How smart meters will affect the UK and its population

A Dissertation

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Abstract

Smart meter technology can be used on gas, electricity and water meters and will have a role to play in the future of these systems. This dissertation weighs up the pros and cons of smart meters for use in the UK and concludes that, whilst they are an indication of the great extent to which science and technology in the 21st Century has advanced, they do have their dangers and these need to be considered in detail. But, as with much modern technology, the dangerous side effects are often waived or hidden in the interests of innovation, human advancement and economic growth. Hence, smart meters will play a role in the future of electrical power.

Keywords: *smart meter technology, smart grid, gas, electricity, water, worldwide application, EMF, RF, energy management, energy efficiency, domestic loads, renewable energy.*

1. Introduction

There are anticipated changes in the power system within the United Kingdom (UK) because electricity transmission and distribution systems are ageing and require improvements via reconductoring (replacement of existing conductors or wires) or constructing new networks (Samarakoon, 2012). Plants operating on fossil fuels (coal and oil) are closing due to modern environmental criteria; nuclear plants are approaching an end of their useful life. Hence, within the UK, from the 80 GW of total electricity generating plants, 22.5 GW of coal and nuclear plants will close down by year 2020 (Department of Trade and Industry, 2007).

Greenhouse gas emission reductions are required in order to limit the augmentation of the Earth's average temperature to 2^{o}C above any pre-industrialised levels (i.e. as was the temperature before year 1850). Therefore, the European Union (EU) has called for an attenuation of greenhouse gas emissions by 20% less than year 1990 levels by year 2020 (Commission of the European Communities, 2007). By achieving this, the UK's aim is to reduce its emissions by 34% (i.e. below year 1990 levels) by 2020 and 80% by 2050 (HM Government, 2009).

The world's fossil fuel reserves are non-renewable in the short-term and are, thus, depleting, being focussed in a few regions around the world, hence oil-price and political volatilities must always be considered. It would be better to build home-dependence into the economics of electricity generation (Department of Trade and Industry, 2007). However, although coal reserves can be exploited in many countries, its CO_2 emissions are very high; doubling those when burning gas (natural).

Overall reduction in energy use is a firm goal, but improving electricity infrastructure can be resolved by a reduction in the electricity peak power demand. Although the average usage of generation capacity and existing networks is under 55% (Strbac, 2008), in the current climate of mangled UK, European and World economics, expanding populations, and depleting natural commodities, it is wiser (and, maybe, there is no other choice, but) to reduce consumer loads and to increase the lives of the existing infrastructures.

In recent years, Europe and various other parts of the globe have experienced an upturn in demand for smart meters (Naughton, 2012). Some water and power transmission companies have, in essence, forced their clients to embrace these meters as a way of not just minimising their risks, but also in compliance with regulations relating to environmental preservation. The major driver for the British government's policy of countrywide installation of smart metering was initiated in year 2009 following a European Commission Directive requiring 80 percent of European Union (EU) domestic households to install smart meters by year 2020 (Cornish, 2012).

1.1 Why smart meters?

Many have asked why we need smart meters. Some have little understanding of what they really are and what benefits they bring to the community. Nonetheless, the government, as well as utility providing companies, have been quick to point out that smart meters offer vital information which can help clients make reasonable decisions with regard to their water and

electricity consumption, the importance of which cannot be overemphasised. Gas, heat, water, and electricity consumption information can help clients to realise where they make faults and can take appropriate corrective actions, rather than blaming utility providers for high bills. Notwithstanding, smart meters help clients to understand the reasons behind their costs changes as well as their contribution to greenhouse gas emissions. Many are, however, still sceptical about the ability of these meters to help clients make responsible judgements and act in more rational ways. While this research will provide globally-useful information, this study is limited to data within the United Kingdom.

Smart meters are digital energy meters supporting many functions in order to handle future energy networks. Smart meters have two-way communications between themselves and energy suppliers and domestic appliances with an In-Home Display (IHD). Smart meters measure energy used (or, not used) like a conventional meter, and can measure the import/export of power and energy, voltage, frequency and harmonic distortion. Stored records of measurements are sent to energy suppliers and network operators, from time to time. Smart meters have multiple registers for storing multiple tariff schemes, together with the energy consumption controlling each scheme. Real-time power and energy consumptions, and energy cost can all be transmitted to the IHD at very short time-intervals. The Direct Load Control (DLC) capability of smart meters allows energy suppliers to send control commands to domestic appliances whenever there may be an emergency (Samarakoon, 2012).

1.2 Aims and objectives

It is not easy to ignore the technological craziness surrounding installation of smart meters in replacement for the conventional meters. While this is one of the recent advances in technology aimed at not only enhancing environmental security, but also enhancing energy conservation, not much literature are available in relation to this technology and neither is its potential consumer knowledge sufficient. This dissertation addresses these areas and, therefore, aims to achieve the following aims and objectives:

1. Offer additional knowledge on smart meters for the consumer.

2. Establish whether smart meters are important essential and to UK utilities systems.

3. Establish if and which benefits are derived from installation of the smart meters.

4. Cite implementation milestone and challenges.

5. Establish whether there is a need to revamp and develop a sophisticated infrastructure in order to support smart meters through cost-benefit analysis.

1.3 Research questions

In order to achieve the objectives of this dissertation an attempt will be made attempt to answer a number of research questions. The main research question is outlined below:

1. Are smart meters essential and beneficial in the UK?

Other research questions to be answered by this paper will include:

a. What are smart meters?

b. What implementation challenges do they face?

c. Is it economically feasible to replace the existing infrastructure with more complex smart-meter infrastructures?

Research hypothesis

Null hypothesis: Smart meters are essential and beneficial in the UK.

Alternative hypothesis: Smart meters are not essential and beneficial in the UK.

2. Literature review

2.1 Benefits and negating factors for smart metering

Contrary to assumptions that smart meters would have an obvious impact on the consumption of electricity and water, few researchers who have delved into this area have registered mixed results. While many seem to agree with this assumption, some present reports which disagree with results. Parsons (2008) reported that consumers seemed not to care about the readings displayed in the meter nor the information it provided but rather simply loaded, enjoyed using their electricity and when almost exhausted reloaded again. As a matter of fact, he reported that the only information clients read is the meter reading balance. Nonetheless, Renewable Energy Focus (2009) provides contrary reports, noting that fearing unplanned power cuts, consumers grew more concerned about their power spending and developed habits useful in energy saving. Similarly, he reports that upon realising how much water goes to waste, consumers adopted tendencies which ensured rational water consumption. Many benefits and milestones are attributed to smart metering, inclusive of lower metering cost, energy savings for residential customers, and more supply reliability, variable schemes of pricing to lure new customers and facilitate easy fraud detection (Utterback, 1994). Additional benefits have been forecasted in relation to distributed generation. Smart meters provide lots of benefits to various stakeholders.

2.2 The Electricity market

2.2.1 European markets

Rather than discuss the British smart meter scenario as a stand-alone subject, it is wise to incorporate the smart meter programmes of its European neighbours, as smart metering runs under a European Union directive. Although important efforts have already been promoted and are underway, Europe is only at the start of the Smart Grid transition. However, many European states, including Italy, France, Sweden and Malta have implemented legislative provisions for smart metering and these procedures are outlined, briefly, in what follows. European smart meter projects and investments have a geographical distribution which does not have a uniform distribution. The majority of them are located in EU-15 Member States, while most of the EU-12 Member States have yet to catch up in the race to meet European Union directives (Giordano et al., 2011: 16). The country which leads with investments in smart metering systems is Italy, where a national roll-out of its Telegestore project has already reached its target (Enel, 2010).

ITALY: An existing smart grid project is installed Italy, starting a national roll-out already in 2001 and, where Enel rolled-out in excess of 32 Million smart meters by the end of 2006, with a focus on halting fraudulent behaviour by electricity consumers (and, then to provide improved, less expensive, meter-reading capability). Italian automatic metering infrastructure is now mandatory, and Enel further plans on upgrading existing smart meters with superior and ‘smarter’ meters that can provide more functionality (Enel, 2010; Gerwen et al. 2006;

Giordano et al., 2011: 19).

FRANCE: The French demonstration smart meter project named, Pilot Linky, began in 2007 and 300,000 smart meters were installed in a pilot scheme and a national roll-out scheme is being prepared with envisaged roll-out deployment of 35 million smart meters and an assumed investment of around €4 billion Euros. The goal from January 2012 is to install only electronic meters followed by 95% coverage by the end of 2016. The French regulatory body outlined some guidelines and minimum functional requirements for electricity meters (Giordano et al., 2011: 19).

SWEDEN: The Swedish, in 2003, mandated monthly automatic meter-reading for all electricity meters by July 2009. Within the given timeframe the Distribution System Operators (DSOs) could decide on the rate of implementation. With the new legislation, investments in Smart Metering developed fast and the roll-out at national level was achieved in time. There are a high number of DSOs in Sweden and since 2003 there has, consequently, been a high number of smart meter roll-outs. In summary, Swedish national deployment of smart meters was carried out using around 150 projects, at a cost of approximately €1.5 billion and involving installation of approximately 5 million smart meters (Giordano et al., 2011: 19).

MALTA: In 2008, Malta deployed its use of smart meters with a five year pilot phase to install 250,000 meters, using the Italian Enel technology and aiming to locate any problems ahead of its scheduled replacement of all electricity and water meters in Malta. In 2010, Enemalta introduced its roll-out plan to replace all electricity and water meters by the end of 2012 (Giordano et al., 2011: 19).

FINLAND: The Finnish smart meter roll-out is well underway. The new Finnish electricity market act (66/2009 Act on electricity supply reporting and metering) required all connection points over 63 Ampere to have remotely readable hourly metering by 2011. By 2014, this Act requires for full smart meter installation with at least 80% effectiveness. The Finnish Ministry of Employment and Economy generated an estimate of the cost for full roll-out of smart meters at €565–940 million (Giordano et al., 2011: 19).

2.3 Structure of the British market

The structure of the British market includes the Office of Gas and Electricity Markets (OFGEM), which regulates the electricity and gas markets in Great Britain. OFGEM is governed by an Authority (non-executive, executive members and a non-executive chair) determining strategy, setting policy priorities and taking decisions many matters, including price controls and enforcement. The Authority's powers come under the auspices of the Gas Act 1986, the Electricity Act 1989, the Utilities Act 2000, the Competition Act 1998 and the Enterprise Act 2002 (OFGEM, 2007).

2.4 Are smart meters essential and beneficial in the UK?

The UK smart metering program aims to introduce smart meters into all domestic and commercial buildings in the UK by 2019. Smart meters are reported to have significant potential benefits (i.e. both collective and individual) for UK electricity consumers (DECC, 2010a). Some of the potential benefits of these meters are summarised in this literature review. Smart meters will inform electricity consumers of their daily energy consumption and will stimulate consumers to adapt cost saving changes to their energy consumption habits at different times of the day (Waddams-Price, 2002). These meters will also reveal the advantages of energy saving programs and schemes to consumers.

