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A Case Study on Energy focused Smart City, London of the UK: Based on the Framework of 'Business Model Innovation'

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Abstract

We see an energy fucused smart city evolution of the UK along with the project of "Smart London Plan (SLP)." A theoretical logic of business model innovation has been discussed and a research framework of evolving energy focused smart city is formulated. The starting point is the silo system. In the second stage, the private investment in smart meters establishes a basement for next stages. As results, the UK's smart energy sector has evolved from smart meter installation through smart grid to new business models such as water-energy nexus and microgrid. Before smart meter installation of the government, the electricity system was centralized. However, after consumer engagement plan has been set to make them understand benefits that they can secure through smart meters, the customer behavior has been changed. The data analytics firm enables greater understanding of consumer behavior and it helps energy industry to be smart via controlling, securing and using that data to improve the energy system. In the third stage, distribution network operators (DNOs)' access to smart meter data has been allowed and the segmentation starts. In the fourth stage, with collaboration of Ofwat and Ofgem, it is possible to eliminate unnecessary duplication of works and reduce interest conflict between water and electricity. In the fifth stage, smart meter and grid has been integrated as an "adaptive" system and a transition from DNO to DSO is accomplished for the integrated operation. Microgrid is a prototype for an "adaptive" smart grid. Previous steps enable London to accomplish a platform leadership to support the increasing electrification of the heating and transport sector and smart home.

Keywords: *Energy data, Smart city, Smart energy, Business model innovation, Platform leadership*

1. Introduction

Cities are facing the challenge to utilize information & communications technology (hereafter ICT). In the digital transformation, cities lack frameworks to assess how the ICT options has been developed in smart city strategy. There is no "one size fits all" approach, because cities in different countries are complex and many stakeholders are involved due to high dependence on infrastructure. Due to global urbanization, many people live in a limited space, in cities where problems like lack of electricity and water, traffic congestion occur. For

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solving these problems, 'smart city' concept is emerging as an alternative. It is a city using ICT including Internet of things (IoT) for collecting data and using these to manage its resources smartly.

In the smart city, various innovations like artificial intelligence (AI), Big Data, IoT are taking place. Collaborating between existing industries like construction, telecommunications, utility, automotive, and security industries, is essential. If the government support and the capacity of private sectors are harmonized, smart city can be a growth engine of the countries. The smart city's goal is quality of life, a good city to live in, ecological sustainability and economic growth. Its capacity includes mobility, safety, energy, water & waste, building & living, health, education, finance, tourism & leisure, retail & logistics, manufacturing and government [1]. In order to cultivate smart city, it is necessary to develop ICT based platform involving enterprises and to develop business models. This paper has interest in energy focused smart city (hereafter 'smart energy city'). Since there is no generally used method to understand business models of smart energy city and its evolution model either, this paper firstly formulates a research framework for analyzing the use case of the evolving business models of representative smart city, London chosen by Korea Institute of Science & Technology Evaluation and Planning's document about "Smart city" in 2018 [2]. In this paper, two big cities considering energy in priority of smart city are London and New York. The former is urban project and the latter is a district of a borough of New York City, Brooklyn of lower Manhattan. This paper choses London.

2. Theoretical background

2.1. Previous literature review

Díaz-Díaz, et al. (2017) [3] develop evaluation method of city business model and introduce a method "Business Model Evaluation Tool for Smart Cities" in 2013, as Figure 1 shows [4]. It is a flexible system facilitating potential business models. They compare business use cases based on 'Business Model Canvas' and their evaluation methodology is assessed by surveyed professionals and validated applying it to use cases of Santander's waste management and street lighting systems taking advantage of innovative technologies.

