IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2025, 15(2), 391-408.

EJ EconJournals

Developing Conceptual Business Model for IOT Based Smart Energy Consumption

Evan Asfoura[1]*, Gamal Kassem[2]

[1]Faculty of Business Studies, Arab Open University, Riyadh, Saudi Arabia, [2]Department of Business Informatic, German University in Cairo, Egypt. *Email: e.asfoura@arabou.edu.sa

Received: 03 September 2024 **Accepted:** 17 January 2025 **DOI:** https://doi.org/10.32479/ijeep.17383

ABSTRACT

This paper aim to develop a generic business model that is based on the literature review and can be applied in any country. This business model will rely on the Internet of things technologies of smart cities to provide energy consumers with information about their total and appliance energy consumption. When consumers reach a certain limit that they set for energy consumption, they can utilize renewable energy sources and users can choose the energy provider company that best suits their needs and preferences and dynamically switch between them to get the best price schemas. As well as this paper is to analyze the Egyptian market from an expert's point of view and obtain insights from a user's point of view. Lastly, this paper is to build a basic prototype to demonstrate how the energy management solution can work and how the user can be notified when his total energy consumption has exceeded a certain limit. The results will be quantitatively and qualitatively evaluated through distributing survey and conducting interviews in the Egyptian market.

Keywords: Business Model, Internet of Things, Energy Consumption, Smart Cities
JEL Classifications: Q42, N7

1. INTRODUCTION

Sustainability of cities is becoming more difficult as cities are growing at an increasing rate. The development of cities will rely on ICT (Information communication technologies)[1]. <2% of the Earth is covered by cities, however, they produce more than 60% of carbon dioxide emissions and use 78% of the world's energy (Khatoun and Zeadally, 2016). During 2008 CISCO stated that the number of people on the planet was surpassed by the number of things[2] connected to the Internet. The number of connected things will increase dramatically the future. All the devices connected will need to interact to provide smart cities with value. Economic growth of cities and countries will be increased by the value of these solutions and cost savings will be the result of this value (Kyriazis et al., 2013).

1 Technologies that utilize telecommunications to enable access to information (adapted from techterms.com)
2 Any device that can be identified and used to send data

The Internet of Things (IOT) and Smart Cities are getting more attention from industries and academics. Accordingly, many research was focusing on the IOT and it's applications like Ashton, 2009; Madakam et al., 2015; McEwen and Cassimally, 2013; Hu, 2016; Zanella et al., 2014; Atzori et al., 2010) as well as on smart cities like. None of these concepts have clear definitions and to fully understand their potentials, their origins should be examined (Perera et al., 2014). Information systems will work on optimizing infrastructures and involving the public with the services of the city. Information communication technology will aim to handle peak demands by providing better management of resources. Therefore, as energy consumption of cities is increasing as well as their carbon dioxide emissions, energy saving is a topic that should be addressed and technological solutions that can decrease energy usage should be identified as technology now can manage resources efficiently. According to (Richter, 2012), there will be changes in the structure of the energy industry due to the conversion of the electric power sector to renewable energies to offer more sustainable energy production. Utilities will face challenges in the way they do business and will need to adapt their business models as they are the main stakeholders in this conversion to continue being competitive in the new energy landscape.

A main subject in energy management is the control of electricity demand for homes during peak consumption hours. To control the demand, the main policy followed is to dynamically change the unit price of electricity (Kato et al., 2016). For example, in Australia, as a result of the increase in the cost of distributing energy, a considerable increase in the retail electricity prices has occurred since 2007 after a stable or declining trend that lasted for longer than 50 years (Graham et al., 2015). The aim of this paper is to provide a solution that can encourage energy users to reduce their energy consumption and utilize renewable energy resources. The solution is generic and can be applied in any country however, this paper will focus on the evaluation of this solution according to the Egyptian market as it has faced several energy outages the past years and reducing energy consumption is essential.

The issue that this paper is aiming to address and solve is the increase consumption of energy with the decreasing amount of fossil fuels and energy resources. The word is going to run out of resources, as they are limited and non-renewable. Moreover, the increase in energy usage has a negative effect on the environment and is adding to the economic burden of countries worldwide. The some effects of the increasing energy consumptions affect the whole world and some are country specific. All countries are going to have to deal with the scarcity of resources as well as their effect on the environment. But specifically in Egypt, it has become more costly and is adding to the economic difficulties Egyptians now face.

- Egypt has encountered several power outages in the past years and electricity prices are rising greatly
- Renewable energy sources and mainly solar energy is under utilized
- The country is undergoing several economical and political changes and this is a good time to introduce new business models that can bring change.

2. LITERATURE REVIEW

2.1. Current Energy Saving Solutions and Their Barriers

Residential and commercial buildings account for 20%-40% of the global energy consumption in developed countries; they surpassed the industrial and transportation sector's energy consumption levels (Pérez-Lombard et al., 2008). This section discusses the importance of energy saving, the stakeholders involved as well as the current approaches for energy saving and limitations of energy saving solutions.

The worldwide significance of energy usage and preservation is highlighted, with the rapid increase in energy-consuming technologies leading to rising costs and supply instability. Shahbaz et al. (2016) illustrate a substantial surge in energy consumption between 1975 and 2010 in 11 countries. The escalating demand for energy is leading toward an imminent energy crisis, particularly affecting countries reliant on energy imports and external financing. The link between energy consumption, economic growth, and the adverse effects of energy crises is exemplified by Pakistan's experience (Khan et al., 2016). Heightened concerns surround energy supply challenges, resource depletion, and environmental impacts like global warming. The subsequent section delves into the intricate dynamics of energy consumption transactions, involving governments, energy providers, and consumers.

Energy consumption transactions involve two key entities: The supplier and the consumer, both vital for a holistic solution. In the energy supply-demand system, the primary stakeholders are governments, energy suppliers, and consumers, with consumers bearing the brunt of costs. Notably, in Romania, there are millions of household electricity consumers and non-household consumers, underscoring the scale of consumer involvement (Oprea and Lungu, 2015). Governments play multifaceted roles, encompassing law enforcement, market regulation, incentives for energy efficiency investments, fiscal support for energy-efficient projects, and promotion of energy-conscious practices (Qian and Chan, 2009).

In smart city energy landscapes, six key stakeholders drive interactions: energy retailers, residential prosumers (consumer-producers), commercial prosumers, market operators, service providers, and distribution system operators (DSOs). These stakeholders collaborate to optimize energy consumption in smart cities, aided by real-time data and insights. Importantly, residential prosumers can adjust their consumption to save money or support green energy, while commercial prosumers, like industrial organizations and wind turbine producers, can reschedule energy-intensive processes to mitigate costs. Market operators facilitate and manage the energy market, including services like billing and identity management. Service providers, armed with real-time smart metering, offer new functionalities based on market needs (Karnouskos, 2011). The integration of physical infrastructure and ICT in smart cities enhances services and resource utilization (Morvaj et al., 2011). Efforts to reduce energy consumption encompass various sectors, including street lighting, offices, households, and industries. The public sector, notably street lighting, can benefit from intelligent systems utilizing LED technology and remote control, offering energy efficiency, cost savings, and extended lamp lifetimes. Organizations are adopting more energy-efficient lighting systems within workplaces to decrease energy usage, spurred by the simplicity of such changes (Scherbaum et al., 2008). For individual users, strategies to save energy involve reducing the duration of light source usage and minimizing wattage, complemented by effective management through occupancy sensors and natural daylight utilization (Bhusal et al., 2006). In industrial settings, energy reduction methods primarily encompass three approaches: Energy management involving employee engagement, operational and equipment enhancements with minimal investments, and the development of new processes and technologies, which often require substantial investments and necessitate return on investment assessments (Mizuta, 2003). Consumers play a crucial role in energy-saving solutions, with identified barriers including cultural, economic, and information-related challenges (Throne-

Holst et al., 2008). These obstacles encompass perceptions of good living standards, payback period expectations, and the need for access to relevant information. Goodier and Chmutina (2014) also recognized barriers in projects for decentralized and energy-efficient buildings, such as financing, administrative conditions, and management constraints. Lunt et al. (2014) conducted case studies to verify the existence of these barriers and uncovered causal relationships between them. For instance, a lack of clear ownership in energy reduction projects led to split incentives and principal-agent problems. Conversely, removing certain barriers can lead to the disappearance of others. Green revolving funds, as discussed by Indvik et al. (2013), provide a mechanism for organizations to implement sustainability projects and reinvest savings, creating a self-sustaining cycle. Some universities have found these funds effective in overcoming financial constraints (Maiorano and Savan, 2015). Lee (2015) highlighted technical risk as a significant barrier to energy efficiency, alongside capital budgets, lack of influence from energy managers, and various costs associated with identifying and implementing energy-saving opportunities.

This chapter examines the importance of energy savings, the stakeholders involved, current solutions, and the barriers in the context of energy conservation. The next chapter will delve into emerging technical opportunities for addressing the energy-saving issue.

2.2. Technical Opportunities and Applications for Energy Saving

There are two main technical opportunities and applications to save energy, Internet of Things and smart cities. As according to Jin et al. (2014), a city that utilizes ICT to enhance its services and increase its efficiency is considered to be a smart city. Services enhanced include energy usage management and the evolving Internet of Things has technologically enabled cities to be smart.

The term "Internet of Things" (IoT) was coined by Ashton in 2009, representing the connection of physical objects or "things" to the Internet. These objects include not only electronic devices but also material, furniture, and equipment. IoT components typically involve physical objects equipped with controllers, sensors, or actuators connected to the Internet. Actuators can produce real-world effects, like vibrating a chair when a user receives an email. IoT aims to integrate physical objects into the Internet, enabling communication and interaction with the real world. Key components of IoT include sensors and actuators found in various devices like cars and household appliances. IoT is characterized by physical objects embedded with software and sensors, forming a network for data collection and exchange. This involves the interconnection of objects through sensors and radio tags within wired and wireless Internet structures. IoT enables various objects to connect, identify, communicate, sense, and collect data. Control over IoT devices can be achieved through touch, remote control, or web browsers, involving multiple stakeholders like owners, governments, and manufacturers. IoT provides capabilities such as object identification, sensors, connectivity, and interoperability, facilitating independent cooperative applications and services. Several differences exist between IoT and the traditional Internet. IoT endpoints are typically small, low-energy devices with limited functions and minimal human interaction, while traditional Internet endpoints are often supercomputers or mobile phones. The traditional Internet focuses on providing services and functionalities to users, while IoT is characterized by limited human intervention. In summary, IoT encompasses the connection of physical objects to the Internet, offering various capabilities, and it complements traditional Internet services. Different literature sources provide multiple perspectives on IoT, with some emphasizing the Internet and things separately, others focusing on the connected objects and their capabilities, and some discussing the differences between IoT and the traditional Internet (Haras and Skotnicki, 2018). IoT has various applications in the energy domain like using sensors in homes to alter temperatures of heating devices based on preference or the climate. Electrical equipment can be automatically turned off to reduce energy consumption and increase energy savings. Moreover, some energy providers try to influence energy consumption by using dynamic pricing during load peaks. A response to that can be to observe when the pricing is high and when it is low based on data from an external web service and consider energy requirements of home devices such as battery chargers, ovens or refrigerators and when to switch off these devices (Atzori et al., 2010; Abdulzahra et al., 2023; Elsisi et al., 2023).