According to Taylor, Schwarz and Cochell (2005), smart metering systems can serve as foundation for the introduction of schemes, offers and services aimed at encouraging and enabling consumers to manage their energy demands in order to ensure collective benefits. The collective benefits are system-wide benefits including the reduced costs of generating electricity, improved efficiency of electricity generation systems in the short as well as the long term, improved management of intermittent electricity sources e.g. wind power, and more precise demand forecasting for energy by region and time due to the availability of accurate and time based customer demand profiles of each region (Ueno, Inada, Saeki and Tsuji, 2005). In addition to the above mentioned benefits for consumers, smart meters will also ensure operational cost savings for suppliers. These meters will ensure reduced meter reading costs due to the ability of remote communication. They are also reported to result in more precise billing that will result in decreased customer complaints. Smart meters will send data of daily electricity consumption of every household and business to the central system (Ofgem, 2012). Suppliers can optimise their network investment through appropriate management and analysis of this data. They may also come up with better price choices for consumers between networks of supply and demand oriented solutions.

The overall benefits of smart metering are estimated to be £7.1 billion by the DECC (Department of Energy and Climate Change). The estimated benefits can only be realised if smart meter's operation and design are coherent and reliable and the roll out of smart metering systems is successful (DECC, 2010a). However, design coherence as well as roll out success is dependent on addressing the concerns of consumers and meeting their requirements. It is logical because the consumers are the people who will have to accept and agree to have a smart meter installed into their homes, check and respond to its signals and

feedback, and bear all the costs incurred due to smart metering systems which will be passed on to them through their bills.

2.5 Interests and Concerns of Consumers

The UK Government tends to promote its smart metering promotion program by emphasising the benefits for consumers. However, there are concerns and questions about the extent to which the promised and potential benefits will be passed onto the consumers in their electricity bills (Ofgem, 2012). In order to review the benefits of smart metering for consumers and its coherence with the needs and interests of consumers, it is essential to review consumers' needs and interests. It will help to assess the design of smart metering programs from the consumer's perspective. In broader terms, the interest of consumers in smart meter roll out can be described in terms of related costs, confidence and reliability on the working of this program, benefits, fairness in measuring electricity usage (Ofgem, 2012). The experts from CSE and '*Which?*' have utilised their direct experience of working with and for electricity consumers to identify different consumer – oriented objectives for smart meter roll – out.

Roll-out of smart meters should be associated with lowest possible operational costs and these costs should be efficiently incurred. Recovery of costs incurred in installing and running smart metering systems by electricity suppliers as well as other service providers should be fair and transparent (Ofgem, 2012). These costs should be fairly distributed among existing and future consumers. This program should inspire confidence among consumers and it should be trustworthy. Once installed, smart meters should demonstrate robust, confidence inspiring and secure operations. The system should ensure complete realisation of the benefits associated with smart meters by ensuring effective data display, management and consumer friendly interface of the IHD (DECC, 2010b). The system should enable new services with collective benefits for the whole energy system and benefits and choice for the individual consumers. Transparent and fair estimates of the benefits accruing to electricity suppliers and other stakeholders in the system should be made and communicated to the consumers (Ofgem, 2012). All the above mentioned areas capture and demonstrate the broader areas of concern and interest for a majority of the UK electricity consumers.

2.6 Benefit for Consumers, Environment and Energy Market

After discussing the objectives and needs of smart meters in the UK from a consumer's perspective, this section explores the major potential benefits of smart meters for consumers. Consumers will enjoy greater and effective control over their energy consumption and per-month energy spending. Smart metering will allow consumers to switch between energy suppliers and adopt the most suitable tariff plans. As the smart meter is capable of time real time pricing of the electricity, it allows energy suppliers to promote different energy deals (Ofgem, 2012). For instance, it can offer low rates during the night when demand of electricity is low. The smart metering system will facilitate the flow of information needed by the network companies to advance the concept of smart grids. In this way, increased reliability will be offered to consumers. This system will also facilitate the advancement of micro-generation due to the ability of the smart meters to measure electricity transferred from the home to the major network (Keirstead and Boardman, 2005). The smart meters will also allow consumers to easily switch between various payment methods; for instance they may switch between credit or debit payment methods through the same meter.

The smart metering system also promises significant benefits for the environment. Initial estimates made by DECC (2012) reveal that smart meters will reduce CO_2 emissions by 15 million tonnes during the period of 20 years because awareness of energy usage will be increased among consumers. It will be significant for environment conservation and reduction in CO2 emissions because household energy use accounts for 26% of the UK's total energy needs and CO_2 emissions. Some of the carbon dioxide emissions are caused by inefficient use or waste of energy by the household consumers. For instance, it was estimated that £900 million was wasted by household consumers each year by keeping their appliances on standby. In addition to offering benefits to consumers and the environment, the smart meters also offer potential benefits to the UK's energy market.

The energy market will reap benefits from the smart meters because these meters will enable more accurate computation of energy consumed that, in turn, will enable the energy market to reduce the total amount of energy generated according to demand (Ofgem, 2012). This will result in reduced carbon dioxide emissions and costs of electricity generation. The information based on hourly usage of energy by consumers of a particular area will enable the network operators to increase the efficiency of their grids. The energy market will experience reduced operating costs because of no need for meter readers as well as the staff

for answering calls of consumers for estimated bills and other complaints regarding billing. Energy theft will be reduced due to the usage of small temper alarms. In addition to these benefits, the energy market will also reap the benefit of efficient procurement of wholesale energy. The Government as well as Ofgem have increased expectations of passing the reduced costs for the energy suppliers to the household consumers in terms of lower energy prices (Ofgem, 2012).

2.7 Costs and Benefits of Rolling-out Smart Meters

One of the most significant benefits of the smart meters is their contribution towards demand management on large scale. Demand management, in addition to efficient use of energy, can make a noteworthy contribution to the sustainable consumption of energy. Demand for electricity mainly depends on day, week and season times. The information about energy demand with respect to time enables the suppliers to identify peak periods of energy consumption. The flexible generation during these peak hours is usually made up of expensive and carbon intensive fossil fuels resulting in increased prices. It was suggested by Waddams-Price, (2002), that demand side response of the consumers is often stimulated by changes in price and is expressed in varying demand. Price is often driven by changes in equilibrium between demand and supply of energy.

Energy Saving: As mentioned above, smart meters display detailed and accurate information of energy consumption to consumers. The aim of providing consumers with this information is to prompt them in making informed decisions on how to reduce their energy spending; in turn, reducing the use of energy and carbon dioxide emissions. Energy Demand Research Project (EDRP) has been carried out by Ofgem with an aim to assess the benefits and efficiency of smart meters and compare it with traditional methods for reduction in energy consumption at a domestic consumer level. Ofgem (2011) analysis revealed that 60,000 household consumers were studied in the trial out of which 18,000 consumers had smart meters installed. Smart meters providing real time display of energy consumption resulted in a consistent saving of 3%. These results showed consistency with the international evidence where a smart metering system has been adapted and installed. The IHD will be offered to domestic consumers for making the Government's case effective. The impact assessment (2012) showed that rolling out smart meters will cost about £11.5 billion and will reap benefits of £18.6 billion. These figures have not significantly altered from the earlier

assessment. Overall, net benefits of domestic and non – domestic roll out of smart meters are expected to be over £7 billion.

2.8 What are smart meters?

Ofgem (2012) described smart meter as, *"A smart meter is a gas or electricity meter that is capable of two-way communication. It measures energy consumption in the same way as a traditional meter, but has a communication capability that allows data to be read remotely and displayed on a device within the home, or transmitted securely externally. The meter can also receive information remotely, e.g. to update tariff information or switch from credit to prepayment mode"*. In other words, a smart meter is an electrical meter that is capable of recording consumption of electric energy at certain intervals of time e.g. an hour or less, and communicates this information back to the information centre for billing and monitoring purposes once a day. There is two way communication between the central system of the electricity supply company and a smart meter (DECC, 2010a).

Both electricity and gas usage will be covered by smart metering. Each house should have one meter for gas and one for electricity. Every smart meter will be installed along with an IHD (In-Home Display) and communications hub. Research is underway for effective communication between smart meters and IHDs in order to reap required benefits from smart meters (DECC, 2010b). As stated by Richards (2012), the SMETS (Smart metering equipment technical specification) was presented to the EU and its revised version was proposed in 2012. It indicates that SMETS for smart metering will develop with the passage of time and advancement in technology. Therefore, all the specifications and elements of smart metering can be finalized in the present versions of SMETS.

One of the main effects of smart metering will be the elimination of the need for electric companies to visit consumers' houses or business places to read the meter. Conversely, consumers will have the facility to control their energy consumption as they would have a real time access to the statistics of their energy consumption (DECC, 2010b). The IHD provided with smart meters will be an up to date and technically efficient device. It will provide consumers with the up to date information regarding the use of gas or electricity in pounds or pence along with the units of energy consumed. Moreover, the installation of the IHD and smart meter will be accompanied with the information about the best use of the IHD (Ofgem, 2012).

2.9 Smart Metering Implementation, Global Context

As stated by Global Energy Review (GER) (2011), the UK has not taken the initiative in smart metering compared to the many countries throughout the world that have begun the implementation of significantly advanced smart meter rollout programs. Italy is the leading country in terms of the number of meters that have actually been installed. However, functioning and range of the smart meters in Italy are limited. In Italy, more than 27 million electricity consumers have been supplied with the smart meters by Enel, an energy provider in Italy, during 2000-05. It has been estimated that smart meters had covered their initial costs within four years of their installation.

The State of California, in the USA, also conducted an ambitious but privately led smart metering implementation program. It involved the installation of more than 9 million smart meters since 2006 by Pacific Gas and Electric Company. This program also faced significant problems concerning consumers, distributors and suppliers. New Zealand and Australia started smart meter rollouts with a more cautious approach and installed a limited number of meters from the initiation of rollout programs in 2005. The rollouts in both these countries have been subjected to internal reviews due to issues such as cost overruns and functioning of meters. According to GER (2011), Australian authorities may abandon their smart meter rollout program due to cost related issues.

2.10 Consumer Concerns over Smart Metering Rollout in the UK

Ofgem and DECC have been conducting the implementation of the UK's smart meter rollout and they are expected to introduce measures for consumer protection from spring 2011. Consumer protection is a difficult task because it poses complex questions like how to ensure that the best incentives are offered to prevent the higher costs of rollout to translate into higher electricity bills for the static use of energy, particularly when this information is supplied to producers and suppliers of energy. Major consumer concerns were reported by GER (2011) that are summarised below.