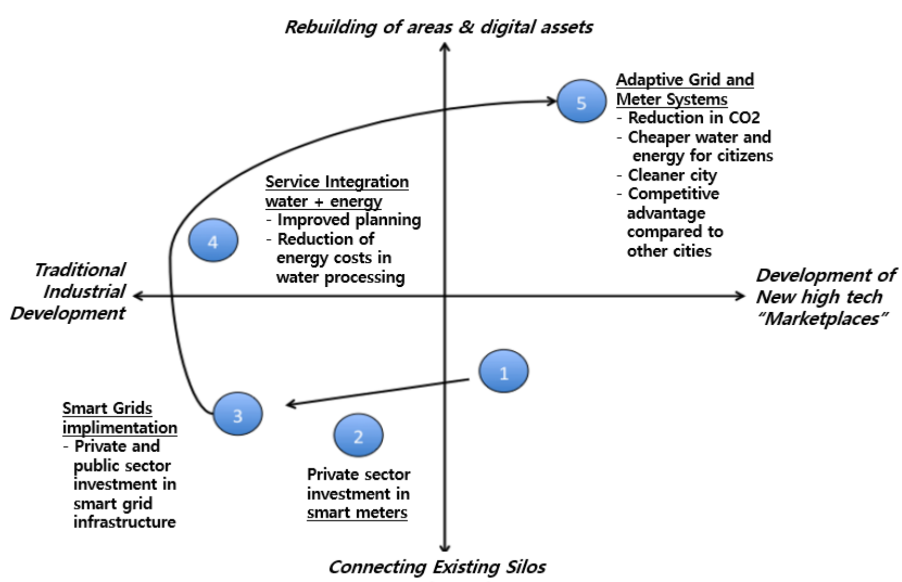

Figure 1. Evolving business models of smart utilities

2.2 Theory of Business Model Innovation

A business model innovation (hereafter BMI) by Henry Chesbrough can be applied to study energy focused smart city's business model [5]. Through the innovation, firms assess where their business model is and take further steps. In first "undifferentiated" stage, in static market, the firms don't think, they need to have a distinct business model. They compete only on price or regional availability. If they have no strategic mind, they are exposed to have 'commodity trap.' In second "differentiated" stage, firms try to have differentiated products or services and it leads to target customers. It allows them to serve less competed specific market. Then, the 'commodity trap' problem is solved. But they can be caught in the syndrome of 'one hit wonder', if they lack related resources and further investment. In third "segmented" stage, companies compete in different segments. More market segmentation means to avoid 'one hit wonder' in first market and to have more profit from the extended markets. The price-sensitive market segment can provide a critical mass and cost-effective production. However, they should plan for their future business via technology roadmaps. Otherwise, they are still in the risk of the 'one-hit wonder' syndrome. The problem is that they are not ready to move to new disruptive technology and innovative business activities, because the current market gives them profitability. However, the industry could have market saturation and the current technology could have limitation.

In fourth "externally aware" stage, companies open themselves to external technologies to move to next business development. It makes them to have a greater opportunity of resources. They provide needs for external technologies and business synergies. The relationships with partners for accomplishing these needs reduce the opportunity cost including R&D, operation cost, and the time it takes to get new service. They share operation risks of new products and services with partners. But this operation partnership can't be long. Thus, internal business roadmaps should be shared with their partners, which enables them to make more systematic use of disruptive technologies of partners and allows both to plan future activities in concert with the companies' innovative business activities. In fifth "integrated" stage, companies' business model plays a key integrative and adaptive role. It means, suppliers and customers can participate in their business process. Both share their technology, business and service roadmaps with companies playing a main role. It takes time for companies to understand the business ecosystem. They understand essential business resources by recognizing 'the customer's customer.' This is based on the two-sided market. They learn about deeper unmet needs of both sides of customer. They move from offering simple and segmented products to offering unmet services.

Last stage is an ideal one referring to the "platform leadership." It is a much more adaptive model than the fifth stage. This capability comes from a commitment to experiment more business model variants. The types of this experimentation are various. Companies can use corporate investment capital as means to explore new business models of start-ups. They can change their corporate governance by spin-offs and joint ventures. They can cultivate internal ventures as incubators for developing new business ideas that are not for commercialization yet. They can make key suppliers and customers be their business partners and have relationships for sharing technical and business risks as well. Suppliers' business models can be integrated into the business plan processes of the companies from scratch, vice versa. One important capability enabling this stage is a companies' capability to establish their technologies as the basis for the "platform leadership." Then, these can attract other companies in various areas to invest resources.