IOT and ICT in general provide many opportunities for increasing the efficiency of managing the city which is highly required because of increasing the rapid increasing of population. Therefore, many governments have invested in these technologies to build smart cities using smarter ways for managing the provided services for increasing the sustainability by those cities (Chourabi et al., 2012). Through the usage of information and communication technologies, smart cities are going to address some of the critical issues faced nowadays such as waste, water, education and energy (Perera et al., 2014). Information and communication technology are going to contribute greatly in the success of the smart city objective. They can be combined to provide solutions for various issues such as electricity and water consumption, heating and waste systems (Lazaroiu and Roscia, 2012). Accroding to Khatoun and Zeadally (2016), there are several areas where smart cities provide huge benefits. First, the security and safety measures in cities are enhanced through the utilization of surveillance camera that provide real time information as well as enhanced responses to emergencies and enabling the capability of sending automated alert messages to the public. Second, transportation solutions and smart streetlights mean that there is a lower level of pollution. Finally, in the healthcare domain, smart cities utilize smart devices and new technologies such as attaching sensors to human bodies or clothes so that real time information is accessible by doctors who can monitor or treat patients. Multiple cities are engaging in smart city initiatives. Angelidou (2014), identified several cases where smart city strategies where applied. In Amsterdam smart city is a partnership including more than 70 partners compromised from various businesses and authorities such as CISCO and IBM. The smart city program spreads across Amsterdam's neighborhood with projects aiming to provide private consumers with monitoring capabilities over their energy usage to encourage them to manage their consumption more efficiently. Form 2009 the city introduced the Climate Street where energy saving technologies such as smart meters in energy buildings and electricity suppliers (Karnouskos, 2011; Morvaj et al., 2011; Almihat et al., 2022; Hui et al., 2023), smart plugs and energy displays were demonstrated. Another project was called West Orange that included four hundred houses equipped with energy management systems such as digital energy or gas meters and energy displays to provide users with more information about their consumption and aid them in saving energy.

The investigating IoT and smart city solutions for energy saving, it was found that the literature focused on how these solutions save energy and how they are applied however, there was lack of literature about how a new business model can be developed that can provide a new way of utilizing the advanced solutions and technologies mentioned in the literature review to decrease energy consumption and provide a sustainable way to monitor and control energy usage. Consequently, this paper aims to answer the research question "How can a new conceptual business model be developed to reduce energy consumption?" The business model developed will be generic as it can be applied in any country however, this paper will also aim to answer the question and how it can be applied in Egypt using interviews and surveys as the country has been facing several difficulties economically, it suffers from several energy outages and renewable energy resources are under utilized.

3. METHODOLOGY

This work presents a new conceptual business model which has been developed for reducing energy consumption through the utilization of renewable energy sources, offering information to users concerning their energy consumption and supplier's information and prices. This business model will be based upon the applications and requirements of IoT and smart city applications for energy saving mentioned in the literature review above and will be evaluated from an expert's point of view using interviews as the qualitative research tool and from a user's point of view using surveys as the quantitative research tool. These tools will also provide information regarding the Egyptian market in general and finally, basic prototyping of some of the business model's functionality will be demonstrated.

3.1. Developed Business Model Requirements

Energy saving is a topic that is gaining more and more attention each day. The importance of energy saving mentioned in section 1 provides numerous motives and encouragement to develop new ways to better manager energy consumption. Moreover, the current energy saving solutions mentioned in section 1 as well, all provide benefits however, they are not enough to face the energy consumption issue faced by the world and especially in Egypt these solution were not sufficient to prevent the server energy outages the country faced the last couple of years and this adds to the need to develop a new business model for energy consumption. The business model to be developed will rely on the IoT technologies and smart city applications mentioned above in the literature review. However, to start the development of the business model there are certain elements defining business models that need to be identified and applied in the development of the business model, Bocken et al. (2014) state that there are three main elements that define business models. The first is the value proposition, which is the product or service that is being provided in return for an economical value. The second is value creation and delivery, which is utilizing new prospects and the third, is value capture which is earning and benefiting from the revenues. Eight sustainable business model archetypes were developed and categorized into three main types technological, social and organizational. However, this paper will only highlight 3 archetypes. The substitute with renewables and natural processes technological archetype value proposition relies on targeting non-renewable resources constraints to decrease environmental impacts. Value creation and delivery is through the advances in the production processes where renewable energy resources are utilized. As for the value capture revenues come from the new services provided as well as the environmental value resulting from the decrease use of non-renewable energy sources and their emissions. Another social archetype is encourage sufficiency, it depends on products and services that aim to decrease consumption of consumers leading to decrease in production. The value creation and delivery is through activities that focus on reducing consumption and encourage durability and value capture is from profitability, loyalty of customers, and social and environmental benefits. The last archetype to be discussed is the scale-up solutions organizational archetype, which is providing solutions at a large scale to increase the benefits for the environment and the community. Value proposition is through the scaling of sustainability services and products to maximize environmental and social benefits. Value creation and delivery is through guaranteeing that a sustainable business model has the ability the scale through utilizing the correct channels and partnerships. Value capture is by having a variable or fixed fee for scaling up the solution.

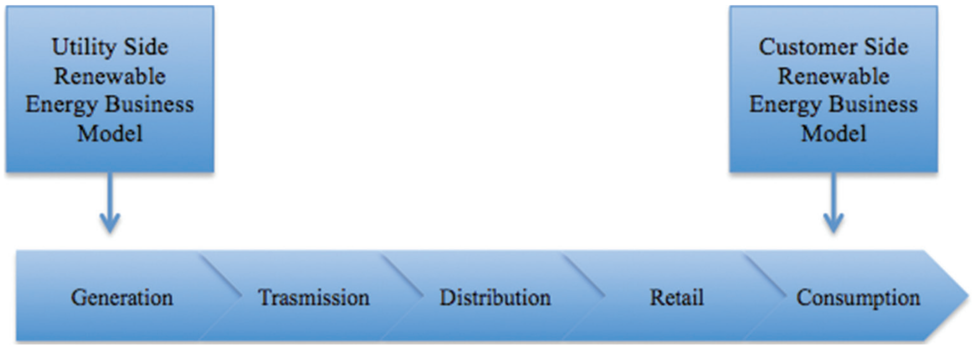
According to Richter (2012), there are two main choices for business models. They can either be utility side based or customer side based. Generation and consumption of electricity are two important sections of the production process. Generation of electricity has to change to utilize renewable energy sources enabling users to be producers and not just consumers, moving the production to the consumption side as well. This is illustrated in the Figure 1 below.

In the utility side renewable energy business model projects are on a large-scale they could be biomass power plants, wind farms or photovoltaic projects. As for the consumer side renewable energy business model, consumers can utilize photovoltaic, CHP micro power, solar thermal hot water, micro wind turbines or geothermal heat pumps. Akorede et al. (2010) explain that photovoltaic are solar panels that are composed of several connected cells, which transform light radiation to electricity and the power produced is directly proportional to these cell's surface area.

3.2. Developed Business Model Evaluation

Two main techniques for evaluation were used to assess the developed business model. First, qualitative research was conducted using interviews as the tool for research and secondly, quantitative research was conducted using surveys as the tool for research.

Figure 1: Two generic business models (Richter, 2012: 2487)



Qualitative research interviews were chosen as a qualitative method to provide insights from experts. Semi-structured, individual interviews with employees in the electrical industry and real state development industry were conducted. The reason these interviewees were chosen is that the interviewee that works in the electrical field can provide valuable insights and information about the current developments in the electrical energy state nowadays and the interviewee form the real estate development background can give insights if this business model is applicable in new compounds or homes being built and what is being applied in new houses nowadays. Interviews were conducted with 3 employees. The first is Mr. Mohamed Saleh, managing director of Bedaya for lighting services as he can provide information about the applicability of the business model and he has experience with what is being applied right now. Mr. Islam Abdel Fattah marketing manager of Bedaya for lighting services, as he has knowledge regarding what the customers want, the current market needs and how to approach users. The third is Mr. Hisham Makeen managing director in a real estate company but he preferred to not disclose the name of his company and just provide information from his own personal point of view based on his experience, as he can provide information with what new buildings and compounds are applying currently.

3.2.1. Quantitative research

A quantitative method using a survey was conducted to better identify the users' needs and their willingness to utilize the methods suggested in the business model. Consumer behavior, knowledge, opinion and attitudes can be measured in business research by quantitative methodologies, and surveys are a dominant methodology (Cooper and Schindler 2014). Only one question was for classification but the rest were target questions, that varied either multiple choice or rating and a short answer question was asked at the end so that users can add any comments or suggestions they have. The first question aimed to identify whether users were satisfied with their current electrical system to make sure that there is basis for developing a new business model. The second and third questions are intended to provide information about the users current behavior while the rest of the questions aimed to investigate their needs and future demands and participation in the business model. For convenience the population of the sample will be Cairo residents, the survey was distributed to three age groups 18-21, 21-35 and above 35. The total sample is 155 participants. The survey was also distributed to people from different backgrounds to make sure that the business model can address various users' needs. The surveys were self-administered surveys and left for the participants to fill them out. The survey was created in 1 week and presented to 2 participants in each of the age groups mentioned above for validation and to make sure that all the questions are understandable before distributing them to all the participants.