Information and its Use: As discussed above, the smart meters collect hourly data of energy consumption, display it to the consumer and transmit this data to the main data centre. Thus, legal issues could arise over the information sharing between different suppliers. The information about the energy consumption and its patterns at different times of the day, week, month, season etc will have a commercial worth and suppliers, as well as competitors, will

pay consumer analysis and credit ratings firms to discover energy consumption patterns. For instance, the data from the smart meters could be used to discover which regions in the UK consume the most energy. Such kinds of information will be vital to suppliers looking at expansion and new market entries and may result in sophisticated cooperation between suppliers, e.g. coordination of prices. Therefore, it would be vital to regulate and monitor the flow of this information. This sort of coordination may benefit consumers living in more profitable regions, but it may also create disadvantages for other consumers as there would be fewer competitors in business. In light of the above concerns, regulatory framework is essential in order to ensure the protection of consumers so that they can enjoy affordable services and their personal data is not misused.

Price Issues and Follow on Sales: The installation of the smart meters will require engineer visits to the premises of consumers and suppliers may use this opportunity to offer new or additional products to their consumers. These products may include smart meter user guides, warranties, service kits, premium meters and different pricing schemes. In this way, customers may consider these products essential and may end up paying for the process that should be paid for by the suppliers according to the rollout mandate.

High Prices: The smart meters will enable energy companies to differentiate between different tariffs instead of applying peak and off – peak tariffs which are one – size – fits – all forms of tariff. It will enhance energy efficiency as some of the price sensitive consumers would carry out energy intensive tasks at times when energy rates are the lowest. If a significant number of consumers show this behaviour, it would result in increased energy consumption which, in turn, would result in a price increase. Moreover, the goal of reduced emissions will not be achieved. According to GER (2011), most of the consumers in the UK cannot alter their energy consumption patterns because they require electricity to heat water and cook in morning and evening times. Therefore, these customers will have to pay higher bills.

Disconnection: Consumers also fear that smart meters will enable the suppliers to disconnect consumers remotely from the grid if or when they fail to pay a bill. The customers expect the government to make legislation that prevents suppliers from disconnecting the customers due to disputed bills. First Utility is one of the foremost energy suppliers that offered smart meter installation. It is being investigated for its disconnection policy because it failed to offer its customers any option of prepayment before disconnecting them from the central grid. It

enhanced the consumers concerns though First Utility has now announced plans to provide this facility.

2.11 Standardisation and Technical Issues

According to GER (2011), little is known about the technical information and benefits promised by smart meters. Darby (2005) has also posed doubts on the groundbreaking ability of smart meters that has been claimed by their supporters. It is of great concern that DECC (2007) estimated a need for an £8 billion investment from the private sector to fund this rollout. The results of large scale smart meter trials conducted in California are also not very encouraging. Smart meters being offered by some suppliers do not meet a universal standard and will not be able to provide the benefits claimed by the government. Standardisation is essential to ensure the inter-operability of communication networks and smart meters. The smart meters should not be supplier specific so that customers are not required to change their smart meters each time they switch their energy providers.

3. Research methodology

The research methodology chapter is designed to present a step forward in order to achieve the major aim of this study which is to examine the significance of smart meters, their overall perception among UK customers and the benefits of these meters for consumers. It specifically presents the methods adapted to address the objectives and achieve the aims of this study. It highlights and entails the research strategy and design adopted for conducting primary and secondary research including questionnaire design, sampling approach, data collection techniques and data analysis methods.

3.1 Research Strategy and Design

Bryman and Bell (2009) described research strategy as the general orientation of the researcher towards the research. Research specialists have identified two main research strategies including quantitative and qualitative. The perception of research methodologists shows that differences between quantitative and qualitative strategies are more than the apparent aspect of quantification and project – ability of data. Therefore, the current research adopted a mixed research approach that involved both quantitative and qualitative strategies to find answers to the questions posed in this research. Research design refers to the methods used to collect the required data from the field, laboratory or the real world where a researcher lives in light of the topic, research objectives and research questions (Lee and Lings, 2008).

The process of research for this study began with the review of literature and selection of the research topic as the effect of smart meters on the UK and its population. After the selection of the topic, the literature relevant to the topic was reviewed to find existing knowledge with regards to the topic and gaps in the emerging literature. According to Saunders et al. (2011), an inductive or deductive approach can be utilised to answer the research questions. Inductive approach results in the formation of a theory while deduction helps in revising existing theories by formulating hypotheses and testing them through empirical research. Inductive approach was adapted in light of the topic and objectives of this research (Bryman and Bell, 2007) as smart metering is a relatively a new phenomenon and requires a lot of exploration and investigation. Saunders et al. (2009) also reported that an inductive approach involves observation and data collection that leads towards theory generation. The inductive approach is justified for this research as it aims to generate a theory regarding the benefits and impacts smart metering in the UK may have on its population. The following section entails sampling

methods and data collection methods used for the collection of primary and secondary data in this research.

3.2 Sampling Methods

We seek to examine the influences that smart meters can have on the use of utilities including water and electricity. This will incorporate multiple data spread across the last two years as well as data collected from utility consumers directly. The key idea behind the study is that if smart meters are non-beneficial to the UK consumers and power transmission companies, then they are indeed non-essential to the UK and resources should not be wasted on construction of related infrastructure. Additionally, if they cannot impact on consumer behaviour in relation to usage of utilities, then any capabilities and opportunities are greatly diminished. Additionally, the paper goes a step further to look at the costs in relation to the benefits of investing in such infrastructure.

Sekaran (2003) suggested that sampling was the most widely used technique that enabled a researcher to collect sufficient data and understand the characteristics of a population by selecting a significant portion of the population. To achieve the above mentioned objectives, the current research adapted convenience sampling as a type of non-probability sampling technique and selected 50 people from the UK population; 10 people were selected from each of the five different city centres including Harrow, Kensington, Becton, Edgware and Watford. Baker and Foy (2008) stated that convenience sampling allowed a researcher to access a sub-group of the population under study and collect information opportunistically. This sampling technique is mainly justified due to the accessibility of the sample, time considerations, and cost considerations were also significant in this context.

3.3 Data Collection Methods

For data collection, surveys and questionnaire based interviews are considered to be the most commonly used methods in social sciences research (Saunders et al. 2009). This research involved the questionnaire, interviews and secondary data (i.e. existing utility data). All the data collection methods were coordinated and utilised to support one another. Interviews were used to obtain in depth information regarding the importance and benefits of smart meters from the consumers' perspective. Thus, the detailed perception of the consumers was obtained through interviews. The focus of these interviews was on the utility consumers. The structure of the questionnaire for the survey is given below.

3.3.1 Questionnaire

The selected research method for data collection was a questionnaire. Therefore, different groups of questions were prepared in light of the title and objectives of the research. The first group entailed questions regarding the personal information of the participants. The second group contained questions regarding the supplier and the awareness of participants about the smart meters themselves. It contained ten questions that were close ended with two options (i.e. yes and no) (Appendix A). The questionnaire was administered online and the participants were asked to complete the survey questions according to the best information they had about the smart meters and their benefits. The third group of questions was relevant to smart meters and it contained 17 questions that were aimed at seeking information regarding the benefits and the issues with regards to smart meters. The researcher tried to keep the questionnaire short and comprehensive so that it did not become tedious for the participants involved.

The last group of questions used a seven point scale ranging from strongly disagree (1) to strongly agree (7). Lee and Lings (2008) stated that it was logical to simplify the questions and minimise the effort on the part of the respondents in order to get appropriate answers. Moreover, close–ended questions made it easier for the researcher to tabulate and quantify the data. It was essential as the study was not exploratory in nature. Kotler and Keller (2006) confirmed the value of using close–ended questions in non–exploratory research looking to find how many individuals thought in one or the other way about a certain phenomenon. Thus, the use of a Likert type scale is justified in this type of study as it also aims to explore the perspective of the UK consumers regarding smart meters.

Questionnaires were designed and placed online, keeping in mind the necessary requirements for the targeted population. They will be used as a feedback form for the study and will be applied towards the end of the study. It will gauge the consumer's feelings in relation to introduction of smart meters. The information obtained will be input into SPSS 17, statistical data processing software and analysed. The existing utility data will be used in establishing, not just the relationship between the introduction of smart meters and changes in utility bills, but also the impact of their introduction to losses incurred by the firms offering the utilities. The data will be spread across the last ten years and examined on a monthly basis.

3.4 Ethical Issues

During this empirical study to explore the effect of smart meters on the UK and its population, different aspects of ethical issues were considered. The questionnaire contained an introductory paragraph about the purpose of the study and the intended use of data. The participants were completely and clearly informed about the aims of the study, confidentiality of the data, the voluntary nature of participation in the research and the promised confidentiality of their contact and personal information. People under the age of consent (i.e. age less than 18) were not included in the research and data was only accessible to the researcher. The participants were requested to participate in the research and were informed that they could withdraw their consent for participation in this research at any stage during the research process. In this way, almost all ethical aspects of this research were taken into consideration.

3.5 Data Analysis

The firms were requested for anonymous client data with reference to utility bills five years before installation of smart meters and five years after installation. The data was either to be classified as water or electricity utility bills, respectively. Through this comparison, the effect of smart meters to water and electricity consumers was to be found independently and also in unison. However, the firms refused to provide utility bill data due to confidentiality issues and the analysis was limited to primary data collected through questionnaire survey and interviews.

In elaborating on what smart meters really are, this dissertation will evaluate the perceived benefits of smart meters, as well as their implementation. Finally, and most importantly, the dissertation will adopt a technical approach in analysis of whether they are indeed beneficial and essential to the United Kingdom. Additionally, the paper will look at the implementation challenges and assess the need for sophisticated infrastructural layout to suffice smart meter systems. On this basis, this dissertation will generate recommendations with regard to implementation of smart meters in the United Kingdom.

4. Data Analysis

This chapter offers a comprehensive and detailed analysis of data and provides answers to the main research questions including the advantages of smart meters, knowledge of the consumers about smart meters, concerns of consumers and expected changes in the energy consumption and electricity bills, potential benefits of smart metering for environment etc. The chapter entails two different sections; the first section presents analysis of primary data collected through online survey and the second section entails analysis of qualitative data collected through in depth interviews with the consumers.

4.1 Descriptive Analysis

4.1.1 Personal Information

The first section of the survey questionnaire asked participants about their name, gender and age. The analysis showed that the age of the survey participants ranged from 24 to 68 years. It was also revealed through descriptive analysis that 54% of the respondents were males and 46% were female (Table 1, Fig. 1). The gender distribution clearly indicates that both genders had almost similar representation in the survey. Moreover, it also reduced the probability of gender bias results as the research is linked with utility bills and the consumption of energy where males and females may have different perspectives. Thus, the results obtained through data analysis are less prone to gender biasness.