Chesbrough explores some barriers to complete this BMI process and insists, the successful leadership of organizational change should be followed. Even if the BMI is meaningful for business success, it is very difficult to achieve it. Therefore, organizational processes must change too. The firm should identify internal leadership for BMI for managing results of processes and delivering new business models. Moreover, the insight of operation managers should be subjected to data if local marketing goals are to be subordinated to those of the firm. Its corporate culture should also embrace new business models, while maintaining the effectiveness of the current one until the new one takes over. In this way, the BMI helps the firm escape the 'trap' of its earlier business models and renew business models [6].

3. Research design

3.1 Research question

As Figure 1 shows, evolving business models of smart utilities shows five steps and the starting point is the conventional silo system with less business model opportunities, usually in a monopolistic market of the utility industry. The BMI begins with the public investment to connect the existing silo system. This paper formulates the research framework is as the following Figure 2 shows

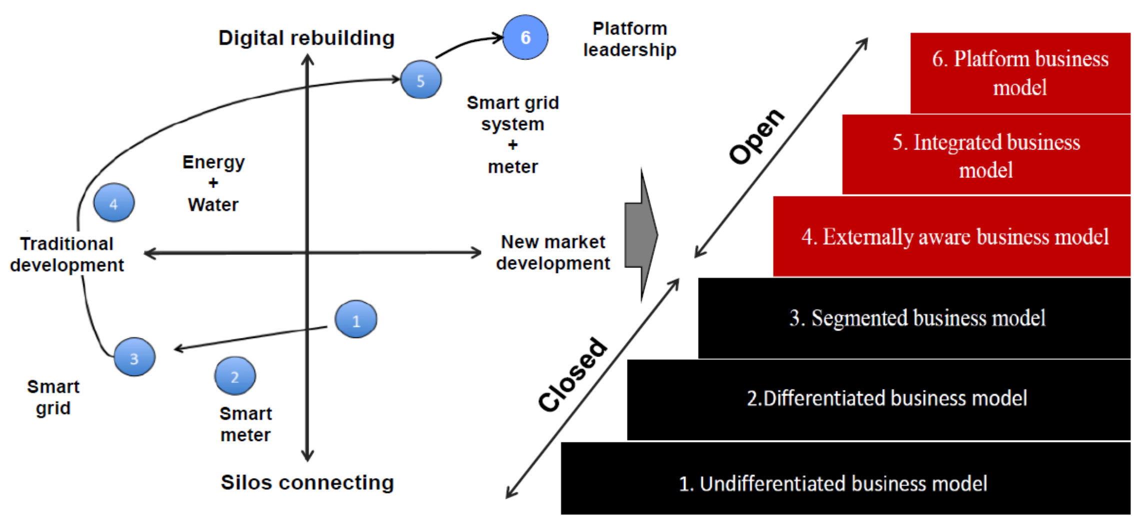

Figure 2. Research framework of Smart Energy City

The left side is reformulated from the evolving business models in smart utilities of Figure 1 and the right side is business model maturity stages of Chesbrough's BMI [7]. It is a research framework acknowledging that cities developing smart energy are not static, but a dynamic ecosystem. BMI from the 4th stage starts to be open to innovation until the smart energy cities gain platform leadership by developing marketplaces for energy services. The idea is understood as energy sector's BMI within the city's broader strategy for becoming a smart city. Each business model maturity stage is clear. This paper chooses the market status of 'Smart London Plan (SLP)' as the starting point which is expected as silo system. The second stage is expected to facilitate private sectors' investment in smart meters driven by government. The third stage is smart grids implementation for segmenting the market. From the fourth stage, the energy market is open its business models to water sector for the efficiency. The fifth stage is a service integration between grid network and related appliances, that is an adaptive microgrid system. The last is platform leadership of the government. To show how the smart energy city, London of the UK evolves, it generates six research questions as follows:

1) How is the market & policy status of the UK in the starting point of smart energy city?
2) How is the device investment of the smart meter as a "differentiated" business model?

