applied in order to address energy efficiency in smart buildings that will yield to low green house emissions. This is particularly true in the case of developing countries like Kenya, where there has been recent incidents and accidents which involve to some large extent the collapse of modern buildings; raising serious policy, socio-economic and technological issues as to the energy efficiency, safety and building standards in the country. This thesis addresses this gap.

## OBJECTIVE OF THE STUDY

The main objective is to develop a model for ubiquitous application enablement platforms (AEPs) for smart buildings.

## SPECIFIC OBJECTIVES

1. To determine whether financing affects application of AEP's for smart buildings.
2. To investigate whether functionality affects application of AEP's for smart buildings.
3. To determine whether comfort and safety concern of buildings affects application of AEP's for smart buildings.
4. To investigate whether architectural value affects application of AEP's for smart buildings.

## RESEARCH QUESTIONS

1. To what extent does financing affect application of AEP's for smart buildings?
2. How does functionality affect application of AEP's for smart buildings?
3. How does comfort and safety concern of buildings affect application of AEP's for smart buildings?
4. In what ways does architectural value affect application of AEP's for smart buildings?

## SIGNIFICANCE OF THE STUDY

A robust and scalable model for ubiquitous application enablement platforms (AEPs) for smart buildings, first and foremost, will be of direct benefit to governments all over the world as such a model will inform policy and subsequent strategy implementation. In the 2000 Green Paper setting forth a strategy to secure energy supply, the European Union named energy efficiency as the best way to establish energy security over a longer term. Smart building can benefit countries through carbon credit program. The global adaptation of smart building technology marks a historic opportunity for a single technology class, Application Enablement Platform, to significantly reduce the energy consumed by cities around the world. In Kenya, there exists a significant gap between policy and strategy implementation which can be filled through increased adaptive capacity. (Cano & Ermoliev, 2014) point out that adaptive capacity encompasses ability of actors to modify exposure to absorb and recover from climate change impacts, and also to exploit new opportunities that may arise through adapting to the changing climate. Consequently, a model for ubiquitous application enablement platforms (AEPs) for smart buildings will enhance the country's adaptive capacity as it will inform and influence different actors and communities propensity or ability to adapt. By reducing buildings' energy consumption, Kenya can reduce dependency on imported energy and strengthen its strategic position. Reducing vulnerability and building adaptive capacity can help to reduce energy consumption of any building. By adopting the smart building, we are aptly concerned with adaptive capacity and different ways of building capacity to adapt to climate change.

Second, researchers and writers will borrow from a model for ubiquitous application enablement platforms (AEPs) for smart buildings when developing theoretical frameworks applicable to those who seek to further their research in this emerging political and social pertinent hot-bed area of research that needs drastic and urgent solutions to fix it. Furthermore, such a model will transform theory into practice by enhancing what is already known into practical technology applications through AEP's. For instance, it is widely acknowledged that upon installation, automated building systems generate profound reductions in a building's energy consumption because the carbon footprint of the building and its city literally shrinks with every equipment installed. Therefore, the application of AEP's for smart buildings has the potential to reduce global energy use sustainably and diverse climatic change effects, through measurable outputs such as carbon credits. These credits are traded in carbon markets, which are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). One carbon credit is equal to one tonne of carbon dioxide, or in some markets, carbon dioxide equivalent gases. Carbon trading is an application of an emissions trading approach. Greenhouse gas emissions are capped and then markets are used to allocate the emissions among the group of regulated sources. The goal is to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions or less carbon intensive approaches than those used when there is no cost to emitting carbon dioxide and other GHGs into the atmosphere. The countries applying AEPs for smart buildings will get carbon credit equivalence dollars that will improve their GDP.

Moreover, effective AEP application for smart buildings will make dramatic energy savings possible for property owners and investors, not only making their investments more attractive in the property market but also positively affecting the energy consumption and air quality of a city.

## SCOPE OF THE STUDY

In order to address the research question and objectives, the study will focus on the extent to which building regulations and guidelines referred to as building codes, as provided for by National Construction Authority, as well as the actual building standards of physical buildings developed and constructed by developers and engineers approved by the National Construction Authority, take into consideration the effects of financing, functionality, comfort and safety, and architectural value in the application of AEP's for smart buildings in Kenya.

The study is grounded on three main theories namely: (1) the theory of things as developed by McKeown and Walewski (2012) which borrows from Heidegger's distinction between objects and things, which posits that an object becomes a thing when it can no longer function according to the use to which it is commonly put; (2) Diffusion theory of Internet of Things, whereby like many evolving IT and networking technologies, the Internet of Things will encounter multiple barriers to adoption. Traditional inertia, budget priorities, risk aversion and other factors will prevent some companies from adopting IoT in the near future; and, (3) Adaptivity Theory as postulated by Folke (2006) that "adaptivity is the cause of the emergence of a perspective for social-ecological adaptation, therefore it can be generally defined as the capacity for a socio-ecological system to: absorb stresses and maintain function in the face of external stresses imposed upon it by climate change; and adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

## LIMITATIONS AND DELIMITATIONS OF THE STUDY

The major limitations of this study relate to time constraints, limited financial resources and geographic distance between the physical buildings in Kenya. The study's limitations will be addressed in the following ways: time and geographical constraints will be overcome by selecting a relatively small sample size that will not compromise the validity and reliability of the research findings and by ensuring the boundary of the research is based on the extent to which financing, functionality, comfort and safety, and architectural value affect application of AEP's for smart buildings within Nairobi and its environs; while the limited financial resources available will be spent on research activities that cannot be undertaken solely by the researcher.

## ASSUMPTIONS OF THE STUDY

According to (Williams and Colomb, 2003), identifying the assumptions behind a given research proposal is one of the hardest issues to address, especially for novice researchers. Such difficulties emerge due to the fact that by nature we all take our deepest beliefs for granted, rarely questioning them from someone else's point of view (Williams & Colomb, 2003). In light of this, the study is based on the following assumptions: that all buildings are well managed, integrate physical and digital infrastructures that provide optimal occupancy services in a reliable, cost effective, and sustainable manner; and that all models can be successfully developed based on a sound conceptual framework and scaled to actual size effectively.

## REFERENCES

Guo, W. (2010). Setback and setup temperature analysis for a classic double-corridor classroom building Energy Build., 42 (2) (2010), pp. 189–197

Leedy, P.D., Newby, T.J. and Ertmer, P.A. (1997). Practical Research: Planning and Design, Upper Saddle River, N.J.: Merrill.

Marnay. C, Venkataramanan.G, Stadler. M,. Siddiqui, R. Firestone, B. Chandran (2008). Optimal technology selection and operation of commercial-building microgrids IEEE Trans. Power Syst., 23 (3) pp. 975–982

Morgan, M. & King, D. (2007). Adaptive-focused assessment of electric power microgrids J. Energy Eng., 133 (3) (2007), pp. 150–164

Stadler, A. Siddiqui, C. Marnay, H. Aki, J. L. (2011). Control of greenhouse gas emissions by optimal DER technology investment and energy management in zero-net-energy buildings Eur. Trans. Electr. Power, 21 (2) pp. 1291–1309