Table 1: Gender Distribution of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	54.0	54.0	54.0
	Female	23	46.0	46.0	100.0
	Total	50	100.0	100.0	

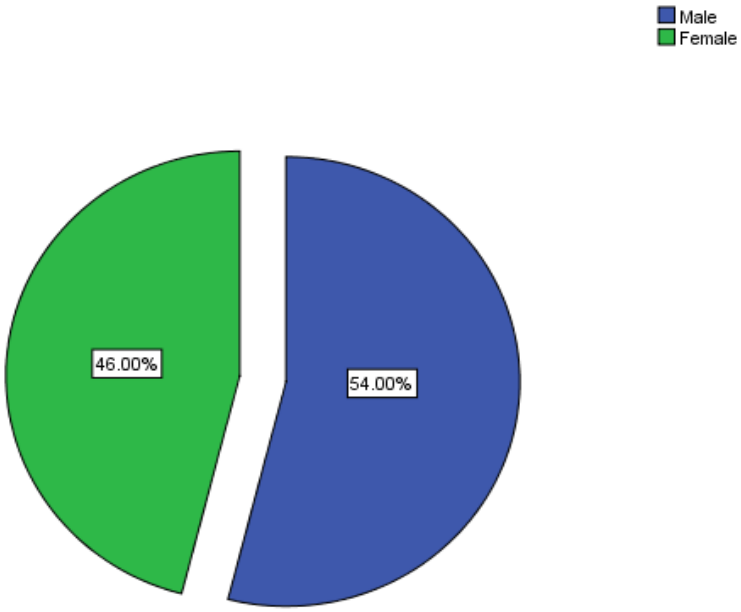

Figure 1: Gender Distribution of the Respondents

4.1.2 Smart Meters/ Energy Suppliers

After the personal information section, the second section asked questions regarding the energy supplier and smart meter from the respondents. The frequencies of the responses are presented in the tabular form in Appendix III. In response to question regarding the change of energy supplier during last two years, 36% of the respondents confirmed the change of supplier while 64% told that they had not changed their energy supplier during this period. It showed although most of the people in the UK do not tend to change their energy supplier yet a significant portion (i.e. 36%) may change the supplier after a certain period of time. 22% of the respondents were of the view that there was difference in the service of previous and existing energy suppliers while 78% did not notice any difference in energy supply or consumption after changing their energy supplier.

The analysis revealed that only 14% of the respondents had a smart meter installed while 86% were not using smart meters. Of those who had a smart meter installed, nearly 43% were of the view that their bill had increased since the installation of smart meters while 57% of the respondents did not report any increased bills. Instead, 57% reported that their bill had decreased since they installed smart meters. 29% of the respondents reported that their energy suppliers tracked the meter depreciation while nearly 71% respondents were of the view that there was no meter depreciation tracking from their energy suppliers. From the literature review, one of the main concerns of consumers was the loss of information from smart meters. From data analysis, it was evident that nearly 43% of the respondents considered that

all information from their smart meters will be lost if they were unplugged. Conversely, 57% of the smart users reported that the data from their smart meters will not be lost if they are unplugged (Appendix III).

The last three questions in this section were regarding the property and employment of the respondents. 56% of the respondents owned property while 44% of the respondents rented their property as revealed by the analysis of data. It was found that most of the respondents were living their own property while a significant number were renting their houses. When asked if they had any job or not, 64% respondents reported that they had a job while 36% had no job (Appendix III).

4.1.3 Perception and Knowledge about Smart Meters

The third section of the survey questionnaire entailed questions to judge the knowledge and information of the respondents regarding smart meters, their benefits and potential disadvantages. When asked if they were aware of a smart meter, 24% and 30% of the respondents strongly agreed and slightly agreed to this statement. It indicated that 24% of the respondents had maximum knowledge about smart meters while 30% slightly knew about these meters. On the other hand, 10% and 24% of the respondents strongly disagreed and slightly disagreed that they had any knowledge or awareness about smart meters. 12% of the respondents remained neutral (neither agreed nor disagreed) to the awareness about smart meters.

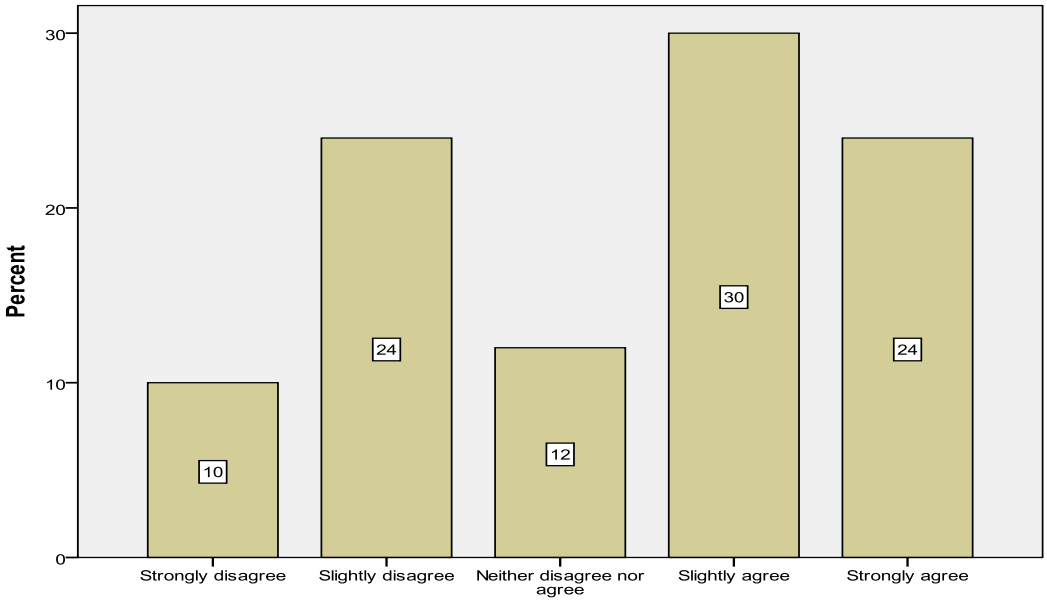

Figure 2: Awareness of smart meters

32% of the respondents strongly agreed that installing smart meters was very important and beneficial while 16% slightly agreed to the significance of these meters. However, 44% respondents disagreed to the importance of installing smart meters and disagreed to the potential benefits as reported by literature. 8% of the respondents remained neutral to this statement. The results are graphically represented in the following figure (Fig. 3).

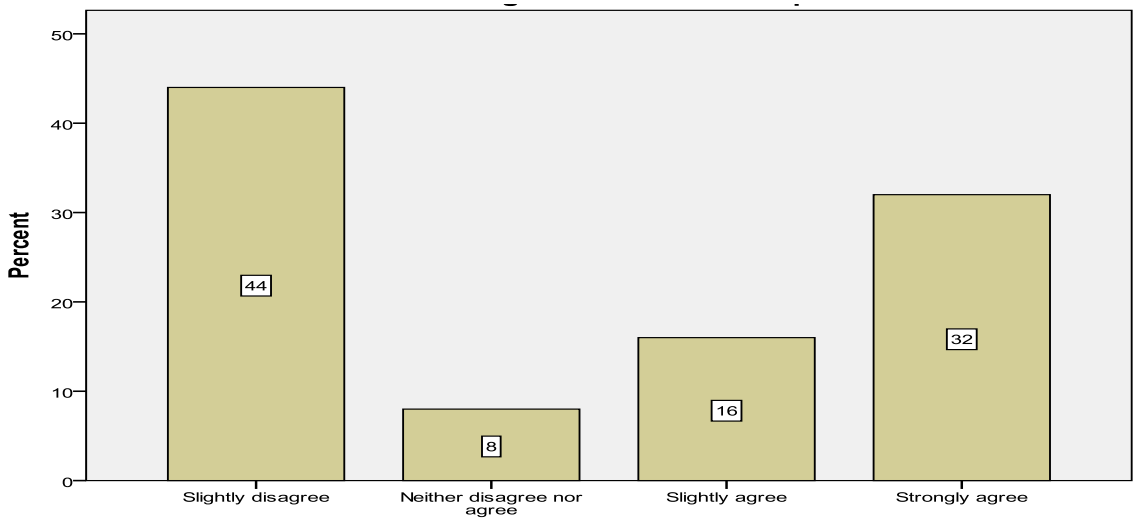

Figure 3: Importance of installing a smart meter

As revealed by analysis of data, 42% of the respondents strongly agreed that installation of smart meters should be made compulsory. However, 18% and 10% of the respondents strongly and slightly disagreed to the compulsion of installing smart meters at a domestic or

commercial level. The results revealed that most of the UK population had positive perception about the installation of smart meters as illustrated in the following figure (Fig. 4).

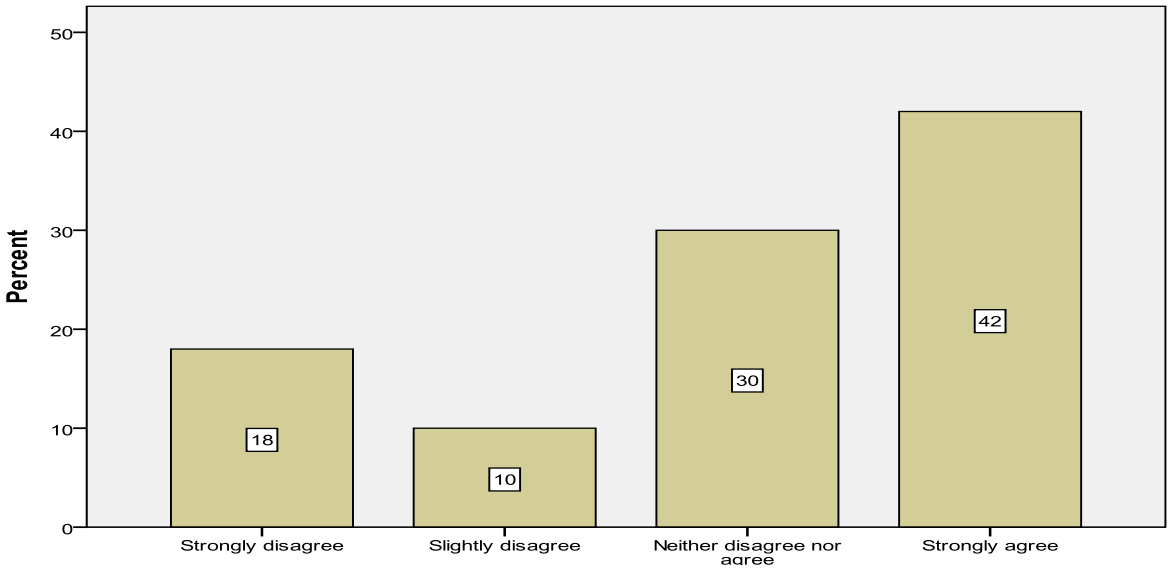

Figure 4: Installing Smart Meters should be Compulsory

When asked about the economic feasibility of installing smart meters, 28%, 12% and 16% of the participants strongly agreed and moderately agreed and slightly agreed respectively that installation of these meters was economically feasible. However, 44% of the respondents slightly disagreed to the economic feasibility of installing these meters as depicted in the following figure (Fig. 5). Overall, the analysis showed that most of the UK population agreed to the economic feasibility of installing smart meters.