3) How is the smart grid implemented as a "segmented" business model?
4) How is the smart energy and water nexus as an "externally aware" business model?
5) How is the adaptive smart grid & meter system as an "integrated" business model?
6) How is the government activity of the UK as a "platform leadership" business model?

3.2 Methodology

'Smart London Plan (SLP)' began in 2013 for solving rapidly growing population, social, health and educational problems. It uses the word of "smart city" for integrating systems like local government, education, medical, transportation and energy by utilizing the ICT. Especially, London is interested in how decentralized energy can form smart energy city for providing more sustainable and resilient supply. Thus, this city conducted technology and market analysis to use ICT and energy services [8]. Starting documents for analysis are from 'SLP' activities like 2016 Manifesto pledging to commit London to be a zero-carbon city by 2050 and Great London Authority (GLA)'s 'London Energy Plan (LEP)' scenarios to 2050, possible related research papers are searched in the web [9]. Status reports and plans of energy organization and universities dealing with business activities of energy sector are also studied. Besides, the websites of Mayor of London, GLA and Great Britain (GB)'s Department of Energy & Climate Change (DECC) and related government documents and academic papers have been searched from the year of 2013, the starting point of 'SLP' until 2019 [10].

4. Results

4.1 Status of the UK's energy in the "undifferentiated " stage

The UK's 'National Technology Power Committee (NTPC)' launched smart city project in 2007 and London announced 'SLP' including energy plan in 2013. With it, London is first city in the whole world to propose 'low carbon society' and set up it with goals to reduce greenhouse gas emissions. It is the starting point for BMI of smart energy city. In 2013, the UK has a silo of energy organizations. There are five components in UK electrical network: Generation operators (GO), transmission system operator (TSO) like National Grid (NG), distribution network operators (DNOs) like UK Power Networks (UKPN), electricity suppliers, and consumers. There are a few independent network operators (NOs) owning and operating private electricity networks, some of which link to embedded GOs running small scale generation plants connected to UKPN like combined heat & power (CHP) plants, solar photovoltaic (PV) [11].

In 2013, the decentralized energy generation didn't contribute to meet the energy demand. Major generators have been located outside of London. The UK's Power is provided from large-scale generation sources such as fossil fuels, nuclear and renewables and it is transported to the demand center through TSOs. NG is licensed by Office of Gas and Electricity Markets (Ofgem) operating high voltage electricity transmission network. Distribution is operation and maintenance of assets allowing electricity to be transferred from the Transmission Bulk Supply Points (TBSPs) via the DNO to consumers. Transformers are used to reduce the voltage, until it is delivered to domestic consumers at 230V and industrial sites are connected to the distribution system at higher voltages. Suppliers sell electricity to end users and they are the first contact points if supplying to domestic, commercial and smaller industrial premises. Users have contracts with them to pay for the electricity. Since the early 1990s, the UK's electricity and natural gas industry has been commoditized for wholesale transactions and delivery. They are traded in large volume with prices driven by traders' perceptions of the balance between supply and demand, based on data analysis, weather forecasts, international events like natural disasters and politics [12].

Electricity market of the UK is one of the most liberalized in the world with a well-established regulation. The retail market operates between suppliers and consumers including domestic, commercial and industrial consumers. Large industrial plants participate in the wholesale market operating between generators and suppliers requiring them to contract directly. 95 % of electricity is traded in wholesale. Suppliers try to satisfy daily and seasonal differences in demand by contracting with generators and some of them sign more than a year in advance. Big amount is carried out within last 48 hours before the supply, for they refine their forecasts for demand with the data of latest weather conditions and other data. The issue is that the system is still centralized. NG has the responsibility for balancing generation and supply across the UK electricity and controls all operations on the transmission network from a ‘Central Control Center (CCC)’ located in Wokingham. Supply can be increased by increasing the output from generation stations or by bringing new reserve generation online. According to Decentralized energy (DE) plan of Greater London Authority (GLA), known as City Hall, 25% DE should be the integrated system utilizing local and renewable energy resources by 2025 and district heating networks and renewable energy supply should account for half of London’s DE. 15% of London’s energy demand should be supplied from local and renewable energy by 2030 [13].

