A Case Study on Smart Energy City of the UK: Based on Business Model Innovation

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Abstract.

The purpose of this paper is to see a smart energy evolution of the UK along with government projects and smart city project like “Smart London Plan (SLP)” in 2013 with the logic of business model innovation (BMI). For this, it discusses the theoretical logic and formulates a research framework of evolving smart energy from silo to integrated system. The starting point is the silo system with no connection and in second stage, the private investment in smart meters, smart grids implementation, energy and water nexus, adaptive smart grid systems, and building marketplaces with platform leadership. As results, the UK’s smart energy sector has evolved smart meter device installation through smart grid to new business models such as water-energy nexus and microgrid service within on the smart energy city system.

Keywords: Smart city, smart energy, business model, business model innovation
1 Introduction

Cities are facing the challenge of managing city growth by utilizing Information & communications technology (ICT). Cases have many challenges in digital transformation of cities, because ICT is evolving. Cities lack frameworks to assess how the ICT options has been developed in smart city strategy. There is no “one size fits all” approach [1], because cities in different countries are complex and many stakeholders are involved due to high dependence on physical infrastructure. Especially due to global urbanization, many people live in a limited space, in cities where activities take place, problems like lack of electricity and water, aging, traffic congestion occur. For solving these problems, ‘smart city’ concept is emerging as a new alternative. It is a city using ICT including Internet of things (IoT) sensors for collecting data and using these to manage its resources smartly.

In the smart city, various innovations like artificial intelligence (AI), Big Data, IoT, etc. are taking place. In addition to ICT convergence, collaboration between existing industries such as 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 final goal is quality of life, a good city to live in, ecological sustainability and economic growth and its capacity includes smart mobility, safety, energy, water & waste, building & living, health, education, finance, tourism & leisure, retail & logistics, manufacturing and government. In order to cultivate smart city ecosystem, it is necessary to develop ICT based platform involving large enterprises and SMEs. It is necessary to develop cooperative business models that SMEs participate and to evolve the previous business models that implements the sustainable ecosystem.

This paper focuses on ‘smart energy city’ and applies logic of the BMI. Unlike companies’ business model aiming at articulating how the company creates and captures customer value, smart energy city’s evolving business model is meant to guide a city administration in articulating how it can accomplish the goals of its smart city strategy. 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 report, two cities considering smart energy in priority are London and New York and the former is urban project and the latter is a district of a borough of New York City, Brooklyn of lower Manhattan. Therefore, this paper choses the UK as the use case.

2 Theoretical background

2.1 Previous literature review

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1.2 Theory of Business Model Innovation [5]

A business model innovation (BMI) by Henry Chesbrough is useful to apply it to a case study of energy smart city’s business model. It is a reasonable logic for reasoning that evolving business models from the primitive to the enhanced. Through following the innovation process, firms assess where their business model is in terms of its potential and take further business model steps. According to this BMI logic, first “undifferentiated” stage from other companies in single market. In static market environment, they don’t think, they need to have a distinct business model. Then, they compete usually on price or regional availability and serve customers on those criteria. That means, those products or services are commodities. If they have no other strategic mind, they are exposed to have a kind of “commodity trap.” Thus, they should move to next stage.

In second “differentiated” stage, companies try to have differentiated products or services and it leads to target customers. Then, it allows them to serve less competed specific market segment. The “commodity trap” problem is solved, but they could be caught in the syndrome of “one hit wonder”, if they lack related resources and further investment. Thus, after they have first “one hit wonders” where they have a successful first product, they should follow up this success with additional, similar successful products.

In third “segmented” stage, companies compete in different segments simultaneously. More market segmentation means firstly to avoid “one hit wonder” in first market segment and to have
more profit from the extended segmented markets. The price-sensitive market segment can provide a critical mass and cost-effective production. For a while, companies’ business is more profitable.

However, they should plan for their future business via technology roadmaps. Otherwise, they are still in the risk of the “one-hit wonders” syndrome. The problem is that they are not ready to move to new disruptive technology and innovative business activities, because the current vertically integrated 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 and synergies. They provide a list of 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. However, this operation partnership can’t be long. Thus, in some level, 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 mail role in this stage. It takes time for companies to understand the business ecosystem, not supply chain. The companies should understand essential business resources by recognizing “the customer’s customer.” This is based on the two-sided market. Then, the companies start to learn about deeper unmet needs of both sides of customer in the two-sided market. Companies move from offering simple and segmented products to offering unmet services.