4. DEVELOPMENT OF CONCEPTUAL BUSINESS MODEL

This paper developed a new business model that is based on IoT applications and solutions that can help reduce energy consumption of users. This business model can then be applied in smart cities, for example it can be applied in the new capital that Egypt aims to build or it can be applied in existing smart city applications mentioned in section 3. Then qualitative and quantitative research was conducted to evaluate the business model.

4.1. Developed Business Model Value Flow

As mentioned in section 4.2, there are main objectives that must be involved to solve cities' major economical, environmental and social issues. The developed business model applies these objectives. First, the enhanced management of resources, which this business model provides as the usage of non-renewable energy resources is reduced and usage of renewable energy sources is increased. Second, energy generation is decentralized, as consumers become producers as they have renewable energy sources applied in their homes or buildings. Moreover, this business model makes use of the developments that have occurred in the smart grid as the business model utilizes smart meters and measures appliances energy consumption.

This paper introduces an energy management solution that provides huge changes in the energy ecosystem in worldwide. As mentioned in section 4, IoT and smart city application offer benefits to both the supply and the demand side. This solution also offers capabilities to the supply side and the demand side. For the demand side it will enable users to minimize their non-renewable energy consumption through utilizing renewable energy sources after reaching a certain limit as well as decrease their own consumption as a result of identifying each appliance's energy use. The energy management solution can also compare between the different prices offered by different suppliers so that consumers are always buying at the lowest price. As for the

Table 1: Developed business model canvas

Key providers	Key activities	• Value proposition	Customer relationships	Customer segments
• Energy suppliers • Renewable energy suppliers • Commercial units	• Monitoring energy consumption (total and appliance specific consumption) • Switching between renewable and non renewable energy sources • Switching between suppliers dynamically based on energy prices • Providing supplier with information about users • Key resources • Smart meter • Web services • Supplier prices and rating	• Energy management solution made available for consumers and suppliers • Saving in the money spent on electricity • Providing suppliers with information to better address their costumers • Utilizing environmentally friendly energy sources	• Email sent through the solution • Advertisements on social Media Channels • Home visits • Social media ads	• Youth recently owning their own home • 18-30 • Older generations • 30-60
Cost structure • Maintaining database server		Revenue streams • Subscription fee from customers • Fee from energy suppliers based on the information provided to them		

supply side, suppliers will be provided with information about all consumers' consumption based on the time of day or area to make their plans more attractive to consumers and increase their market share. The current approaches in the literature review all seem to work independently focusing on one area of the problem only. This is why the business model developed in this paper aims to integrate various solutions and increase interactions between the stakeholders.

As mentioned above the renewable energy business model can be at the supply side or the demand side, the developed model is a customer side renewable energy business model. Moreover, the value proposition, value creation and delivery as well as the value capture of the business model have to be identified. The value proposition of this business model is the energy management solution that is made available to end users and suppliers. This solution will help consumers save money spent on electricity, utilize environmentally friendly energy resources and enable suppliers to better understand their customers and provide better services. Value creation and delivery is through the utilization of smart meter data and advances in technology to identify each appliance's energy consumption as well as utilizing renewable energy sources on a small scale. Value capture is through earning money from end users as a subscription fees and selling consumption data to energy suppliers for a fee.

As mentioned in section 2, there are three main stakeholders; the government, the suppliers and the consumers. The government will provide regulations that all parties should abide by, raise awareness of consumers to reduce their energy consumptions and help raise funds to support renewable energy sources. The energy management solution will act as an intermediary between both the suppliers and consumers. Consumers will be provided with information regarding their total energy consumption, appliance specific consumption, supplier rating and prices in exchange for a monthly subscription fee. Suppliers can purchase information about consumers' energy consumption after the approval of consumers registered on the system and without any personal information being compromised to enable them to compete better in the market. Table 1 illustrates a developed diagram that shows the interactions between these three stakeholders with the flow of information and money.

As seen in the developed diagram in Figure 2, the customers can be public institutes, homeowners or offices. These customers will obtain energy from suppliers in return for a monetary value specified by the suppliers and they will also pay subscription fee in return for their usage of the energy management solution. The energy management solution will provide the customers will supplier prices and environmental rating as well as their energy consumption data. It will also provide suppliers with information about the consumption patterns of users in return for a fee from the suppliers. The government will only act as an authority that makes sure that every entity abides by its regulations.

4.1.1. Energy Management Solution's Requirements

There are two types of requirements, the first are functional requirements that are essential for the solution to work and fulfill the customer's need and are related to the technical functionality of the system. The non-functional requirements are criteria that are not related to the functionality of the system and only address certain conditions. The functional requirements are that the solution should be able to collect total consumption data, appliance specific data and supplier data. It should enable the user to set a budget to his spending and utilize renewable energy sources. The non-functional requirements would be the reliability of the solution; it has to provide users with consistent information. The subscription fee also needs to be within an acceptable range to users so that they are interested in the solution.

4.2. Developed business model canvas

A business model canvas is a graphical outline or template that defines nine fundamental components.[3] The first component is key partners, which identifies the key partners or suppliers in the business model. The second component is the key activities, which are the main functions that are needed by the value proposition. The value proposition identifies the value that is

3 Adapted from https://www.forbes.com/sites/tedgreenwald/2012/01/31/business-model-canvas-a-simple-tool-for-designing-innovative-business-models/#113b150316a7 (Access date: April 20th 2017).

Figure 2: Developed value flow between stakeholders

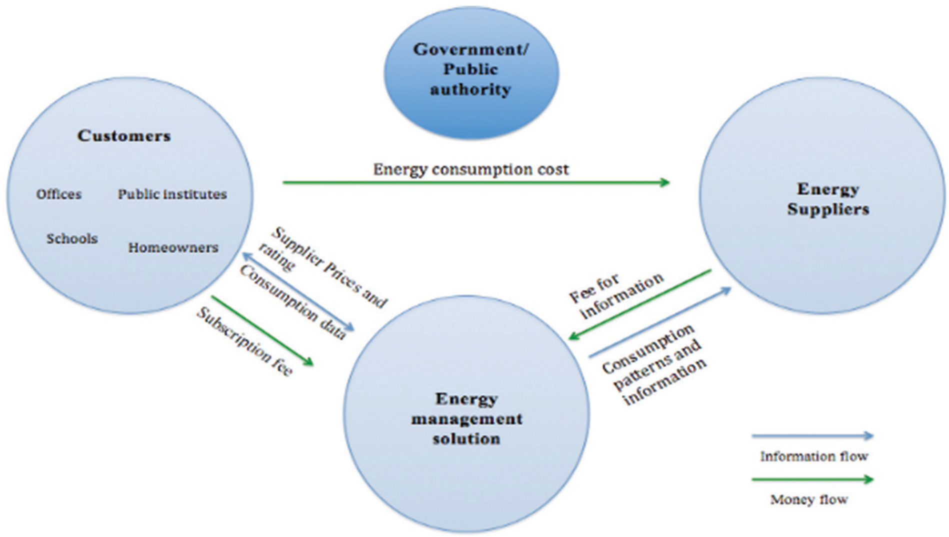
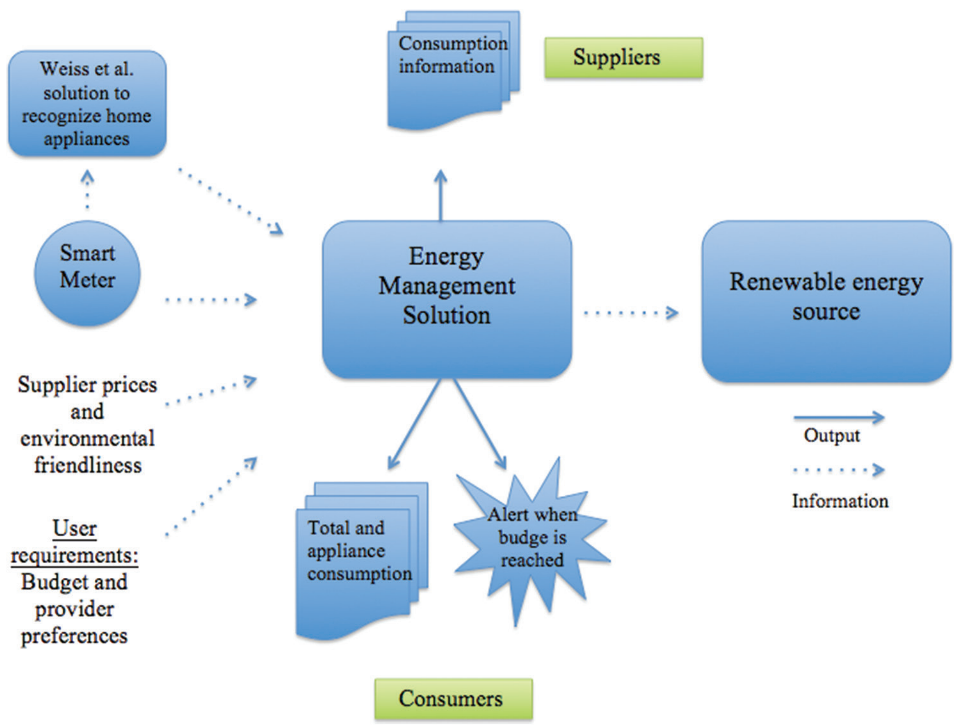


Figure 3: Developed business model information and output flow



made available to users, which problems this business model is trying to solve and what needs is this business model trying to satisfy. The customer relationships state how the business model will keep in contact with its customers and how does the business model attract and retain these customers. The customer segments it distinguishes between the segments that this value is being provided to. As for the key resources it identifies the main resources needed by the value proposition and the channels are the means to reach the identified target segments. Lastly, the cost structure states the main costs encountered by the business model and the revenue streams identifies what money is the business model going to generate form users. Figure 9 below shows the business model canvas developed in this paper. They key partners are the non-renewable energy suppliers, renewable energy sources/application suppliers and the governmental units. The key activities are monitoring energy consumption both total consumption and appliance specific consumption, switching between renewable and non-renewable energy sources based on a limit set by the user as well as switching between energy suppliers that sell at the lowest prices and lastly, providing suppliers with information regarding the energy usage patterns of users. The value proposition is through the energy management solution that is going to be utilized by customers and suppliers. There are also going to be savings in the money spent on energy consumption as well as better utilization for renewable energy sources and specifically for energy suppliers, energy consumption data and patterns of users will be made available for them. The customer relationships will be managed through emails sent to current users through the solution and advertisements to attract new users. The business model targets every energy user however there are two main customer segments. The first are users from age 18 to 30 these are the users who are recently owning a home and users who are of age from 30 to 60 which are current home owners. The key resources of this business model is the smart meter and the data it provides, the web service that is the energy saving solution and the supplier prices and rating information. For the channels there are the customers will be reach through home visits or advertisements. Finally, the main costs of the business model will be the costs of maintain the database and server that support the energy management solution and the revenue streams are from the fees paid by the customers as well as the fees from the suppliers.