4.2 Smart meter investment in the "differentiated" stage

Energy sector needs private sectors’ investment of smart meter. In 2013, the network control interface between NG and DNOs is located at the ‘Grid Supply Points (GSP)’ and UKPN has operational areas of London, Eastern and South Eastern, which are controlled from a ‘Control Room’ located in Ipswich. They have a back-up facility. Network loadings, status alarms and all switching operations on the electricity network are sanctioned and controlled from ‘CCC’. There are initiatives of SLP to reduce London’s 80% carbon (CO_2) emissions in 2050 drive energy efficiency and security and encourage uptake of renewable energy and DE. Those are opportunities to develop “differentiated” energy services and drive innovation projects to help develop a deeper understanding of the dynamics of the electricity network and to identify technological solutions allowing TSO and DNOs to operate the electricity network in a safe and reliable manner. Each of the licensed bodies, NG and UKPN, produce comprehensive planning statements setting out their capital programs to meet the changing demands on the electricity network and to identify the additional infrastructure required to cater for commercial development. The plans are regularly reviewed to take account of changing government policy, specific development applications and advances in technology [14].

There are some lifestyle changes including growth in air conditioning & cooling load increasing summer electricity demand, increase in big buildings producing high point loads coupled to a requirement for supply duplication to provide resilience in case of network faults, with increased evening activity and seven day trading arrangements. UKPN tries to increase levels of distributed generation and it leads to difficulty in managing fault levels on the distribution network. In addition, there is greater demand for electricity with electric vehicles (EVs) and greater use of electricity for heating as the grid decarbonizes. For demand side response, smart meters record electricity consumption every half-hour and allow interactivity. The data can be used to set smart tariffs and manage other needs of demand side. Home consumers can set up home appliances like thermostats, lights and washing machines responding automatically to price signals from smart meters. Then, they use home energy more efficiently and cheaper.

Consumer engagement plan has been set to make them understand benefits that they can secure through smart meters. In the short-term, they can see their consumption of gas and electricity in real-time. Bills are based on actual consumption and they don't need to check meters to secure an accurate bill. They can only choose to share their consumption data with third parties. In the long-term, they can benefit from availability of dynamic 'Time-of-Use' tariffs supporting smart home appliances that automatically seek out the best value times to use their energy. These show that there are a significant number of installations in the foundation stage of roll-out before Autumn 2015. From that until the end of the program in 2020, it is intended that millions of householders accept an installation of smart meter in their homes [15]. Through this rollout coordinated by the DECC (53 million meters, ca. 26 million homes costing about £11 billion), a net benefit to the UK is expected to be £6.7bn. During the foundation period, main energy suppliers can lead the rollout, coordinated by government with industry support and a data analytics firm, 'Data and Communications Company (DCC)' has been created to enable greater understanding of energy networks and consumer behavior. It helps energy industry to be smart via controlling, securing and using that data to improve the energy system.

4.3 Smart grid implementation in the "segmentation" stage

Smart grid refers to an automated system of repair and power outage management, a 'self-healing power grid'. There has been a steady development of the UK's smart grid since the early 2000s. It tried to capture feasible benefits of ICT. By setting regulatory and commercial frameworks for supporting demand side management, DNOs' access to smart meter data has been allowed, while safeguarding consumer privacy. With this, the segmentation starts from smart grid which have automated distribution & communication systems and distributed energy resources (DERs) as well. The functions of smart grid optimize asset utilization and minimize maintenance expenses. It needs interactive communication involving consumers' own decision on how to use their energy. With the application of energy management and interactive communication, consumption load has been reshaped. The energy generation shifts to real-time demand need base and consumers are co-providers in balancing supply and demand [16]. According to Smart Grid Forum (SGF), smart electricity's goals are carbon reduction and renewable energy development. DEEP procures technical, commercial and legal advisory services to help beneficiaries bring DE schemes into operation. Community and local governments develop local sources of renewable energy to reduce energy costs. DNOs functions as local system operators and they offer balancing services [17]. Thanks to the support, the UK's electricity capacity from renewables has increased dramatically from 9 GW in 2010 to 25 GW in 2015 with solar PV [18].