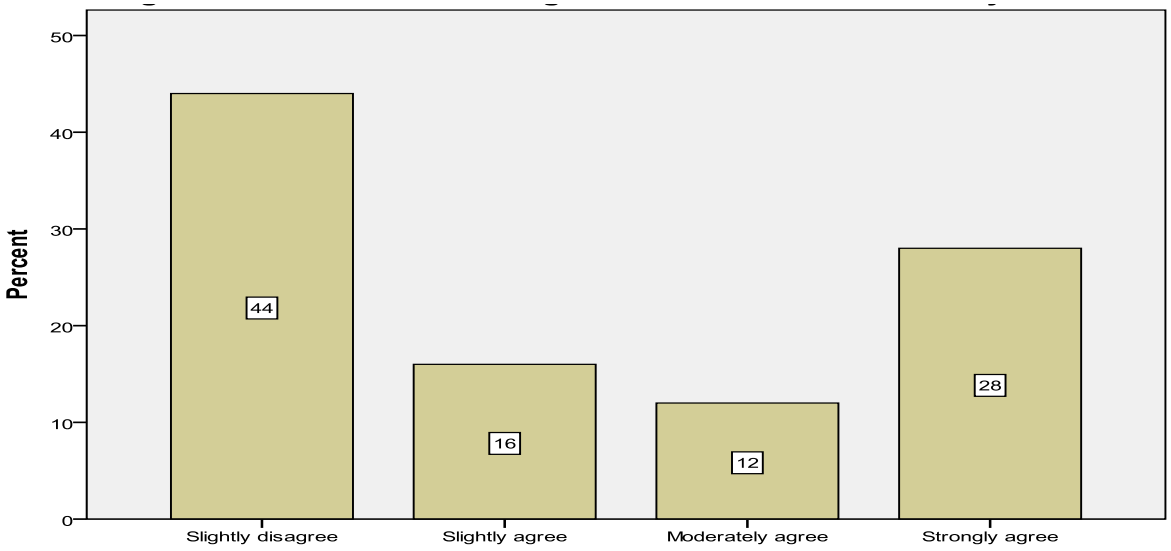

Figure 5: Installation of smart meters is economically feasible

Regarding the support for smart meters, 18%, 16% and 36% of the respondents strongly agreed, moderately agreed and slightly agreed that they supported the installation of smart meters. Thus, overall support (i.e. 70%) for the smart meters was found from the analysis of data. Only 18% of the respondents did not support the smart meters in the UK. These results are depicted by the following figure (Fig. 6).

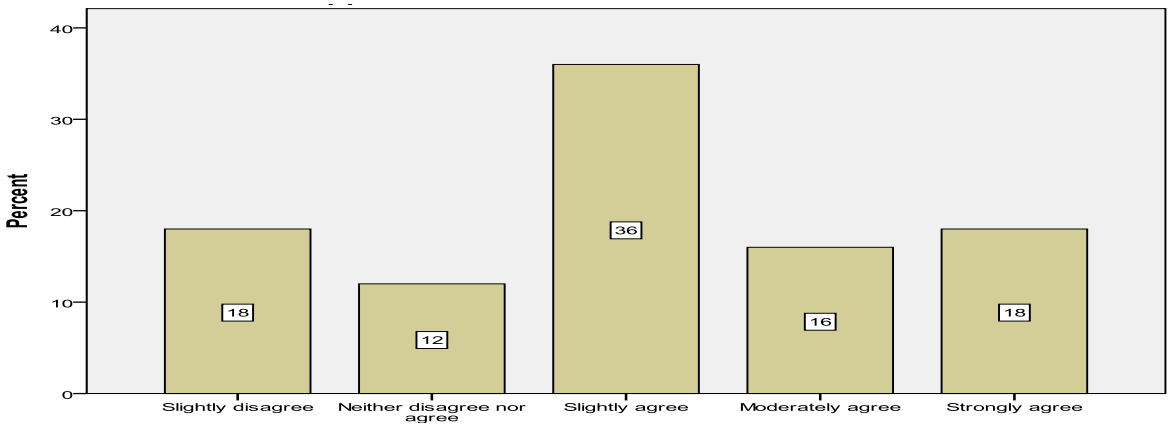

Figure 6: Support of Installing Smart Meters

Collectively 84% (i.e. 28% strongly agreed and 56% slightly agreed) of the respondents were of the view that smart meters will benefit consumers and were beneficial for them. Thus, the results confirmed that smart beneficial and economically feasible for most of the respondents. Only 16% of the respondents slightly disagreed to the benefits of smart meter installation (Fig. 7).

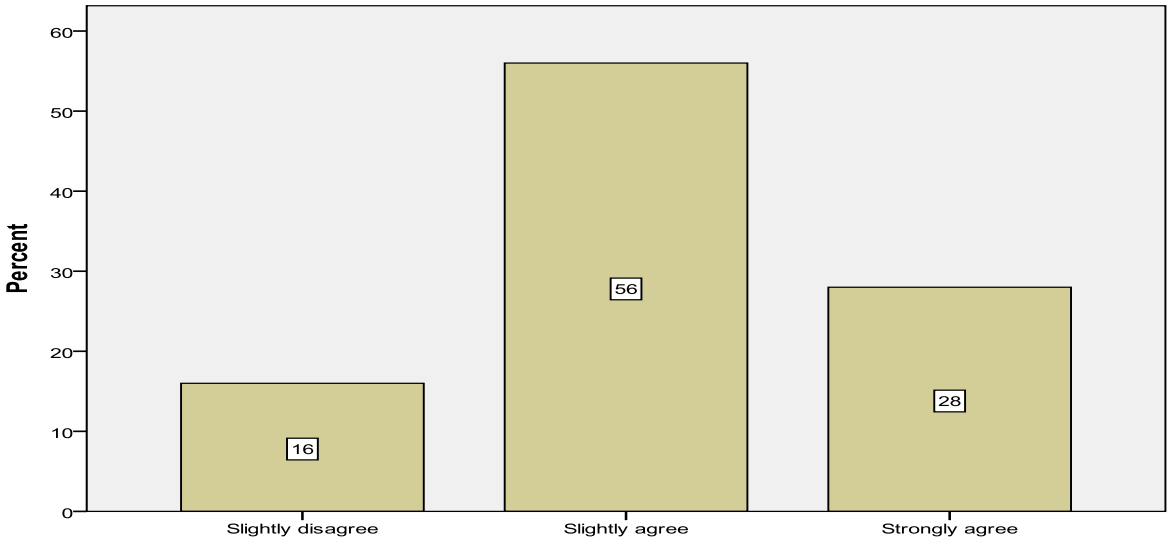

Figure 7: Installing smart meters is beneficial

46% of the respondents (i.e. 26 strongly agreed, 14 moderately and 6 % slightly agreed) agreed that installation of smart meters would save them money but most of the respondents (52%) slightly disagreed to money savings from smart meters (Fig. 8). These results emphasise the need for promotion of benefits associated with smart meters to the UK population because of them are not aware of these benefits.

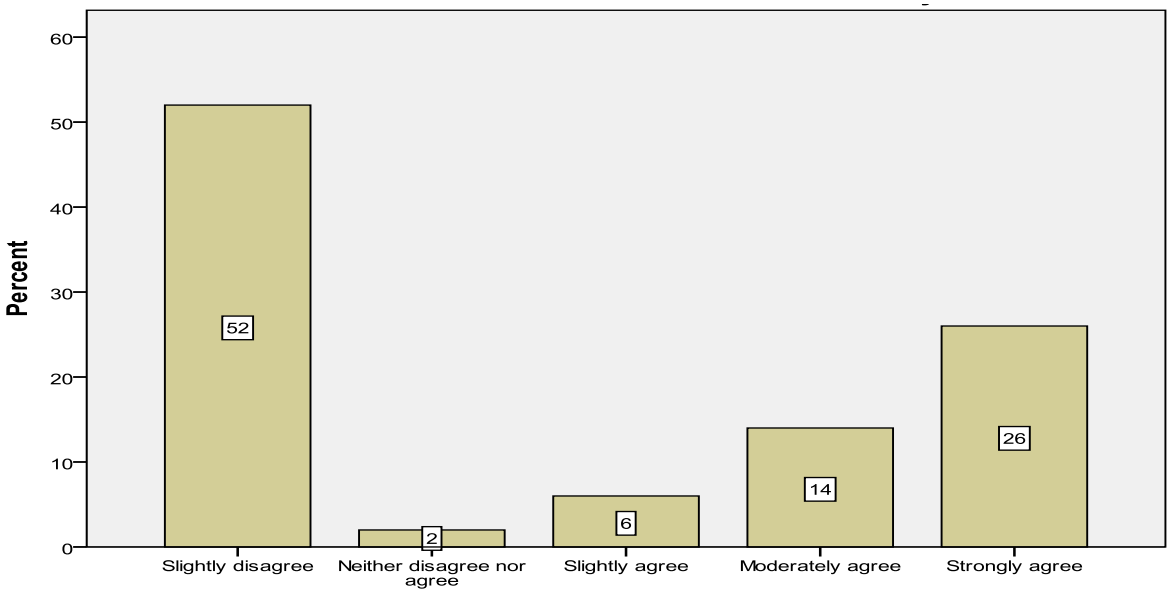

Figure 8: Smart Meters will Save Money

Regarding the secure nature of energy consumption and data transfer through smart meters, the analysis revealed that 28% of the respondents moderately agreed that smart meters were secure. On the other hand, it was also revealed that most of the people were not aware of the security concerns associated with smart meters and their ability to transfer data securely

because 56% of the respondent remained neutral and neither disagreed nor agree to the secure nature of smart meters (Fig. 9).