4.3. Energy Management Solution’s Explanation

As mentioned in section 2, IoT and smart city applications can provide huge capabilities in energy saving. This is why the main components that are basis for this business model are IoT applications. The smart meter is going to continuously monitor the consumption data and store it in the database (DB). The mobile application solution that was discussed in the literature review will also store the energy consumption of each appliance in the house. The new solution now has the total energy consumption of the house as well as each appliance’s consumption. The solution presents both of the data in a user-friendly interface and analyzes data from both sources to provide users with information on how to minimize their energy usage and notifies the users when they have reached a certain limit of usage to utilize renewable energy resources. The solution also compares supplier prices and their environmental friendliness so that users can switch between suppliers based on their budget and set preferences. The energy management solution will provide users with information about their consumption and send an alert when they exceeded the budget set for consumption. The solution will also provide suppliers with energy consumption patterns of users. The solution’s information flow and output are presented in the developed diagram in Figure 3 below. Weiss et al.’s (2012) solution was chosen because unlike other solutions it does not need a sensor to be attached to each appliance to determine its energy usage and thus making it cheaper than the alternatives. This solution communicates with a gateway that responds with a JSON message that is presented to the user on their mobile phone. The solution proposed will receive responses from the gateway according to Weiss et al.’s proposed architecture and provide the user with information about each appliance’s usage. The solution will also pull the smart meter data every second and store it in an sql database. Along with the user preferences, which relate to the electricity budget and supplier, which the user will provide at first. The database schema is shown in Figure 4 below.

The supplier pricing refers to whether the supplier follows dynamic or static pricing and the rating will be regarding to their friendliness to the environment on a scale from 1 to 4, 1 being the lowest. The system will continuously measure the total consumption and when it reaches the budget specified by the user it should turn the renewable energy source on as shown in Figure 5.

The user can also choose to have his supplier dynamically changed based on the price offered. For example, if a supplier that utilized dynamic pricing in a certain hour increases cost the user can switch to another supplier that charges at a lower rate as demonstrated in the Figure 6 below.

4.3.1. Solution data

Data samples were chosen from online open resources and information about suppliers was created as an example to better explain what the business model should provide. There are four categories of data that this solution will rely on.

4.3.1.1. Total energy consumption data

The first is the energy consumption form households, this data was downloaded from SDG&E’s website which is a regulated public utility operating in San Diego and southern Orange counties that offers energy services through electric meters and gas meters, the

Figure 4: Developed business model database scheme

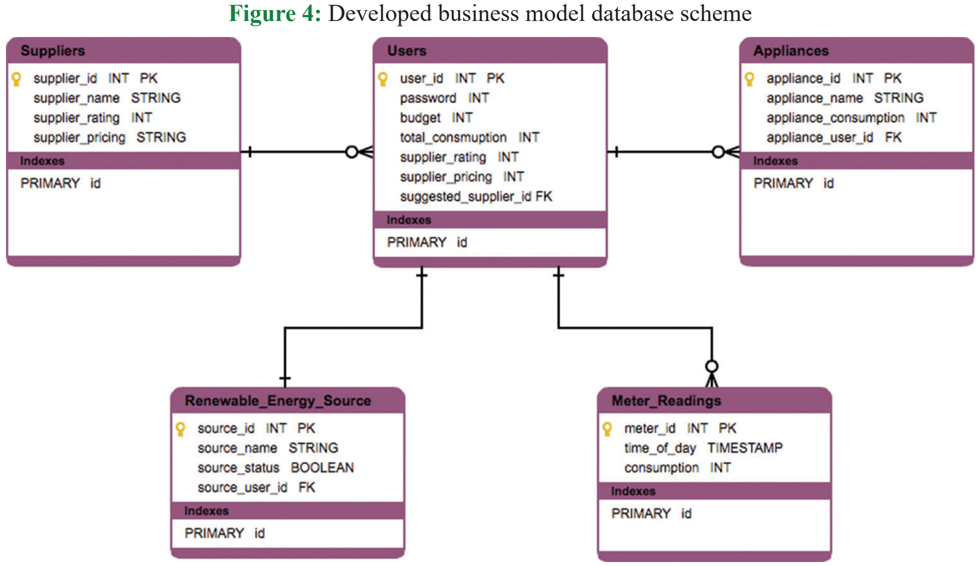


Figure 5: Developed business model operation of renewable energy

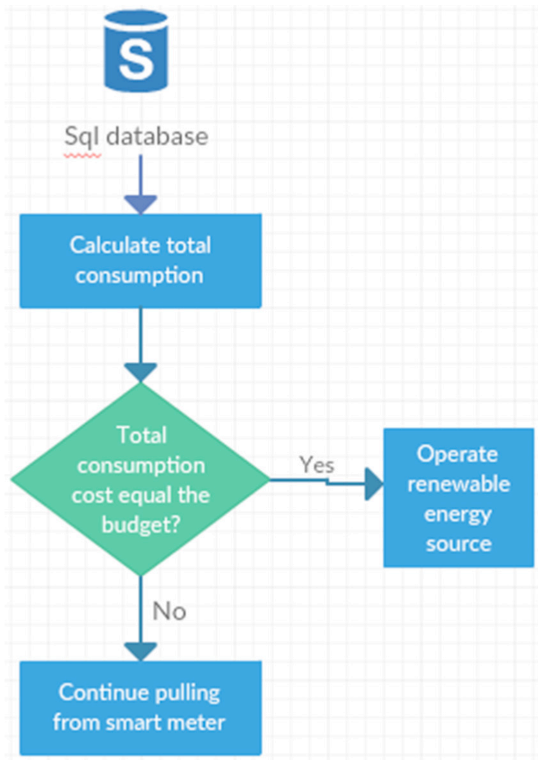
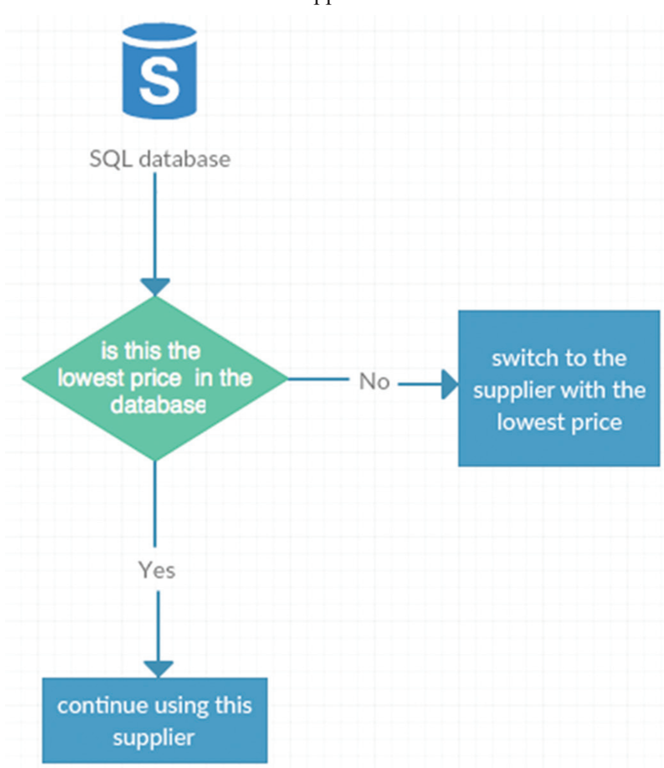


Figure 6: Researcher developed business model switching between suppliers



data is from green button – 60 min meter interval sample data set in csv (Comma separated values) format. A sample from the data is shown in Table 2.

This data is an example of the data that can be the input to the

Table 2: Total consumption sample data (green button 60 min meter interval)

Date & Time	Use (KW)	Gen (KW)	Electric Rang	Dryer (KW)	GarageMuder	Dininig Room	MudRoom	MasterBath	Garageoutle	Basementou
01-01-2016 00:00	0	0	0.00385	0.0034	0.00461667	0.0021	0.00325	0.00486667	0.0061	0.00058333
01-01-2016 00:01	0	0	0.00386667	0.00343333	0.0041	0.002	0.00308333	0.00486667	0.00611667	0.00056667
01-01-2016 00:02	0	0	0.00386667	0.00343333	0.00365	0.00188333	0.00308333	0.00488333	0.00613333	0.00058333
01-01-2016 00:03	0	0	0.00386667	o.oo341667	0.00363333	0.00188333	0.00296667	0.00488333	0.00613333	0.00058333
01-01-2016 00:04	0	0	0.00393333	o.oo341668	0.00341667	0.0024	0.00296667	0.0045	0.00558333	0.00055
01-01-2016 00:05	0	0	0.00393333	o.oo341669	0.00333333	0.00253333	0.20861667	0.00448333	0.00558333	0.00053333
01-01-2016 00:06	0	0	0.00393333	0.00328333	0.00331667	0.00253333	0.22218333	0.00448333	0.00555	0.00055
01-01-2016 00:07	0	0	0.00395	0.00328333	0.00333333	0.00253333	0.22195	0.0045	0.00558333	0.00053333
01-01-2016 00:08	0	0	0.0039	0.00331667	0.0033	0.0024	0.22191667	0.00446667	0.00555	0.00053333
01-01-2016 00:09	0	0	0.00391667	0.00328333	0.00325	0.0024	0.22075	0.00446667	0.00551667	0.00053333
01-01-2016 00:10	0	0	0.0039	0.00331667	0.00326667	0.00241667	0.21948333	0.00445	0.00553333	0.00053333
01-01-2016 00:11	0	0	0.00391667	0.00331667	0.00326667	0.00243333	0.22001667	0.00445	0.00556667	0.00055

Table 3: Appliance level consumption data (UMass Trace Repository)