In the smart grid, DNOs can invest in small scale of wind generation, community driven microgrid, and other initiatives to decarbonize. They can manage the interactive communication flows of electricity. The licensed DNOs can operate networks, collect data from customers and improve the service quality. The price monitoring, 'Electricity Distribution Price Control Review (DPCR)' has been conducted by Ofgem every 5 years. To encourage DNOs' low-carbon efforts, 'Low Carbon Network Fund' (LCNF) has been established and it supported £500m over five years price control until 2015 as single largest pot of money, integrated trials working with third parties. DNOs can recover a proportion of their expenditure (£16 million per year). There is an annual competition event for allocating £64 million to some flagship smart grid projects. Every year, around five have been awarded by Ofgem. For more precise price monitoring starting from April 2015, 'Electricity Network Innovation Competition (ENIC)' and 'Network Innovation Allowance (NIA)' have been created. 'ENIC,' annual competition for electricity and gas, started from 2013. Electricity network companies compete for fund raising to research, develop new ICT, and commercial arrangements. The fund belongs to the best projects helping electricity network operators to understand what they need to do to provide environmental benefits and security of supply as the UK moves to a low carbon economy. With funding events, smart grid could be supported by new equipment and services. Full monitoring is possible by this new network equipment. It means, smart grid can be self-healing and resilient. For this, the use of power electronics has been investigated and the energy storage has been explored to determine how and where it brings value to the operation and to determine technology neutral specification targets for developing the grid storage [18].

Smart grid opportunities in the UK are possible by initiatives and smart meter rollout and some projects focusing on DN including real-time data flows and interactive communication between suppliers and consumers. Roll out of smart meter provides opportunities for smart grid implementation in network planning and operations and for customer engagement through the DR. Smart meters can provide suppliers and networks with huge usage data, consumer behavior, network operations and distribution weak points. With this, electricity network can intelligently integrate the actions of users connected to it.

4.4 Energy and water nexus in the "external aware" stage

Energy and water nexus mean their close links and the ways where changes in one sector have an impact on another sector. In smart city plan, strategies are needed in order to facilitate redevelopment of existing environments. Energy supply accounts for some amount of freshwater withdrawals per year. An efficient way is collaborating among related infrastructures like energy, water, and food for resource management [19]. Issues like climate change, sustainability, population growth and security of supply need an appropriate policy. Water is an important resource in energy generation sources like nuclear. The required energy must be measured for operating water distribution facilities. It means, the output of one is the input of the other [20]. In 2010, UK energy use in water sector increased by 10% over the last 8 years [21]. The energy sector's water demand has also increased and accounted for 32% of total freshwater abstraction. In England and Wales from 2000 to 2012, 76% of water abstraction was used for electricity supply [22]. It is expected that UK can save the amount of water used in energy generation if its ambitious renewable energy plan is realized.

An organization needs to be established in order to oversee implementation of water-energy integration. In the UK, this unit can be activated by water regulator, Ofwat and energy regulators, Ofgem to identify planning of water and energy resource. An approach to assess infrastructure can eliminate unnecessary duplication of works and reduce interest conflict. It has been verified in Brazil and in the US [23]. In London, water supply derives from the River Thames. As London's population increases, water supply needs to be expanded. Thus, London set a plan to reduce energy-related gas emissions by 60% from 1990 to 2025 [24]. In 2010, London accounts for half of the non-transport energy use, and two third of London's natural gas use [25]. 20% of this final energy serves water-related purposes [26]. So, energy water nexus is more of importance for the both of energy and water savings. As Figure 3 [27, 28] shows, linkages between the water and energy systems for London has been estimated in 2010. The left side shows the volume of water related to energy use and the right side shows the estimated energy related to water use. Water supply expansion and stricter regulations require more strict treatment of wastewater to higher standards. From the perspective of the linkages with the energy system, the end-use of water should be focused. As results, government level energy strategies should assess water and climatic futures as part of the energy strategy. For this, an organization should monitor and evaluate strategies in all two sectors for environmental impacts.