Last sixth 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 startups. They can change their corporate governance by spin-offs and joint ventures. They can cultivate internal ventures as incubators to 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, vise versa. One important capability enabling this stage is a companies’ capability to establish their technologies as the basis for a 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 questions

The evolving business models of smart utilities [1, 3] shows five steps in smart utility sector and the starting point is the existing silo system with less business model opportunities, usually in a monopolistic market. 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.

Fig. 2. Research framework of Smart Energy City [3]

The left side is reformulated from the evolving business models in smart utilities introduced in previous paper [3] and the right is the business model maturity stages of Chesbrough’s BMI [7]. This is a research framework acknowledging that cities developing smart energy are not static, but a dynamic ecosystem whose key players are in constant flux. In this, BMI from 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 as of the ‘Smart London Plan (SLP)’ as the starting point which is expected as silo system with no connection. 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 means an adaptive microgrid system. The last is platform leadership of the government.

To show how the smart energy city evolves, this paper generates six research questions as follows:

Question 1) How is the market & policy status of the UK in the starting point of smart energy city?
Question 2) How is the device investment of the smart meter as a “differentiated” business model?
Question 3) How is the smart grid implemented as a “segmented” business model?
Question 4) How is the smart energy and water nexus as an “externally aware” business model?
Question 5) How is the adaptive smart grid & meter system as an “integrated” business model?
Question 6) How is the government activity of the UK as a “platform leadership” business model?

3.2 Methodology

London city’s ‘SLP’ has begun in 2013, in order to solve the rapidly growing population and the social, health and educational problems. It uses the word of “smart city” to integrate different systems like local government, education, medical, transportation and energy through ICT. Especially, London city is interested in how decentralized energy can form smart energy 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 and related research papers are searched [9]. After this, status reports and plans of energy organization and universities dealing with business activities of energy sector in the UK are studied. Besides, the main 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 2013, the starting point of ‘Smart London Plan’ until now [10].

4 Results and discussion

4.1 Status of the UK’s energy in 2013 [11, 12]

In the first stage, companies don’t have a differentiated business model. Thus, they rely on the simple product selling and compete usually on price and geographical availability. They sell commodities in ways that are no different from other companies.

The UK’s ‘National Technology Power Committee (NTPC)’ launched smart city project in 2007 and London city announced ‘SLP’ including energy plan in 2013. With this, London is the first city in the world to propose ‘low carbon society’ and set up this with goals to reduce greenhouse gas emissions. This is the starting point for BMI of energy sector. As of 2013, the UK has a silo of energy organizations including utility and there were more ‘talking’ than ‘doing.’ It means a huge gap between practice and aspirations and energy is dealt as ‘means’ for smart city, not ‘ends’ to achieve smart city.

In order to understand how energy system might evolve, it is important to have a basic understanding of current system. There are five components in the 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 small number of 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).

As of 2013, decentralized energy generation didn’t contribute to meet the energy demand and major generators have been located outside of London. Th UK’s Power is provided from largescale generation sources including fossil fuels, nuclear and renewables. It is transported to the demand centers through TSOs. NG is licensed by Ofgem operating high voltage electricity transmission network.

Distribution is the 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. Industrial sites are connected to the distribution system at higher voltages. Suppliers sell electricity to end users. Thus, they are the first contact points if supplying to domestic, commercial and smaller industrial premises. Users have contracts with those suppliers to pay for the electricity they consume.

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 of economics, weather forecasts, international events like natural disasters and politics.

Electricity market of the UK is one of the most liberalized in the world with a well-established regulation with two markets. Firstly, the retail market operates between suppliers and consumers who include 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, rest in indirectly to supply and demand match. Suppliers try to satisfy daily and seasonal differences in demand by contracting with generators. 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.

However, the issue is, the system is centralized. NG has the full 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 existing generation stations or by bringing new reserve generation online.

According to Decentralized energy (DE) plan of the GLA, 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. Furthermore, 15% of London’s energy demand should be supplied from local and renewable energy by 2030. DE includes solar PV installations and heat networks utilizing firstly heat pumps with secondary heat sources. For the implementation, London supports boroughs and private sectors through ‘DE Enabling Project (DEEP)’ providing technical, commercial, financial and other supports. From 2011 to 2015, 18 projects, 16 boroughs, and 5 private sectors have been supported by Mayor of London and the budget was £3.5m with contracts to deliver 17,400 tons of CO₂ reduction and 3MW of renewable energy generation capacity by 2019. For it, the GLA has established ‘DE consultancy framework’ as the table 1 [13].
Table 1. GLA’s DE Consultancy Framework [13]

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4.2 Smart meter investment [11, 14]

In second “differentiated” stage, the company can try different business models allowing it to target its customers. Smart energy sector needs private sectors’ investment of smart meter and offers a greater opportunity for DNOs to balance supply and demand. 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 to cover for any catastrophic failure in Ipswich. 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 (CO2)
emissions in 2050 drive energy efficiency and security and encourage uptake of renewable energy and DE.