Time Period (start)	Time Period (end)	Usage (KWH)
01-02-2011 00:00	01-02-2011 01:00	0.385
01-02-2011 01:00	01-02-2011 02:00	0.365
01-02-2011 02:00	01-02-2011 03:00	0.425
01-02-2011 03:00	01-02-2011 04:00	0.5
01-02-2011 04:00	01-02-2011 05:00	0.63
01-02-2011 05:00	01-02-2011 06:00	0.69
01-02-2011 06:00	01-02-2011 07:00	1.02
01-02-2011 07:00	01-02-2011 08:00	0.83
01-02-2011 08:00	01-02-2011 09:00	0.325
01-02-2011 09:00	01-02-2011 10:00	0.22
01-02-2011 10:00	01-02-2011 11:00	0.315
01-02-2011 11:00	01-02-2011 12:00	0.225
01-02-2011 12:00	01-02-2011 13:00	0.29
01-02-2011 13:00	01-02-2011 14:00	0.245
01-02-2011 14:00	01-02-2011 15:00	0.28
01-02-2011 15:00	01-02-2011 16:00	0.265
01-02-2011 16:00	01-02-2011 17:00	0.285
01-02-2011 17:00	01-02-2011 18:00	0.39
01-02-2011 18:00	01-02-2011 19:00	1.78
01-02-2011 19:00	01-02-2011 20:00	1.75
01-02-2011 20:00	01-02-2011 21:00	1.73
01-02-2011 21:00	01-02-2011 22:00	1.01
01-02-2011 22:00	01-02-2011 23:00	0.59
01-02-2011 23:00	01-02-2011 00:00	0.585

Table 4: Supplier information and pricing

Supplier_ ID	Supplier_ Name	Supplier_ Rating	Supplier_ Price
S1	Nadicita	3	200
S2	Energetica	2	150
S3	Zoola	5	250
S4	Satica	1	140

solution from the smart meter and different meters can provide data at different intervals of time, for example, the interval can be either a couple of minutes or half and hour.

4.3.1.2. Appliance level consumption

The solution will also have the consumption data of the appliances at homes or institutes monitored and should provide users with a summary about the consumption of these appliances in a user friendly way. A sample of how this data will look like is obtained from an online open source the UMass Trace Repository. As shown from the sample data in the screenshot below in Table 3, there will be numerous devices in a household and thus it is essential that the energy saving solution can maintain these devices and still present their consumption to the user in an easy and understandable way without overwhelming the user with a lot of numbers.

4.3.1.3. Supplier information and pricing

The solution will also collect information about supplier's pricing schemes whether dynamic or static and their rating in terms of the friendliness to the environment. At the beginning this data can be entered manually at once but in the future this solution can be integrated with the supplier's information systems so that the data is sent automatically in real time without any human involvement. An example of how the data can be maintained is shown in the screenshot in Table 4. This data is only created as an example by the researcher; these suppliers and prices are not real.

Figure 7: Consumer consumption in KWH on the y-axis and user_id on x-axis

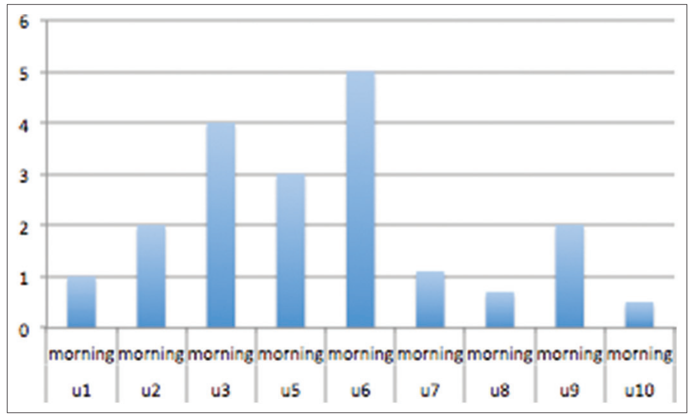
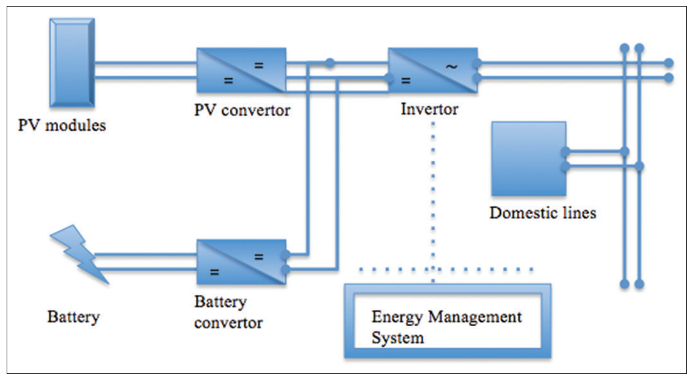


Figure 8: Solar energy system (Bragard et al. 2010: 3054)



4.3.1.4. Consumption patterns

The last data set relevant to this solution is the users energy consumption patterns. Suppliers only have access to the consumption information of their own subscribers but this solution can offer them consumption information regarding their competitor's users. This will only be done after the consent of the users, as they will benefit form the increased competition between suppliers because it will lead to better pricing schemes. Example of how suppliers can be provided with information is provided in the screenshot in Figure 7. This data is created by the researcher as an example and is not real information.

Suppliers can be provided with reports about the consumption of users and as a result they can offer tailored prices of certain customers such as lower prices during certain times of the day or encouraging them to utilize certain products during certain times of the day to decrease their energy consumption.

4.3.2. Stakeholders

Users in this business model can have very different specifications. For example if the user is an individual home user it would be best for him to utilize solar panels on the house's rooftop. However, if there are a couple of users who live in a remote rural area they can choose to utilize wind renewable energy.

4.3.3. Individual city users

Solar panels can be placed on the rooftops of households. These solar panels will charge batteries that are connected to the electricity grid. The system discussed by Bragard et al. (2010), provides an output of 5 kW, energy from the sun is transformed into electrical energy by solar panels on the roof and PV converter, battery converter and an inverter deliver the energy to the house or the grid. A schema of the system is shown in Figure 8.

The energy solution proposed by this paper will communicate with the management system of the invertor to determine when it should be operated so that the household in no longer relying on energy from the energy supplier but is utilizing energy from the solar panels on the roof top.

4.3.4. Group of users/remote rural users

For users who live in remote areas or areas where there are empty fields next to them, they don't have to solely rely on solar panels placed on rooftops. Wind energy can be utilized as a renewable energy resource as there will be enough space to operate the device and its noise will not bother the residents.

4.3.5. Suppliers

There are two types of suppliers involved in this business model, energy suppliers and renewable energy source suppliers. The energy suppliers will sell energy to the users and will purchase data about energy consumption such as at what time do users in a certain area consume the most energy. This is beneficial, as suppliers will now have information about the consumption of users who are not their customers and that will provide more insights on how to better address the customer needs and increase the market share. As for the renewable energy suppliers, they will not be as involved in the business model as the energy suppliers as they will only provide the solar panels or wind turbines at first and only assist customers when needed or for maintenance.

4.3.6. Government and supervision

The government should be the authority that forces rules and regulations that will govern this business model as well as raise awareness and create incentives to encourage users to utilize renewable energy sources. Starting with the first role as the authority forcing rules, the government should impose high taxes on houses or factories that consume a huge amount of energy and provide discounts and benefits to those who utilize renewable energy sources. The second role which is raising awareness about the importance of renewable energy, the government should hold campaigns about the dangers the environment face and also the economical effect of relying on a huge amount of energy and how if the country cannot relay on its own generation and has to use exports will decrease the value of the national currency and increase cots of living.

As mentioned in section 4, three main fundamental factors for the establishment of smart cities were identified which are investments in technology, people and institution. The business model addresses these three factors, as it requires investments in technology to start utilizing smart meters and to introduce new suppliers to the ecosystem. The needed hardware will be the smart meters and the software is the software used by the smart meter as well as the energy management solution's software. The second factor is the human factor and that is also addressed in the business model as it requires collaboration between all the stakeholders. There is going to be more transparency between customers and suppliers regarding consumption and prices. Lastly, the institution factor also appears in the business model as the government acts as the supervisory role and ensures that all its regulations are being applied and followed. Section 4 also addressed the communication and operational requirements that are needed for these applications. This also applies to the developed business model as various different suppliers can provide the smart meters in the business model and this means that the energy management solution can be able to receive and send data to various suppliers.

The business model developed can be applied in any country, as it is generic. It utilizes technologies that are emerging nowadays and playing a bigger role in our daily lives as mentioned in the literature review. Moreover, as mentioned in section 3, there are now cities that are taking an active role in implementing energy saving solutions based on IoT and are becoming smarter cities as Amsterdam and this business model can be applied in these cities to provide guidance over the overall process and increase the energy consumption reduction. This business model can also be applied in Egypt as Egypt is currently in the need of implementing changes in its energy consumption process due to the economic difficulties as well as the energy outages.

5. CONCEPTUAL BUSINESS MODEL EVALUATION

The proposed model has been evaluated in Egyptian context. Egypt is facing numerous challenges in meeting its customer energy demands, energy outages have occurred the past couple of years, economic difficulties are adding to the burden of the government and there is no utilization of the country's renewable energy sources. The developed business model will be evaluated using interviews and surveys as the qualitative and quantitative research tools because it introduces new changes and is difficult to implement nationwide. Expert's point of view will be obtained through the interviews as they can provide information regarding the Egyptian market as well as discuss the business model's strength and weaknesses and any possible changes it requires. The consumer's point of view will be obtained through the survey as they are one of the main stakeholders and the success of the developed business model highly relies on their views and engagement.