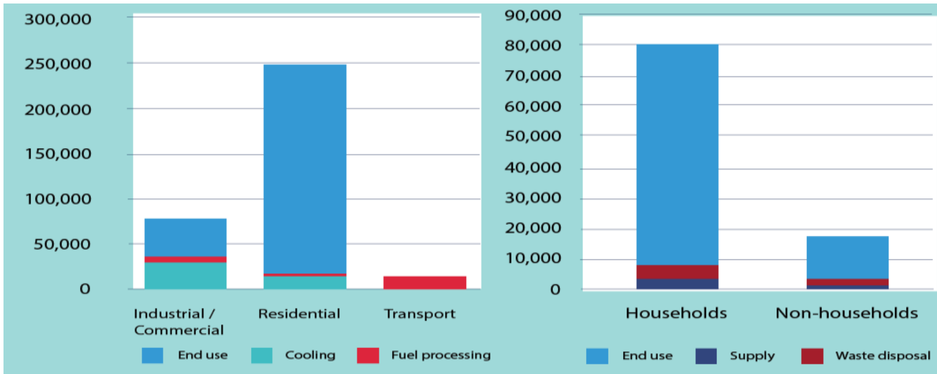

Figure 3. Water-energy nexus in London (2010)
Volume of water related to energy use (L) Estimated energy related to water use (R)

4.5 Adaptive smart grid and meter system in the "integrated" stage

In energy sector, smart meter and smart grid can be integrated as an "adaptive" smart grid system and a transition from DNO to DSO is needed for the integrated operation. In consumer side, advanced metering infrastructure (AMI), renewable energy, Plug-In Hybrid Electric Vehicles (PH EV) & EV and storage are adaptive areas. Microgrid is a prototype for an "adaptive" smart grid because of its flexibility. Microgrid can include renewable resources, distributed storage and demand response programs in distribution. It can be connected to a network working for the reliable services. Then, it can monitor and heal itself [17]. After implementing smart grid including network through LCNF and work under DECC and Ofgem-chaired SGF, smart meters and grids can be automatically managed to reduce power outages. If a sensor is recognized abnormal in power grid, it can be isolated before affecting one grid to impact other grids. Smart meter suppliers can provide 'Time-of-Use' tariffs to reward users shifting their demand. Distributed generators (DGs) can manage the demand. Consumers can balance supply and demand. DNOs can transform themselves to be distribution system operators (DSOs) supporting optimization and asset management.

Traditionally, over-capacity has been built to allow networks to be shut down for accommodating routine maintenance, new connections, reinforcement, and equipment failures without any power loss. Now, this can be integrated with the improved operation of networks, the use of real-time asset capabilities, and the real time control of demand, generation, and storage. Moreover, a wider operation of the distribution system can be performed by installing sensors, power switches, and communication devices. The UK's National Infrastructure Commission (NIC) tries to remove some regulatory barriers to DSR for delivering clearer price signals to allow flexibility from consumers in 2016. An adaptive smart grid system integrating storage, demand side response (DSR), networks, and interconnection can reduce the needs for a redundant increase in reserve generation capacity. DSR exists in industrial & commercial sectors and residential 'Time of Use' tariff has started since 2015. UK Power Networks, EDF Energy and partners have led this tariff and its aim is to investigate the value of residential DR to supplier for contributing to system balancing and to DNO for managing local network constraints. Around one thousand households have received variable price signals in response to different events at different times. Households could reduce their demand in response to network constraint events by ca. 10%. For those responding to price signals and consuming electricity at different times by changes with smart appliances, the potential for savings is expected to increase more and more [29].