Those challenges 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 [12].

In terms of the DN, there are 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, lifestyle changes 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. There is also 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 in time period, every half-hour and allow interactivity. These data can be used to set smart tariffs and manage other needs of demand side at home. 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.

As results, consumer engagement plan has been set to make them understand benefits that they can secure through smart meters as follows: 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 energy. These show that there are a significant number of installations in the foundation stage of roll-out before Autumn 2015, as figure 3 shows. 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].

Fig 3. Plan of smart meter installation until 2020 [15]

As result, through this rollout from 2015 to 2020 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 called ‘Data and Communications Company (DCC)’ has been created to enable greater understanding of energy networks and consumer behavior. It will help a traditional energy industry to be smart via controlling, securing and using that data to improve the energy system.

4.3 Smart grid implementation [16, 17]
In the “segmentation” stage, price-sensitive segment provides the volume base and the company’s business model is more profitable. Smart grid is the case. It refers to an automated system of repair
and power outage management, a ‘self-healing power grid’. There have been a steady development of a smart grid since the early 2000s. UK’s smart grid tried to capture feasible benefits of ICTs. Thus, by setting the regulatory and commercial frameworks for supporting demand side management, DNOs’ access to smart meter data has been allowed, while safeguarding consumer privacy. With this allowance, the segmentation starts from smart grid which have automated distribution & communication systems and distributed energy resources (DERs) as well. The functions optimize asset utilization and minimize maintenance expenses. Smart grid needs interactive communication involving consumers’ own decision on how to use their energy. With the application of energy management and interactive communication, consumption load can be reshaped. The energy generation shifts to real-time demand need base and consumers are coproviders in balancing supply and demand [16].

According to Smart Grid Forum (SGF), smart electricity’s main 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 groups and local governments can develop local sources of renewable energy to reduce energy costs. DNOs functions as local system operators and they offer balancing services [18]. Thanks to this support policy, 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 also invest in small scale of wind generation, community driven micro-grid, and other initiatives to decarbonize. They can manage the interactive communication flows of electricity. There are fourteen licensed DNOs by Ofgem. They operate the networks, collect data from customers and improve their quality of service. The price monitoring called ‘Electricity Distribution Price Control Review (DPCR)’ has been conducted by Ofgem every five years. To encourage DNOs’ low-carbon efforts, ‘Low Carbon Network Fund’ (LCNF) has been established. LCNF supported £500m over the five year price control period 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 projects. Every year, around five projects have been selected and 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 and electricity network companies compete for fund raising to research, develop and trial for new technology, operating and commercial arrangements. The fund belongs to the best innovation projects helping electricity network operators to understand what they need to do to provide environmental benefits and security of supply at value for money as the UK moves to a low carbon economy. With these funding events, smart grid has been supported by new equipment and services, particularly the application of ICTs. Especially, demand side is harnessed for the optimization of the power systems. Full monitoring is possible by this new network equipment. That means, the smart grid can be self-healing and resilient. For this resilience, 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].

As result, smart grid market opportunities in Britain start from the government driven initiatives and are possible by smart meter rollout and some smart grid projects focusing on DN including real-time data flows and interactive communication between suppliers and consumers.
Especially, rolling out of smart metering provides huge 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 new usage data, consumer behaviour, network operations and distribution weak points. In future, how to use this data effectively is a key success factor of the smart grid. Based on this, an electricity network can intelligently integrate the actions of all users connected to it. Thus, a transition from DNO to DSO is needed for operating the UK smart grid.

4.4 Energy and water nexus [19, 20]

In “external aware” stage, a company opens itself to external asset. It can reduce operation cost and save the time for new service offering. It can share risks with external partners for new products and processes and internal roadmaps can be shared enabling the company to make more use of innovative technologies from them.

Energy and water nexus refers to the close links between these two sectors and the ways where changes in one sector have an impact on another sector. In smart energy city plan, global strategies are needed in order to facilitate re-development of existing environments. For instance, energy supply accounts for some amount of global freshwater withdrawals per year. An efficient method is the collaboration among the related infrastructures like energy, water, and food for resource management [19]. Issues like climate change, sustainability, population growth and security of supply need a appropriate policy and design. In fact, water is an important resource in energy generation sources such as nuclear. The required energy must be measured for operating water distribution facilities. It mean, the output of one is the input of the other [20]. As of 2010, UK energy use in water sector has increased by 10% over the last eight 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.