5.1. Realization of the Business Model to the Egyptian Market

As mentioned before this business model can be applied in any country however Egypt has faced huge difficulties in managing energy outages that would last for hours and it also has abundant resources that are not being utilized to respond to this issue. This business model will relay on a complete change in the Egyptian energy ecosystem, as the government is the only energy supplier. As utilizing solar panels, batteries and wind turbines will be required,

Table 5: Solar suppliers in Egypt

Supplier name	Website	Services
Efregreen	www.efregreen.com/	Off/On grid panels and storage
Green Tech Solutions	www.gts-solar.com/	Solar panels and batteries
ETS Electric	ets-electric.com/inde x.php?r=home/index	Solar panels, batteries, invertors and charge controllers
Target Consulting Project Solution	www.targetcps.com/	Solar panels
Egyptian Solar Energy Systems Company	www.egyptsolar.net/	Photo-voltaic
Advanced Green Energy and Control	http://agec-eg.com/	Solar panels and batteries
Arab Consulting Office	www.acoegypt.com/	Solar modules and batteries
Sun Power for Renewable Energy	sunpower-eg.com	Solar panels

Table 6: Wind energy solution suppliers in Egypt

Supplier name	Website	Services
Elsewedy Electric	www.elsewedyelectric.com	Wind blades, towers and turbines
Green Iso	http://www.greeniso.net	Wind turbines and Wind/Solar hybrid system
Egyptian Association for Energy and Environment	www.eaee-eg.com	Wind pumps
Ener Global Renewable Solutions	http://www.ener-global.com/	Wind mills
DSD Ferrometalco	www.ferrometalco.com	Wind towers

identification of some of the suppliers of these technologies in Egypt will be discussed next. Information regarding suppliers in Egypt examined the services they provide, there are numerous suppliers in Egypt that offer solar energy solutions such as solar panels, storage systems, solar water pumping, street lighting and solar water heaters however for the scope of this thesis only the solar panels and storage solutions will be discussed. There are various types of solar solutions; off grid systems are systems that provide energy to remote areas that do not have access to the energy grid. On grid systems are systems that are connected to the energy grid enabling the user to relay on solar energy besides the energy from the electrical supplier. If the user generates excess energy than his consumption it could be sold to the government in return for money or reductions on the electricity bill. Tables 5 and 6 below identify some of the suppliers currently in the Egyptian market that provide solar panels, batteries and wind turbines.

5.1.1. Solar panel and battery providers

The integration of solar panels and batteries is a pivotal component in advancing renewable energy solutions for sustainable energy consumption. Solar panels convert sunlight into electricity, while batteries store this energy for use during non-peak sunlight hours, ensuring a consistent energy supply. These technologies form a crucial part of decentralized energy generation, empowering consumers to transition from traditional energy reliance to self-sufficient systems. The Key Providers in the Egyptian Market has been shown in table 4.

5.1.2. Wind turbine providers

Wind turbines represent a critical component in the transition to renewable energy sources, particularly for regions with consistent wind patterns. By harnessing wind energy, turbines generate electricity without greenhouse gas emissions, contributing to sustainable energy development. Wind turbines are versatile, ranging from large-scale installations for grid supply to smaller units suitable for remote or off-grid locations. The Key Providers in the Egyptian Market has been shown in table 5.

5.2. Qualitative Research Findings

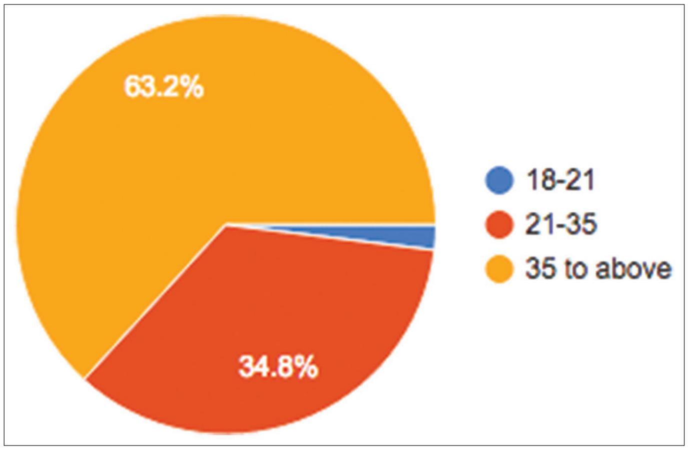
The information collected from the 3 interviews conducted were gathered and categorized in terms of challenges, possible changes, economic effect and stakeholder resistance.

5.3. Challenges in the Energy Market

There were several challenges identified by the interviewees facing the energy market. The first is that the consumers are focused on short term spending; meaning that they will buy cheaper products regardless of their energy consumption instead of products with higher costs that will consume less energy. Another challenge is that the government should completely change the management of the electrical energy in Egypt. The government is selling electricity at a much cheaper price than its actual cost as a result of the subsidization[4]. This is becoming an obsolete, unrealistic approach to manage electricity as the number of poor consumers being supported by the government is increasing, the dollar price is rising and the reliance on fuel energy for generating electricity. All these factors are increasing the gap between the cost and the price that the electricity is being sold at. Moreover, the infrastructure is outdated, it is not being maintained regularly and the population is increasing at an accelerating level. All these factors as well are contributing to the deficit in energy generation and the electricity outages that last for hours that Egypt has been facing the past couple of years. This shortage required immediate action from the government and as a result the government obtained numerous new stations to increase the generation of electricity. This way is only addressing the issue for a short time. The root causes of the problem, have not been addressed and no approaches were taken to ensure that this issue will not happen again in the future and the solution the government resorted to is only adding to the economic burden that the country is facing nowadays.

4 Government subsidization is a benefit that individuals receive from the government that can be in the form of money of tax reduction to remove a type of burden. (Adapted from www.investopedia.com/terms/s/subsidy.asp) Access date: April 22nd 2017.

Figure 9: Participants' age groups



5.4. Possible Changes to Address Challenges

To address the challenges mentioned, changes need to be identified and applied. The most important issue is raising awareness about the effect of increases energy consumption on the environment and the country's economy. For any change to be effective it has to come from the people as they are the consumers and they are the ones in control. The main way Egyptian consumers believe is there to save energy is to switch off the lights or air conditions however, consumers should be aware of the various way to save energy by utilizing renewable energy sources and appliance's that do not consumer huge amount of energy; being smarter regarding saving energy. This can be due to the fact that the government is selling the electricity at a much lower price than its real value and consumers taking that for granted. So the government needs to raise awareness about the importance of reducing energy consumption and utilizing renewable energy sources. Moreover, the government should stop subsidizing electricity and re-price it with the real market value and provide extra support to companies that provide IoT and smart city application in energy saving.

5.5. Business Model Strengths and Weaknesses

The strength of the proposed business model is that it integrates between various ways to save energy. First, it informs users with their consumption and that awareness makes consumers more conscious about their spending. It also utilizes renewable energy sources and that is a step that is greatly needed worldwide as non-renewable energy sources are limited and in Egypt to utilize the resources that are not fully used to their potential. It takes the burden of the government and transfers it to suppliers, which would release the government from the economic load of subsidizing. The weakness is that it requires great investments, first in educating users about the renewable energy technologies and the second is the changes in infrastructure as Egypt is overlay populated in certain areas that there might not be enough space to place solar panels.

5.6. Business Model Economic Effect and Stakeholder Resistance

This business model will introduce new investments in the market. First, companies will provide products that are more environmentally friendly as consumers can now take energy consumption of the product into consideration. Solar panels and wind energy technology

Figure 10: Participants' energy spending

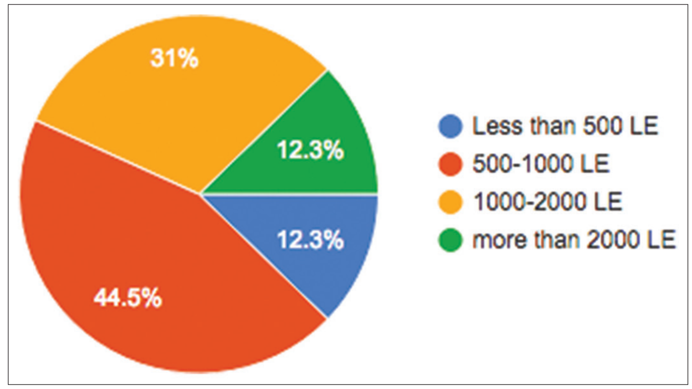
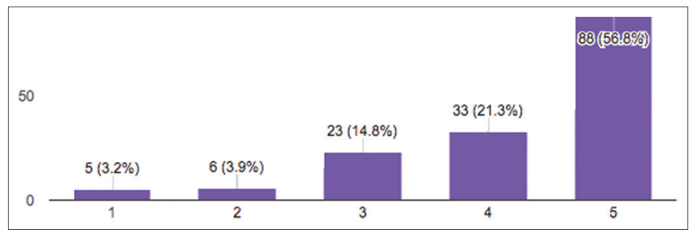


Figure 11: Participants' willingness to utilize the energy management solution



companies will have increased presence in the market. There will be need for more suppliers whether electricity suppliers or renewable energy technology supplier and that can attract numerous foreign investors resulting in the creation of new jobs and increased entry of foreign currencies. As for the resistance, it can be from both consumers and the government, first from consumers as there is lack of education and awareness about the effect of the increased energy consumption and the new available technologies. Second, from the government, as this business model requires major changes in the ecosystem and infrastructure, which needs huge investments that the country cannot afford currently.

5.7. Quantitative Research Findings

The survey participants were chosen from three different age groups, as different backgrounds would affect each person's view. The main target of the survey where users older than 35 years as these users have their own homes and are greatly affected by the electrical energy increasing cost. Moreover, their interest in the system would mean that they are not resistant to change and that they are willing to completely change their energy consumption behavior. The second main target where users from ages 21 to 35 as these participants are assumed to be fresh graduates or newlyweds who are buying new homes and their interest in the solution means that from the start, in the process of subscribing to an energy supplier they would take into consideration renewable energy sources. The percentage of each age group's participation in the survey is illustrated in Figure 9.