4.6 Government's "platform leadership" for energy ecosystem

Thanks to strong leadership by Mayor of London, 'SLP' is an integrated smart city strategy including smart energy city, zero carbon city, zero waste city, WHO (World Health Organization) PM2.5 targets for air quality, green cover to 50%, plans for fuel poverty and solar, funding to catalyze action, and energy efficiency services. Previous steps for a smart energy system enable London city to accomplish a platform leadership to support the increasing electrification of the heating and transport sector and smart home. These steps can contribute to the whole evolution of smart energy cities in the UK as well. The goal of zero carbon city initiates Londoners to save their energy use by improving the efficiency of homes and buildings. Due to the rolling out of smart meters, 30% of London's CO2 emissions are attributable to consumption of heat as of 2018.

Another goal of 'SLP' is cutting fuel poverty by energy efficiency targeting to low income homes. An example is Islington's Seasonal Health Intervention Network (SHINE)'s fuel poverty network from 2016 providing a single point linking up 100 organizations facing other problems like health or finances. If some households need support on keeping their home at a safe temperature, SHINE offers an affordable service. Energy bill discounts are secured for most clients and half of them receive visiting service of 'Energy Doctor in Home'. Some benefit from a package of 'Warmth on Prescription' having heating and insulation measures installed at home. Supports include home maintenance, fire safety, medication reviews, befriending services, health problems and so on [30].

Within the 'SLP', London city also helps homes and businesses connect to communal heat networks using local energy sources. London Heat Map website has been available since 2011, which uses interactive global information system (GIS) and provides spatial intelligence on factors relevant to DE development like heat loads & supply, heat networks, DE clusters, and so on. Thanks to the 'SLP', clean energy generation in London increases by giving grants to community groups, pilot projects promoting lower cost solar panels, and by putting solar panels on buildings. London supports some programs to replace old polluting commercial boilers with new cleaner ones and has trials of low carbon technologies like heat pumps, batteries and so on.

For Londoners' communication, London city opens 'Talk London' website to facilitate citizen participation in 'SLP', providing citizens with the opportunity to participate in decision-making processes online. To install the online platform, the city is also operating 'London Datastore', a platform for opening public data in conjunction with the 'SLP' policy, providing an overview of London's economic, social and environmental statistics as well. 'London Dashboard' website has been also opened to provide a variety of information to citizens. One example initiative, 'Smart London Innovation Network' has been started in 2014, with more than 100 'Opportunity Locations' in the London Olympic Park.

London city proves its true leadership to co-ordinate start-ups in DSR services and storage, to give opportunities of smart energy to London businesses and citizens, even though London is seen as difficult and expensive city to engage with. UKPN is interested in potential of smart energy and is 'in transition' from passive asset owner to proactive system operator. But the nature, scale and speed of transition is still dependent on the government policy and regulatory interventions to structure markets and incentives. In 2017, smart meter roll-out has still lacked focus on how to make it work well in London. At that time, programs had many problems which need resolving, but real role of the GLA and Mayor of London has been accepted by stakeholders as honest marketplace enabler. Without the platform leadership, energy system will be less smart than it could be, limiting future opportunities for zero carbon energy. Without the leadership, activity will cherry-pick best opportunities and largely fail to distribute financial benefits widely or gain social benefits on offer from smart energy [31].

5. Conclusion

Smart energy evolution of the UK has been accomplished along with government projects and smart city plans. Based on the BMI of Chesbrough, we analyze the case of the UK's London city based on the research questions by formulating the research framework of evolving smart energy city. We set the 'SLP' starting year of 2013 as the first stage of BMI. After the second stage, the government & private investment in smart meters installation, the third is smart grids implementation and the fourth stage is energy and water nexus. The fifth stage is an adaptive smart grid system, microgrid. Lastly, building marketplaces is initiated with the London City. Whole evolving activities of smart energy has been contributed by a wide range of the Mayor's significant strategic objectives and policy goals for London, zero carbon by 2050, leading global city by being open and competitive market, better air quality with renewable energy with EVs, tackling fuel poverty DE in new build, lower energy bills for Londoners, reinvigorated communities & better social interaction, and so on. Some of these require effective application of smart energy techniques and others can be enhanced by creating new opportunities for action and potentially reducing costs by analyzing big data. In conclusion, government leadership takes an important role for coordinating with policy, planning decisions, resource of budget, engagement into the private sector experience, and political commitment.

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