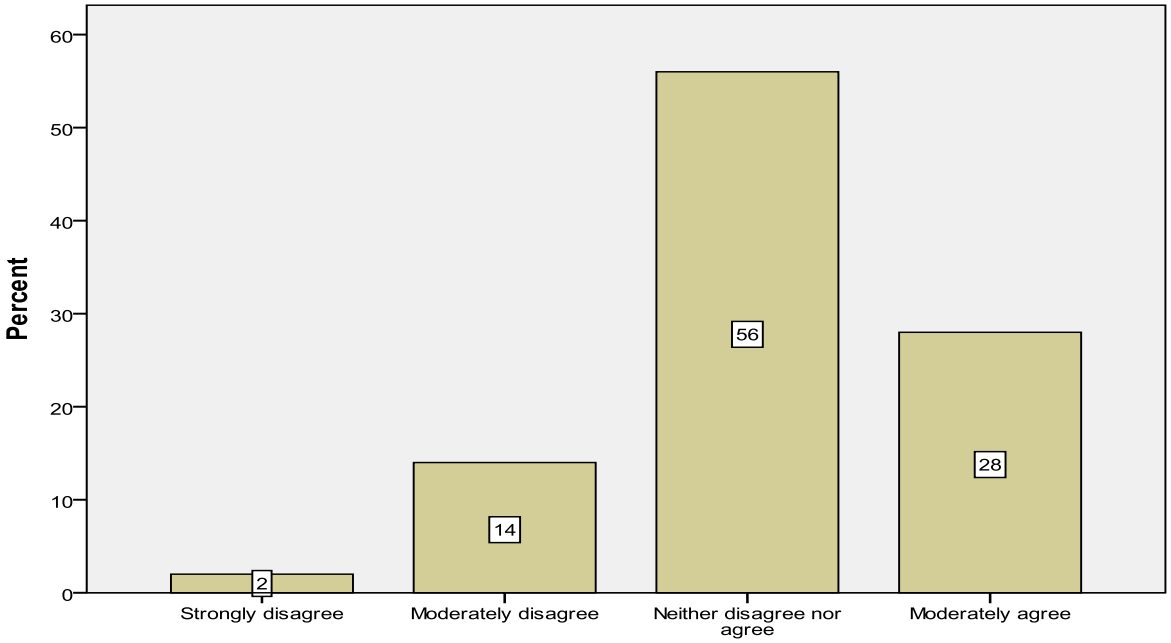

Figure 9: Smart Meters are Secure

A question was asked about the ability of the respondents to read smart meters. The results obtained from statistical analysis revealed that 22%, 22% and 28% of the respondents strongly agreed, moderately agreed and slightly agreed that they were able to read a smart meters (Fig. 10). Thus, it was confirmed that most of the respondents were able to read these meters conveniently. Only 12% and 16% of the respondents moderately and slightly disagreed that they could read smart meters respectively.

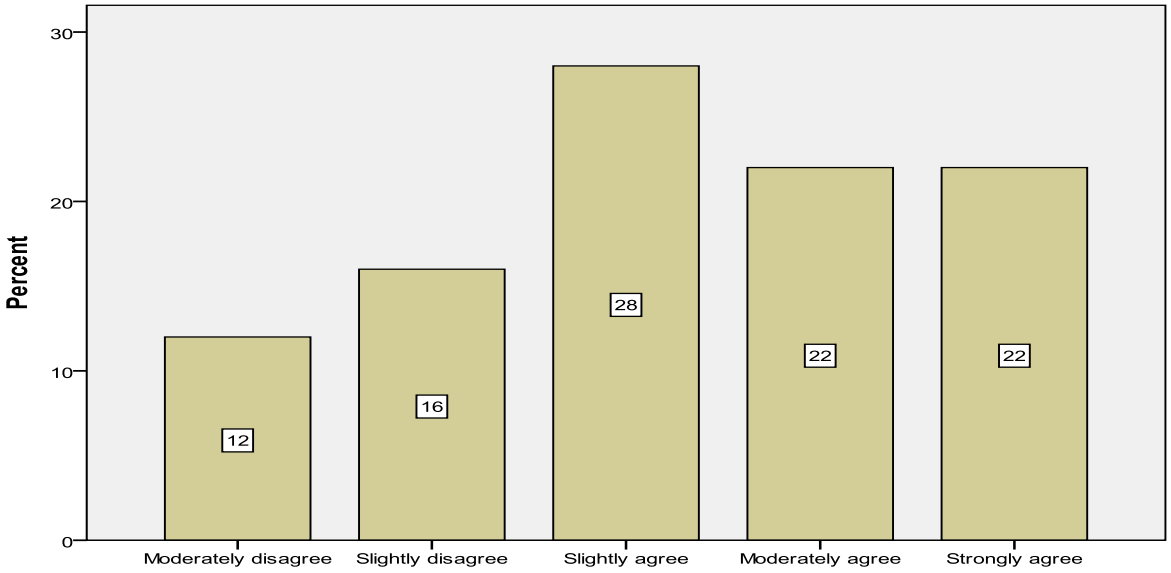

Figure 10: Smart meters are easily readable

It was also revealed that most of the respondents (52% with strong and 4% with moderate skills) had good IT skills (Fig. 11) and they could easily use smart meters as well as the display provided with these meters to inform consumers regarding the utilization of energy in different times of the day (i.e. mostly on an hourly basis).

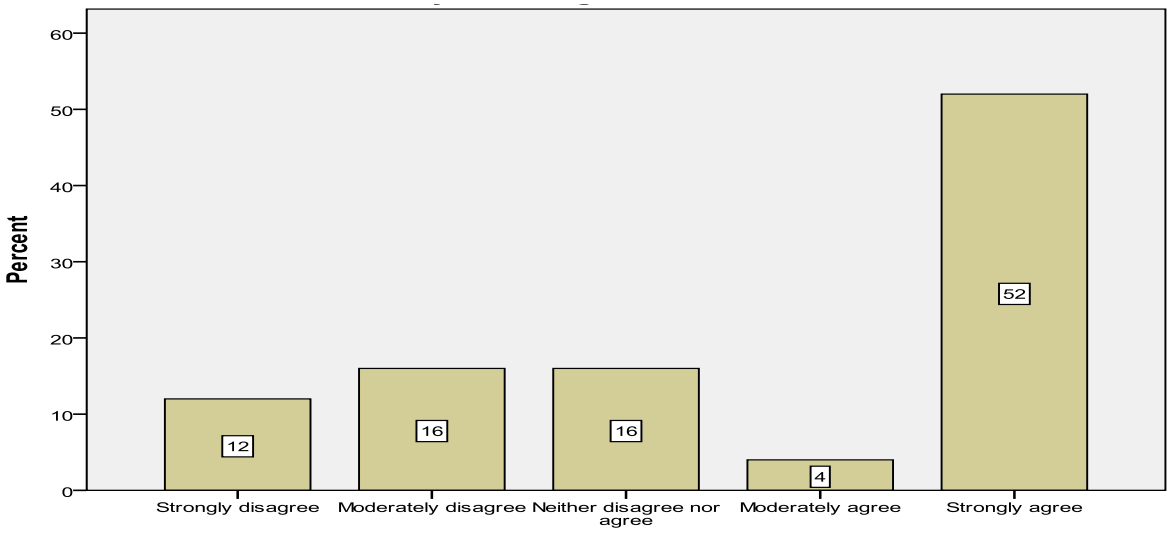

Figure 11: You have good IT skills

There are concerns about the accuracy of smart meters due to the involvement of time based tariffs (i.e. peak hours and low energy consumption hours). However, 56% of the respondents (i.e. 6% strongly, 44% moderately and 6% slightly agreed) confirmed that they had no issues with the accuracy of smart meters and they considered these meters to be accurate (Fig. 12).

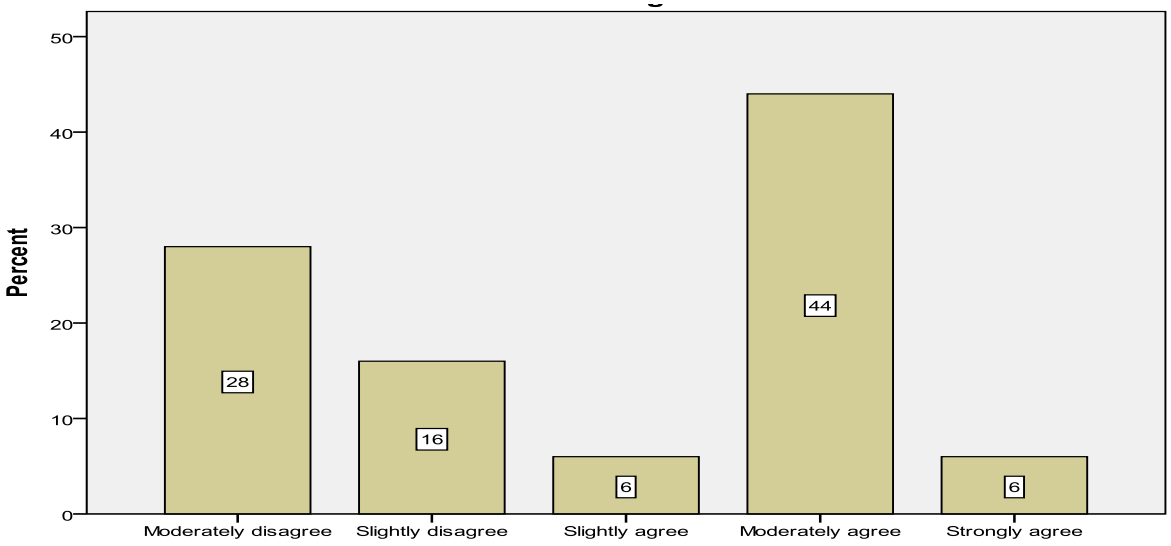

Figure 12: Smart meters are accurate

When asked about the adverse effects of smart meters on the consumers' health, 16% of the respondents strongly agreed, 14% moderately agreed and 28% slightly agreed to the adverse health effects of smart meters for consumers. Conversely, 32% of the respondents slightly disagreed and 10% moderately disagreed to the adverse health effects associated with smart meters (Fig. 13).

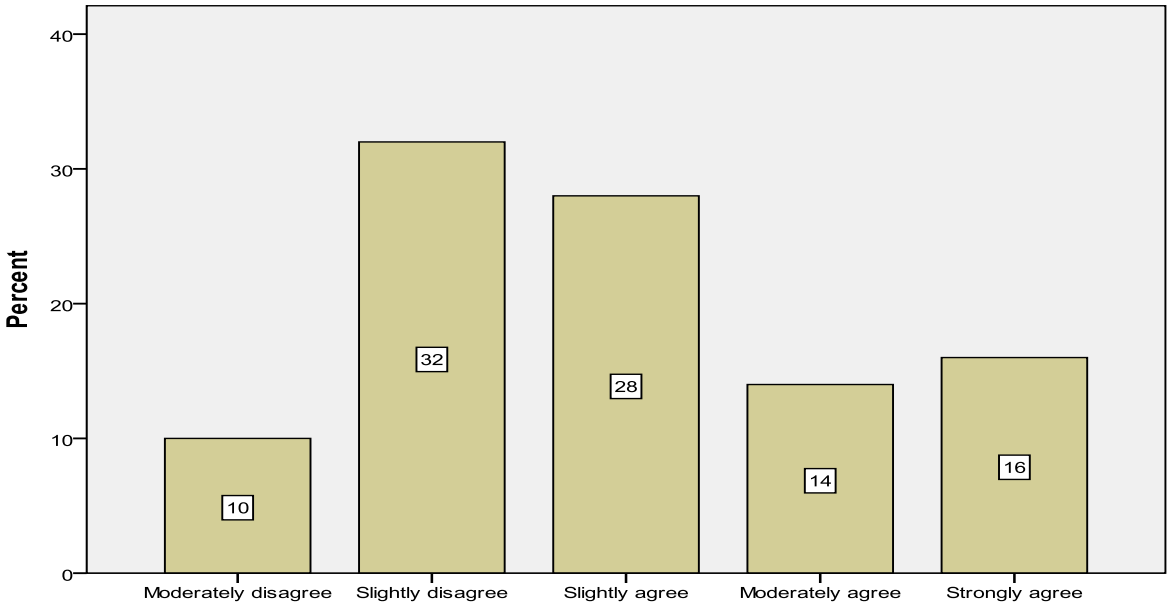

Figure 13: Smart Meters Have Adverse Health Effects

From the review of emerging literature on smart metering, it was revealed that rollout of smart meters is expected to bring change in the life-style and energy consumption habits of the people and will facilitate reduction in greenhouse gas emissions. However, the analysis of

data collected through survey revealed that collectively 60% of the survey respondents believed that smart meters had no substantial impact on the life – style and energy consumption habits of the people. Only 18% strongly agreed, 12% moderately greed and 6% slightly agreed that smart meters could affect lifestyle of the people (Fig. 14).