Based on the survey results, 47% of the participants believe that the electrical energy state is unstable, expensive and does not satisfy their needs. While 36% felt neutral and only 13% were satisfied with the service. This adds to the need of serious changes to the electrical state of energy in Egypt as that means that more than

Figure 12: Energy management solution code enabling the user to enter his budget

```
//  Allows user to enter his budget
            Scanner sc = new Scanner(System.in);
            System.out.println("Save your money and the environment, set a limit to your energy spending.");
            System.out.println("Enter Your Consumption Budget Please:" );
            double budget = sc.nextDouble();
            System.out.println("Budget accepted " + budget);
```

Figure 13: Total consumption data and supplier prices are read from the CSV file

```
//          saving smart meter data into a List

            String filePath = "/Users/zeinasaleh/Desktop/test.csv";

            List<Double> list = new ArrayList<Double>();

            BufferedReader br = new BufferedReader(new FileReader(filePath));
            String line = br.readLine();

            while (line != null) {

            String[] content = line.split(",");
            double usage = Double.parseDouble(content[2]);

            list.add(usage);
            line=br.readLine();
            }

            br.close();

//          Getting the supplier price

    String supplierFilePath = "/Users/zeinasaleh/Desktop/supplier.csv";

            List<Supplier> list2 = new ArrayList<Supplier>();

            BufferedReader br2 = new BufferedReader(new FileReader(supplierFilePath));
            String line2 = br2.readLine();

            while (line2 != null) {

            String[] content2 = line2.split(",");

            Supplier s = new Supplier (content2 [0], Double.parseDouble(content2[1]));
            list2.add(s);

            line2=br2.readLine();
```

Figure 14: Calculating the cost of usage

```
//          Calculating the cost of usage

    //          getting the minimum price

            double min= list2.get(0).price;
            String supplierName=list2.get(0).name;
            for (int i=0; i<list2.size(); i++){
                if (list2.get(i).price<min){
                    min=list2.get(i).price;
                    supplierName=list2.get(i).name;
                }
            }
```

80% is either unsatisfied or is neutral and doesn't feel that their money is being spent on a service that they feel is satisfactory. As for the cost of energy to consumers the 45.5% pay more than 500 LE and <1000 LE while 31% pay more than 1000 LE and <2000 LE. These costs are predicted to change as electricity costs in Egypt are expected to increase in the future especially during the summer. Moreover, regarding the participants attitude towards renewable energy sources 84% reported that they do not utilize energy saving almost 100% agreed that they would be willing to utilize renewable energy sources or at least open for the idea. The next aspect that the survey aimed to address is the customer's interest in their supplier's environmentally friendliness, 79% agreed that this aspect concerns them while 71.6% reported that if two suppliers offer the same price schemes they would prefer to subscribe with the supplier that has a better environmentally friendliness rating. As for the participants' willingness to subscribe in the information system mentioned in the business model, 78% said that they would be willing to subscribe to the system while the rest where neutral and only 5 participants reported that they would not subscribe in the system. This means that the system will receive great support from the users and that it fulfills requirements that consumers are highly in need of. Furthermore, 88% reported that they are interested in identifying each appliances energy usage meaning that this offering in the solution is of importance to the subscribers and has to be presented in a user-friendly manner, as it would be one of the most important services provided by the system. Lastly, the final rating question aimed to determine the level of interest of users in the system to the extent whether they would recommend it to other consumers or not. 69% reported that they would actively take a role in encouraging other consumers to decrease their energy consumption and utilize renewable energy sources. Figure 10 illustrates the participants energy spending and Figure 11 shows their willingness to become subscribers in the energy management solution developed.

The last question in the survey was indented to identify the participants' suggestions or comments on the current electrical energy state in Egypt so that their answers might provide useful insights to any future changes the proposed business model may need. Participant's suggestions and comments can be classified into three main points. The first point is that the participants believe that they are paying more than they should and that the published prices do not match their consumption cost. The proposed business model solves this issue as it relies on smart meters and on two-way communication between the supplier and consumer. This two-way communication will lead to transparency of costs and consumptions levels and the consumer will have better understanding of the cost of consumption which might encourage users to save energy to reduce costs. The second addressed issue is the need of the use of renewable energy sources, as participants believe that renewable energy sources should be relied on more in Egypt especially solar energy, as Egypt is usually very sunny. This is also addressed by the business model as renewable energy sources are introduced in homes and institutes whether solar energy or wind energy. The last addressed issue is the government's role. Participants believe that the government should invest more in utilizing renewable energy source, raise awareness and provide incentives to encourage users to decrease their energy consumption.

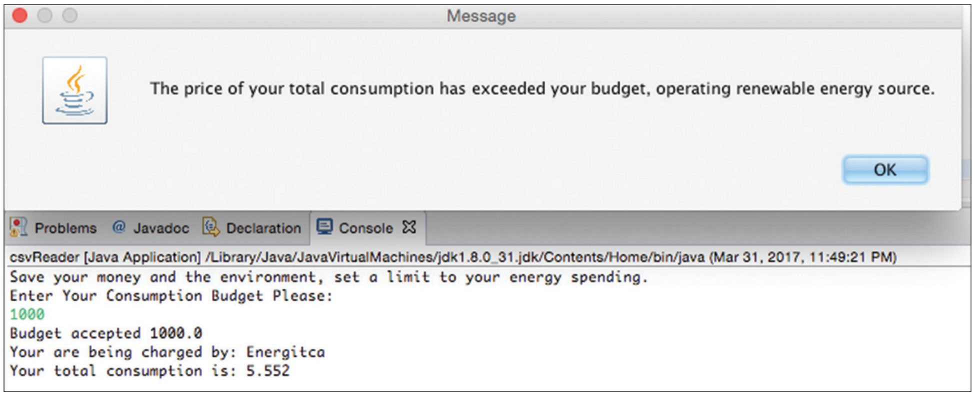
5.8. Function Prototyping

The business model proposes an energy management solution as explained above. As discussed this solution manages various types of data and the data mentioned above needs to be monitored and analyzed, as they will be used in deciding when to utilize the renewable energy source. Companies that will use this business model have two options in building the information system. The

Figure 15: The supplier with the minimum price is then selected and the cost of consumption is calculated

```
// calculating the cost of consumption to make sure that user did not exceed the budget

        double alertValue= budget-10;

        double totalConsumption=0;

        for (int i=0; i<list.size(); i++){
            totalConsumption= totalConsumption+list.get(i);
        }

        double priceOfConsmuption= totalConsumption*min;

        System.out.println("Your are being charged by: "+ supplierName );

        System.out.println("Your total consumption is: "+ totalConsumption);

        if (priceOfConsmuption >= alertValue){

            final JFrame parent = new JFrame();

            JOptionPane.showMessageDialog(null, "The price of your total consumption has exceeded your budget, operating renewable energy source.");

              } }
```

Figure 16: An alert message is displayed to the user when the consumption cost has exceeded the set budget



first is build their own system that will analyze the data using their in house developers or they can use data analysis tools already available and integrate their results in their solution. As some companies might prefer to build their own solutions, a sample code written in Java was written to analyze the data from CSV files that had information about the total energy consumption and suppliers' prices to alert the user when the budget set for energy consumption has been exceeded. This sample code is a demonstration of how the business model energy management solution can function. Figure 12 shows how the code receives the users input, which is the budget that he is willing to pay for energy consumption.

The code should be capable to read consumption data from CSV file as well as read the suppliers' saved information and prices. The code to provide this functionality is shown in Figure 13.

Moreover, the code should also calculate the cost of usage based on the consumption measured from the data saved as well as the lowest price of the supplier to alert the user when he has exceeded his specified budget as shown in Figures 14 and 15.

Finally, the user should see and alert when the total price of his consumption has exceeded the budget specified and it should show that the renewable energy source has to be utilized as shown in Figure 16 below.

6. RESULTS

This paper had three main objectives, which were the development of a conceptual business model, analyzing the Egyptian market in general and in regards to the business model using qualitative and quantitative research tools and prototyping of some basic functionalities offered by the business model. The objective of this paper was met and the outcomes are briefly discussed below.

6.1. Development of Conceptual Business Model

The conceptual business model was developed based on applications and information discussed in the literature review. The business model aims to decrease the consumers' energy consumption through utilizing renewable energy sources as well as notifying users with their energy consumption level. The business model's value flow and canvas were discussed as well the energy management solution's explanation. The business model makes use of IoT and smart city applications such as smart meters and applications identifying each appliance's energy consumption to provide users with information regarding their consumption in return for a subscription fee. The business model also allows users to enter a budget at which they are notified when their energy consumption reaches a certain limit and renewable energy sources re utilized and will allow suppliers to obtain information regarding the user's consumption.

6.2. Business Model Evaluation in Egyptian Market

6.2.1. Qualitative research results: Interview findings

This developed business model was then evaluated using interviews as the qualitative research tool. Three interviews were conducted to discuss the energy state in Egypt and to discuss the business model's strength and weaknesses. The interviews showed that the business model could be successful and that Egypt is need for changes in its energy supplying process. However, the consumers in the Egyptian market need to change their perception of energy management and how electricity is being dealt with as a commodity with low value even though its price is increasing and will continue to increase in the future.

6.2.2. Quantitative research results: Survey findings

Surveys were used as the quantitative research tool to obtain the customers' feedback. Surveys were distributed to 155 participants who mentioned that they would be willing to contribute in the business model. The survey aimed to assess the customer's feedback on each aspect of the business model. The consumers are eager for a solution that will aid in decreasing the amount of money spent on energy consumption and consumers will also be interested in identifying each appliance's energy consumption and would encourage others to decrease their energy consumption as well and subscribe in the energy management solution.

6.2.3. Basic functionality prototyping

Finally, some of the functions introduced by the business model were prototyped to ensure that the business model is realizable and can be applied in the future. Only some basic functionalities of the business model were demonstrated using Eclipse. Such as the reading supplier's prices, consumer's energy consumption from CSV files. This data is then measured to identify the supplier with the lowest pricing. The user's consumption is also measured and multiplied by the supplier's pricing and the total cost is compared to the budget initially entered by the user. If the total consumption is near the budget the user is notified and is alerted that the renewable energy source needs to be utilized.

To summarize, the research showed that the business model will encourage consumers to decrease their energy consumption as well as utilize renewable energy sources and the objectives mentioned in section 1 were met.

7. CONCLUSION AND FUTURE WORK

To conclude, this paper proposed a new business model to provide a new enhanced way to manage energy consumption. First, previous literature utilizing IoT and smart city applications was investigated as these applications are used as the building tools for this business model. Also, it is shown that these applications provide both supply and demand side benefits and that the advances in technology can bring great savings in energy consumption.

To answer this paper's research question, which is "How can a new proposed business model be developed to reduce energy consumption?" a new business model was introduced with its main activities, data needs and stakeholders. To evaluate the business model both interviews and surveys were conducted to provide the assessment from the expert's point of view and the customer's point of view as qualitative and quantitative research tools. This can contribute in reducing energy consumed by providing users with insights regarding their total and appliance lever energy consumption as well as new sources of energy generation. This business model can be applied in smart cities and in the new Cairo capital through the investments in infrastructure taking place in these cities.