Therefore, an organization needs to be established in order to oversee implementation of water-energy integration. In the UK, this unit can be activated by UK water regulator, Ofwat and UK 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 [20]. It has already been verified in Brazil and in the US [23]. In the UK, especially in London, water supply derives from the River Thames. As London’s population increases, water supply needs to be expanded. Thus, London city 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 total energy use, and two third of London’s natural gas use [25]. Around 20% of this final energy serves water-related purposes [26]. Therefore, energy water nexus is more of importance for the both of energy and water savings.
As figure 4 [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 purpose, an organization should constantly monitor and evaluate strategies in all two sectors for environmental impacts.

4.5 Adaptive smart grid and meter system

In the “integrated” stage, core company can develop an adaptive area in customer segment. Suppliers and customers have access to the key company’s innovative business model, and this access is reciprocated. It formulates a two-sided market, where the customer’s customer gives the key company to give revenue source. Then, the key company moves from offering simple ‘products’ to offering ‘services.’

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 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. As an ingredient of the smart grid, 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, further action is required. Smart meters and grids can be automatically managed to reduce power outages. For example, if a sensor is recognized anomalous in power grid, it can be isolated before affecting one grid to impact other grids.
Figure 5 shows the stakeholders’ relationships in electricity industry in the UK: Smart meter suppliers provide ‘Time-of-Use’ tariffs to reward end users who shift their demand. Distributed generators (DGs) manage the demand. Energy consumers balance supply and demand. DNOs transform themselves to be distribution system operators (DSOs) supporting optimization and asset management. Traditionally, overcapacity has been built to allow networks to be shut down for accommodating routine maintenance, new connections, reinforcement, and equipment failures without any power loss. However, this is 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 [18].

![Figure 5: Roles & relationships in the electricity industry [17]](image)

As results, the UK’s NIC (National Infrastructure Commission) 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, 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 purpose 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 automated smart appliances, the potential for savings is expected to increase more and more [29].

4.6 Government leadership for energy ecosystem

The market with “platform leadership” is more adaptive and open than the former five stages and it requires different leadership. All participants have relationships in which both technical and business risks are shared. However, it is very difficult process. A leadership of organizational change is needed.

Thanks to the 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 enables London 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. The goal of zero carbon city initiatives Londoners to save their energy use by improving the efficiency of homes and buildings. Due to the rolling out smart meters, 30% of London’s CO2 emissions are attributable to consumption of heat as of 2018 [13].

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 which often face other side 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 also 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 GIS and provides spatial intelligence on factors relevant to DE development like heat loads & supply, heat networks, DE clusters, and so on [13].

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 city 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 decisionmaking 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.

As results, 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 government policy and regulatory interventions to structure markets and incentives. As of 2017, smart meter roll-out lacks focus on how to make it work well in London. Programs has many problems which need resolving, but real role of the GLA and Mayor of London has been accepted by stakeholders as lead and honest marketplace enabler as of 2017 [31].

5 Conclusion

This paper investigates the UK’s smart energy within the smart city project. Smart energy evolution of the UK has been accomplished along with several government projects and smart city plans like ‘SLP’ in 2013. For this, it discusses previous research papers with keywords of ‘smart city
and smart energy’. The theoretical background is the BMI of Chesbrough. With this backdrop, this paper analyzed the case of the UK based on the research questions by formulating the research framework of evolving smart energy city.

The starting point of the UK is the conventional silo system with no connection. This paper set the ‘SLP’ starting year of 2013 as the first stage of BMI. Second stage is the government & private investment in smart meters installation and the third is smart grids implementation. The fourth stage is aware of external asset and energy and water nexus has been dealt. The fifth stage is an adaptive smart grid system, microgrid and lastly, building marketplaces is initiated with platform leadership of 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 like zero carbon by 2050 including energy, 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 goals require effective application of smart energy techniques and others can be enhanced by creating new insights and opportunities for action and potentially reducing costs.

In conclusion, without leadership, there won’t be smart energy activities as technologies, services and markets develop, even if it is still lacking London oriented. 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]. UK’s energy sector is evolving step by step for the final goal of smart city from smart meter installation plan to make an environment to develop new business models on the smart energy system. It is implicated, government leadership takes an important role for coordinating with policy, planning decisions, resource of budget, engagement into the private sector experience, political commitment, and so on.

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