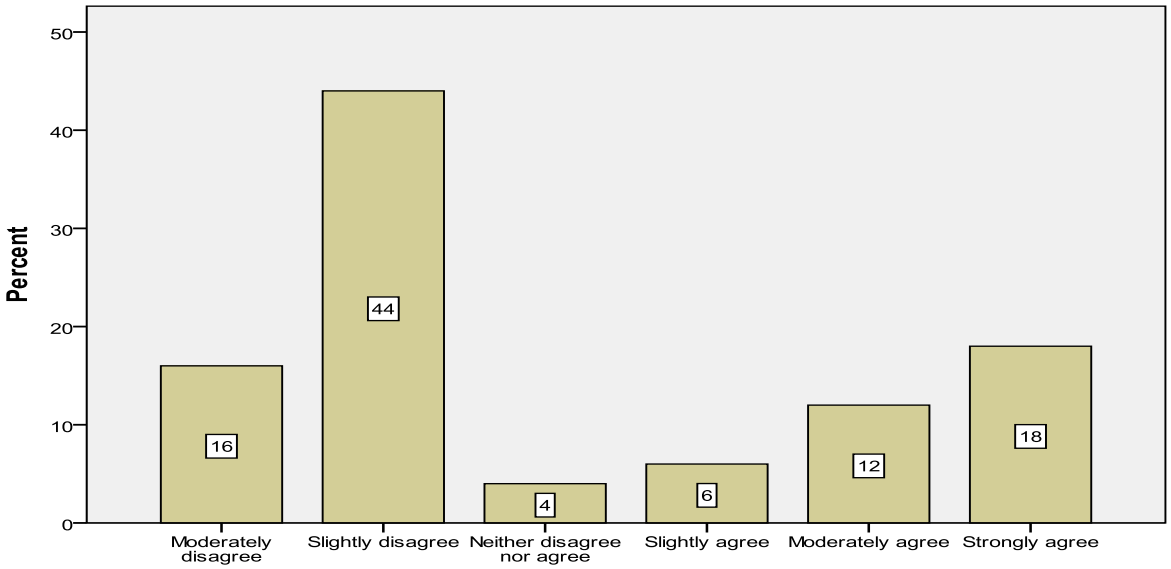

Figure 14: Smart meters have substantial Impact on people's lifestyle

The consumers are concerned about the use of energy consumption data and privacy issues related to this data. The analysis of data revealed that most of the people (i.e. 64%) had no idea about the privacy issues linked with the use of smart meters. However, 20% (i.e. 4% strongly agreed and 16% moderately agreed) to the privacy issues related to the use of smart meters (Fig. 15). On the other hand, 12% moderately disagreed and 4% slightly disagreed with the presence of any privacy issues due to the use of smart meters. However, these issues were not significant as only 28% of the respondents were concerned about the privacy issues arising from utilization of smart meters (Fig. 16).

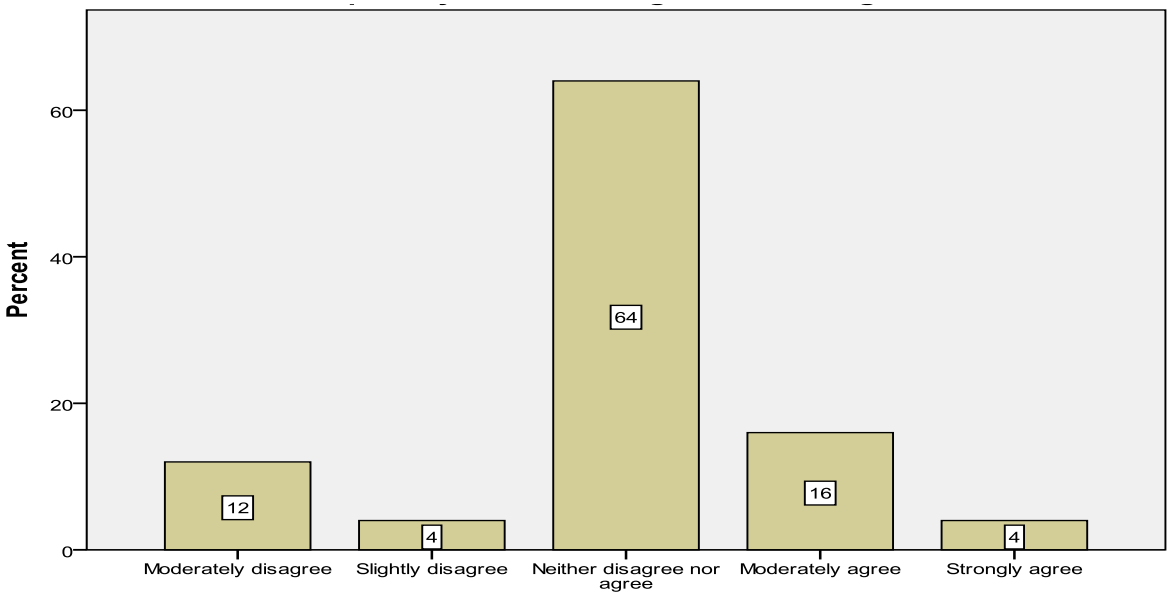

Figure 15: Awareness of privacy issues arising due to usage of smart meters

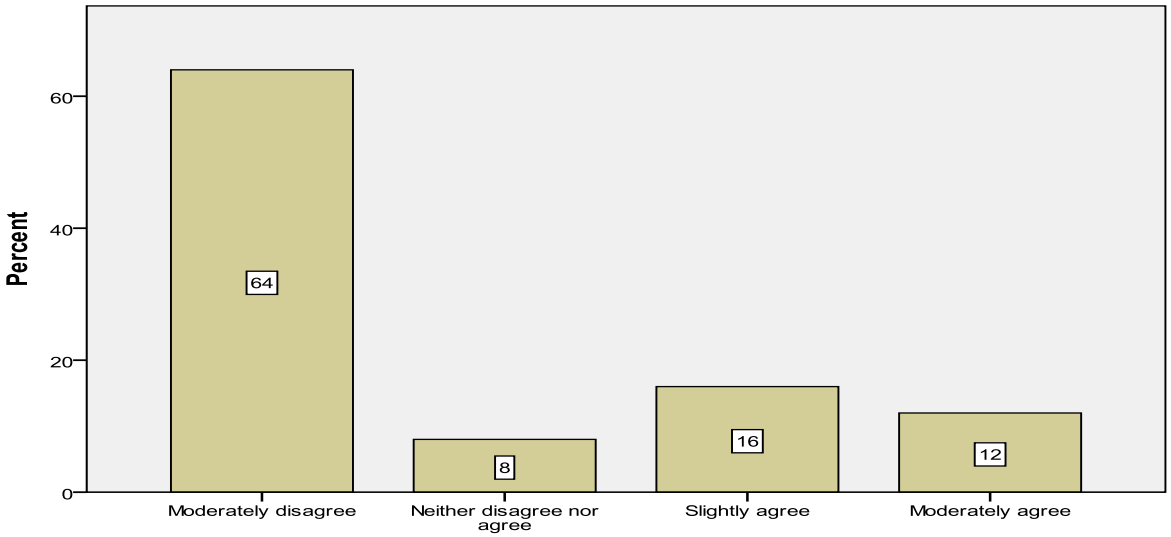

Figure 16: Concerns regarding the privacy issues arising due to usage of smart meters

Only 16% of the respondents moderately agreed that smart meters will help in reduction of the carbon footprint. 52% did not know how to respond to this question while 24% moderately and 8% slightly disagreed that smart meters will play any role in reduction of carbon footprint (Fig. 17). After getting information about smart meters, 52% of the respondents moderately agreed that they would get smart meters installed in their home as illustrated by the figure (Fig. 18).