This business model can be applied in any country and can be used in the new capital that is being built in Cairo as it relies on utilizing advanced technologies, it can be applied in any country as it represents a way of managing energy consumption and is not specific or especially tailored of a certain specific or certain condition. The business model introduces a new way to manage energy consumption and it relies on technologies that are available nowadays and suppliers of these requirements are available worldwide.

The important lessons learned are that there are several new ways to make better use of existing energy saving solutions and that integrating all these solutions will lead to huge savings in energy consumption. Moreover, that experts' point of view and consumers' point of view are essential as these experts will be the suppliers in the business model and the consumers will be the users and making sure that their requirements are meat is crucial for the success of the business model. Future research can focus on the exact investment required by the government to change the electrical infrastructure in Egypt to provide a more sustainable business model as well as how to handle the costs of maintaining the server and database and any security concerns that the customers may have. Another future research aspect can also how to effectively manage integration between various suppliers and how the suppliers' information systems can be integrated with the energy management solution so that they can send users messages through the solution for example. Moreover, future research can identify the best way to approach Egyptian consumers as a major challenge to the business model is the consumer's perception.

The main limitation was that data used in the business model was from online open sources as smart meters are not yet widely utilized in Egypt and Egyptian companies refused to provide one to use to provide a real time information as companies are now biding against each other to be the main supplier for the Egyptian government and they had concerns that their software might be stolen or compromised to their competitors. Based on the literature review in section 1 as well as the information form the interviewees, several challenges and barriers were identified. First, starting with the economic barrier. Saving money is the main concern that consumers want to address nowadays. Electricity prices and outages are increasing and this is adding to their economic burden. Users are concerned in seeing the result of their savings in a short period and will be less inclined to invest in a solution that only offers saving after a long period of time. The business model will address this challenge directly as users can set a budget for their spending and as a result they will see the change during the 1st month. Another economic barrier can also be the lack of funds, users or institutes may be reluctant to add any extra costs to their spending but as this business model relies on a subscription fee users will not be obliged to invest a huge sum of money at first. Furthermore, institutes can utilize green revolving funds as mentioned in the literature review to provide sources of investment in renewable energy sources. This business model also addresses the burden on the government due to subsidization as the government is no longer the supplier of the electricity but new suppliers will handle this process and the government will only act as a supervisor.

8. ACKNOLEDGEMENT

The authors extend their appreciation to the Arab Open University for Funding this work through AOU research fund No. (AOUKSA-524008)

REFERENCES

Abdulzahra, A.M.K., Al-Qurabat, A.K.M., Abdulzahra, S.A. (2023), Optimizing energy consumption in WSN-based IoT using unequal clustering and sleep scheduling methods. Internet of Things, 22, 100765.

Akorede, M.F., Hizam, H., Pouresmaeil, E. (2010), Distributed energy resources and benefits to the environment. Renewable and Sustainable Energy Reviews, 14(2), 724-734.

Almihat, M.G.M., Kahn, M.T.E., Aboalez, K., Almaktoof, A.M. (2022), Energy and sustainable development in smart cities: An overview. Smart Cities, 5(4), 1389-1408.

Angelidou, M. (2014), Smart city policies: A spatial approach. Cities, 41, S3-S11.

Atzori, L., Iera, A., Morabito, G. (2010), The internet of things: A survey. Computer Networks, 54(15), 2787-2805.

Bhusal, P., Tetri, E., Halonen, L. (2006), Quality and Efficiency of Office Lighting. In: Proceedings of the 4th European Conference on Energy Performance and Indoor Climate in Buildings and the 27th International AIVC Conference (EPIC 2006 AIVC). Lyon, France. p21-23. Available from: https://www.aivc.org/sites/default/files/members_area/medias/pdf/inive/epic2006/volume_2_epic06/e13/083_bhusal.pdf [Last Accessed on 2016 Apr 23].

Bocken, N.M.P., Short, S.W., Rana, P., Evans, S. (2014), A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner Production, 65, 42-56.

Bragard, M., Soltau, N., Thomas, S., De Doncker, R.W. (2010), The balance of renewable sources and user demands in grids: Power electronics for modular battery energy storage systems. IEEE Transactions on Power Electronics, 25(12), 3049-3056.

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J.R., Mellouli, S., Nahon, K., Scholl, H.J. (2012), Understanding Smart Cities: An Integrative Framework. 2012 45th Hawaii International Conference on System Sciences, (HICSS). IEEE. p2289-2297.

Cooper, D.R., Schindler, P.S. (2014), Business Research Methods. New York: The McGraw-Hill Companies, Inc.

Elsisi, M., Amer, M., Su, C.L. (2023), A comprehensive review of machine learning and IoT solutions for demand side energy management, conservation, and resilient operation. Energy, 281, 128256.

Goodier, I.C., Chmutina, K. (2014), Non-technical barriers for decentralized energy and energy efficient buildings. International Journal of Energy Sector Management, 8(4), 544-561.

Graham, P.W., Brinsmead, T., Hatfield-Dodds, S. (2015), Australian retail electricity prices: Can we avoid repeating the rising trend of the past? Energy Policy, 86, 456-469.

Haras, M., Skotnicki, T. (2018), Thermoelectricity for IoT-A review. Nano Energy, 54, 461-476.

Hu, Z. (2016), A Data Acquisition and Control System in Smart Home Based on the Internet of Things. International Journal of Simulation--Systems, Science & Technology, 17(7), 17.1-17.5.

Hui, C.X., Dan, G., Alamri, S., Toghraie, D. (2023), Greening smart cities: An investigation of the integration of urban natural resources and smart city technologies for promoting environmental sustainability. Sustainable Cities and Society, 99, 104985.

Indvik, J., Foley, R., Orlowski, M. (2013), Green Revolving Funds: An Introductory Guide to Implementation and Management. Sustainable Endowments Institute (NJI). Available from: https://files.eric.ed.gov/fulltext/ED539859.pdf [Last accessed on 2016 Apr 23].

Jin, J., Gubbi, J., Marusic, S., Palaniswami, M. (2014), An information framework for creating a smart city through Internet of things. IEEE Internet of Things Journal, 1(2), 112-121.

Karnouskos, S. (2011), Demand Side Management Via Prosumer Interactions in a Smart City Energy Marketplace. In: Innovative Smart Grid Technologies (ISGT Europe), 2011 2nd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies. IEEE. p1-7.

Kato, T., Tokuhara, A., Ushifusa, Y., Sakurai, A., Aramaki, K., Maruyama, F. (2016), Consumer responses to critical peak pricing: Impacts of maximum electricity-saving behavior. The Electricity Journal, 29(2), 12-19.

Khan, K., Shah, A., Khan, J. (2016), Electricity consumption patterns: Comparative evidence from Pakistan's public and private sectors. The Lahore Journal of Economics 21(1), 99-122.

Khatoun, R., Zeadally, S. (2016), Smart cities: Concepts, architectures, research opportunities. Communications of the ACM, 59(8), 46-57.

Kyriazis, D., Varvarigou, T., White, D., Rossi, A., Cooper, J. (2013), Sustainable Smart City IoT Applications: Heat and Electricity Management and Eco-conscious Cruise Control for Public Transportation. In: World of Wireless, Mobile and Multimedia Networks, 2013 IEEE 14th International Symposium and Workshops IEEE. p1-5.

Lazaroiu, G.C., Roscia, M. (2012), Definition methodology for the smart cities model. Energy, 47(1), 326-332.

Lee, K.H. (2015), Drivers and barriers to energy efficiency management for sustainable development. Sustainable Development, 23(1), 16-25.

Lunt, P., Ball, P., Levers, A. (2014), Barriers to industrial energy efficiency. International Journal of Energy Sector Management, 8(3), 380-394.

Madakam, S., Ramaswamy, R., Tripathi, S. (2015), Internet of Things (IoT): A literature review. Journal of Computer and Communications, 3(5), 164-173.

Maiorano, J., Savan, B. (2015), Barriers to energy efficiency and the uptake of green revolving funds in Canadian universities. International Journal of Sustainability in Higher Education, 16(2), 200-216.

McEwen, A., Cassimally, H. (2013), Designing the Internet of Things. United States: John Wiley & Sons.

Mizuta, Y. (2003), A case study on energy saving and new energy services in Japan. Management of Environmental Quality: An International Journal, 14(2), 214-220.

Morvaj, B., Lugaric, L., Krajcar, S. (2011), Demonstrating Smart Buildings and Smart Grid Features in A Smart Energy City. In: Proceedings of the 2011 3rd International Youth Conference on Energetics (IYCE). IEEE. p1-8.

Oprea, S.V., Lungu, I. (2015), Informatics Solutions for Smart Metering Systems Integration. Informatica Economica, 19(4), 28-42.

Perera, C., Zaslavsky, A., Christen, P., Georgakopoulos, D. (2014), Sensing as a service model for smart cities supported by internet of things. Transactions on Emerging Telecommunications Technologies, 25(1), 81-93.

Pérez-Lombard, L., Ortiz, J., Pout, C. (2008), A review on buildings energy consumption information. Energy and Buildings, 40(3), 394-398.

Qian, Q.K., Chan, E.H. (2010), Government measures needed to promote building energy efficiency (BEE) in China. Facilities, 28(11-12), 564-589.

Richter, M. (2012), Utilities' business models for renewable energy: A review. Renewable and Sustainable Energy Reviews, 16(5), 2483-2493.

Scherbaum, C.A., Popovich, P.M., Finlinson, S. (2008), Exploring individual-level factors related to employee energy-conservation behaviors at work[1]. Journal of Applied Social Psychology, 38(3), 818-835.

Shahbaz, M., Mahalik, M.K., Shah, S.H., Sato, J.R. (2016), Time-varying analysis of CO_2 emissions, energy consumption, and economic growth nexus: Statistical experience in next 11 countries. Energy Policy, 98, 33-48.

Throne-Holst, H., Strandbakken, P., Stø, E. (2008), Identification of households' barriers to energy saving solutions. Management of Environmental Quality: An International Journal, 19(1), 54-66.

Weiss, M., Helfenstein, A., Mattern, F., Staake, T. (2012), Leveraging smart meter data to recognize home appliances. In: Pervasive Computing and Communications (PerCom), 2012 IEEE International Conference on Pervasive Computing and Communications. IEEE. p190-197.

Zanella, A., Bui, N., Castellani, A., Vangelista, L., Zorzi, M. (2014), Internet of things for smart cities. IEEE Internet of Things Journal, 1(1), 22-32.