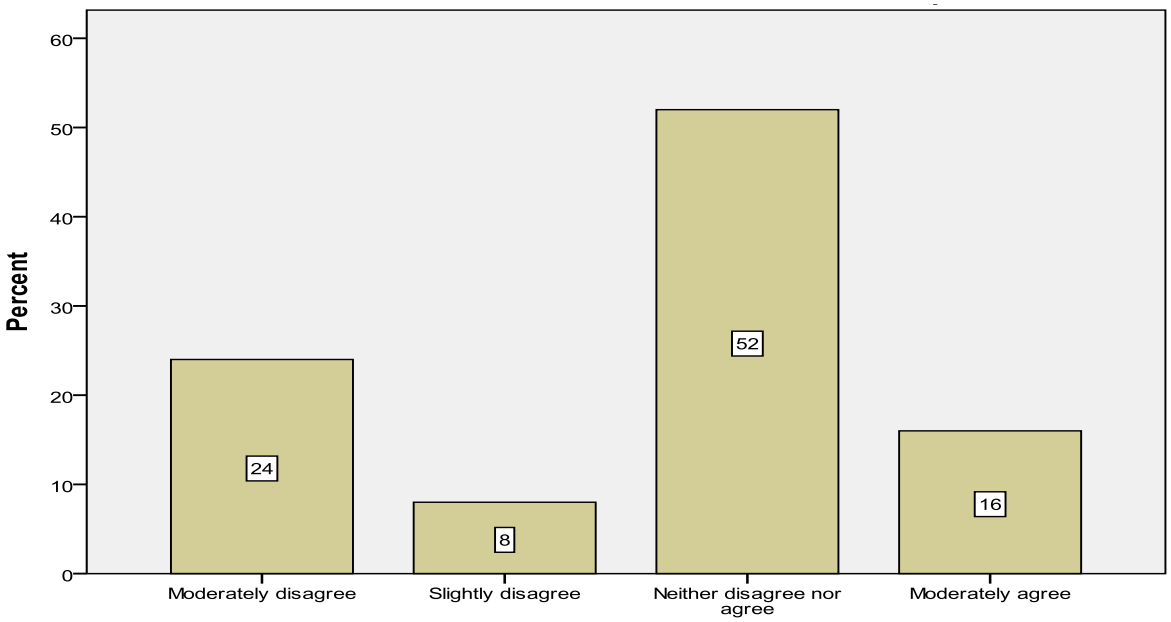

Figure 17: Reduction of carbon footprint due to smart meters

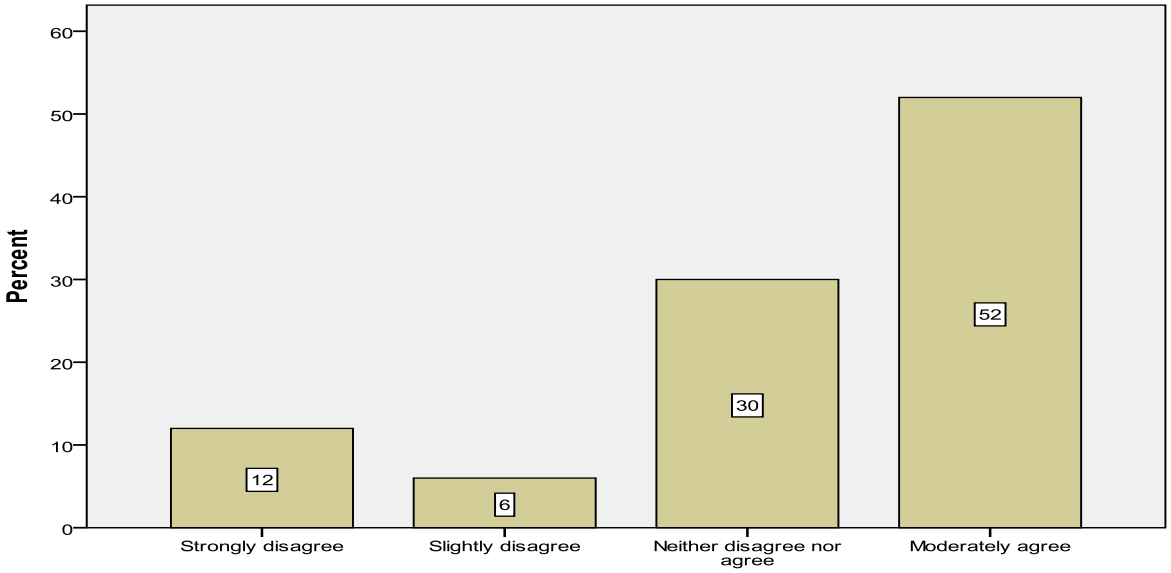

Figure 18: Installation of smart meters at your home

4.2 Analysis of Qualitative Data

An open ended questionnaire (Appendix I) was used to conduct interviews with ten people, two from each of the five city centres selected for conducting the online survey. The main aim of these interviews was to get in depth information about the awareness of the people regarding smart meters, their benefits, potential disadvantages and consumer's perspective regarding use of energy meters, taking readings, tendency to save energy and willingness to get smart meters installed after knowing the advantages of smart meters. The content analysis of the responses from different participants showed that almost half of the interview

participants reported that they were familiar with smart meters because they had get them installed or had heard of these meters from one or the other source. All the participants were aware that smart meters enabled consumers to track their energy consumption and control the utilisation of energy. According to one of the participants, "*A smart meter gives you more access to your gas and electricity usage and also helps you gain more control over usage amount"* (Appendix II). It was also revealed from the analysis of qualitative data that almost all participants were concerned about the high energy bills and the main reason for this concern was the global recession in the recent past. It was found that most of the consumers did not check their meters to keep record of their energy consumption but most of them wanted to track their energy consumption and control the energy bills, especially during winter when the energy consumption is relatively higher. Most of the participants were not clear about the way a smart meter functions but they wanted to minimise their energy expenditure. From the qualitative data, it was also concluded that most of the participants showed consent to get smart meters installed at their homes to keep record of their energy consumption and minimise the energy wastage. The results revealed by content analysis were in conformity with the results obtained quantitative analysis of the data collected through online survey.

5. Discussion of Data and General Overview

Keeping in view the aims, objectives and main research questions of this study, the data analysis has provided answers to the main research questions. This chapter also discusses the way the main objectives of this research have been met. The first object was to raise awareness and provide more information about smart meters which has been achieved through the review of literature covering introduction to smart metering, potential benefits and pitfalls of smart meters, concerns of consumers about smart meters, working of smart meters and major aspects of the smart metering rollout in the UK. Moreover, the economic feasibility was also discussed in light of the estimates of costs and savings expected from the smart metering rollout that has to be completed till 2019.

The data collected through the survey questionnaire and its analysis clearly revealed that awareness about the smart meters is not very widespread. Only 14% of the respondents had a smart meter installed and had any awareness about its use and function. It was concluded that smart meters were beneficial for the consumers because they allowed the consumers to keep track of their energy consumption and control or minimise the energy consumption to save money. The majority of respondents reported that their electricity bills were reduced after installing smart meters. These results confirm that smart meters will enable consumers to control their energy usage and avoid energy wastage due to its ability to provide continuous record of the hourly energy usage. Moreover, no difference was found in energy bills when the participants changed their energy supplier.

Regarding benefits and concerns of smart meters, it was concluded that the UK population had little knowledge about the working of smart meters and their usage. The results of data analysis can be generalised to whole of the UK population and it can be concluded that most of the population considered the installation of smart meters economically feasible. They considered that smart meters were secure to use; they helped consumers save money by enabling them to control their energy consumption habits and overall, the installation of smart meters will benefit the energy consumers in the UK. It was also concluded that most of the UK population supported the installation of smart meters, considered it important to enhance overall energy consumption efficiency and supported the smart metering rollout by the UK Government. They were of the view that the installation should be made compulsory due to the potential benefits of the smart meters. Moreover, it was also concluded that very few privacy related issues were associated with installation of these meters. Most of the

participants disagreed with the harmful effects of using smart meters on the environment. The results revealed that the energy consumers in the UK did not confirm the role of smart meters in reducing carbon footprints; they were of the view that carbon emissions will not be reduced as it was very difficult to control the energy consumption habits keeping track of the energy consumption with the help of smart meters. This finding puts a serious question mark about the goal of smart metering rollout to reduce carbon emissions.

5.1 Potential disadvantages of smart meters

5.1.1 Health and safety hazards of smart meters

In North America, with respect to public health and electromagnetic fields (EMF) and radio frequencies (RF), smart units and their technology have been blamed for inducing sleeping difficulties, stress, headaches and cardiac problems. However, lead sheeting placed around a smart meter can help to eliminate the EMF and RF problems via Electromagnetic Sensitivity (ES) (Elwart, 2013). The World Health Organization officially recognized that wireless radiation such as emitted by smart meters is a possible carcinogen with short- and long-term effects (WHO, 2011). Smart appliances will be extremely dangerous (accumulatively), especially when used in addition to all other wireless devices (cell phones, Wi-Fi routers, baby monitors, cordless phones – up to 30 devices that emit pulse radiation). Smart units can also become an incendiary problem (Elwart, 2012a). If one considers that a wireless smart meter is as safe as a mobile phone and these are in general use by most of the population (in the UK since 1985), then one also needs to realise that mobile phones are not at all safe, due to the aforementioned EMF and RF problems, notwithstanding EMF and RF problems with transmission masts. However, mobile phones too close to a human body for long periods is dangerous - whereas, smart meters are not in close proximity to the body if they are at least 1 metre away. It is a weak argument, because like Wi-Fi, RF and EM are everywhere (Doyle, 2011).

5.1.2 Environmental hazards of smart meters

Anthropogenic global warming via an increase in the average temperature of the earth (planet warming) has been caused by man through industry, vehicular commuting, and the over consumption of electricity. Electricity is generated primarily by natural gas and coal fired power plants that emit CO2, which contribute to global warming. North American research demonstrates that EMF and RF from smart meters may be contributing factors to the absence of plant pollinating insects in domestic gardens, such as absence bees, butterflies, hummingbirds and other small insects. Colony Collapse Disorder (CCD) is also experienced by bees in beehives as well as damage to other insect colonies (Elwart, 2012b).

5.1.3 The North American economy and smart meters

Anecdotal information notes that cost-savings regarding smart meter technology is based upon a drive towards total domestic energy independence (way from expensive foreign energy sources) by economising on domestic electricity consumption. Smart meters are just

one part of a North American governmental scheme to reduce dependence on foreign fossil fuels. Less electricity will be consumed in homes and businesses; the extra power plant capacity will be used to power electric cars.

5.1.4 The UK economy and smart meters

Replacement (instalment only) of circa 53 million meters (gas and electricity) by smart metering devices within the UK might cost more than £11 billion in year 2014 (Cornish, 2012).

Privacy invasion via smart meters

Smart meters are distrusted with respect to the invasion of privacy. Insurance companies could monitor household use of electricity with respect to the movements of the family and might sometimes infer that people are not at home in the night-time, hence, they may be out imbibing alcohol and simultaneously driving a motor vehicle, which would augment their insurance risk and premium (Elwart, 2012b).

Woudhuysen (2012) is calling the new smart meters, "guilt" meters, because domestic users may be chastised for their personal energy consumption rates in an energy conscious society using mass psychology techniques of behavioural economics with these new Big Brother machines watching andvobserving our socioeconomic movements. Woudhuysen (2012) describes that the devices are about socially focusing people's common thinking with respect to energy and its use and the machines are about elevating public awareness. Woudhuysen (2012) warns that behavioural economics does not work and that the new machines are not at all smart in terms of domestic household economising.

Does a smart meter allow my energy supplier to limit my energy use (also known as load limiting)?

No energy supplier currently uses load limiting; they are committed to not using load limiting without notifying Consumer Focus and OFGEM. The latter considers that this could have an identical impact disconnection of your supply, hence, introduced new consumer protection rules on this area on interest (October 2011). Consumers can contact the Citizens Advice Customer Service with respect to offerings or experiences of load limiting.

Technical possibilities with a smart meter

At present electricity is freely available with no limitations on amount of usage (as long as the bill is paid). In future, smart meters will enable energy suppliers to offer less expensive tariffs with a ‘load limit’ (this function is handy for cases of debt). In having this type of tariff energy suppliers could limit the amount of electricity that one can use at any one time (such as a very low level of electricity, as in, enough to power lights, a refrigerator and television). An energy supplier could also, in agreement with the consumer, put a limit on the amount of usable energy in a given period (per day or per week). This is called ‘load limiting’. As aforementioned, none of the energy suppliers are currently using load limiting (Citizens Advice Consumer Service, 2013).

Will smart meters make it easier for suppliers to disconnect me?

Consumers are always well advised to contact their energy supplier as soon as they realise that they may have difficulty with paying a bill. Debts can build-up and become increasingly difficult to pay off if they are ignored for too long a time period. A supplier must help if a consumer has difficulty in paying a bill; they will likely offer some different options for refunding any outstanding amounts (Citizens Advice Consumer Service, 2013).

Will energy suppliers be able to control specific appliances in my home?

The current situation concerning controlling specific appliances is as follows:

1) A normal smart meter would not control any specific appliances within a household, such as turning off a dishwasher. This type of appliance control requires additional smart technologies to be installed in the home (smart appliances or smart plugs) and, strictly with your consent as part of an additional service.

2) With respect to appliance control trials, this type of technology is not yet widely used in Great Britain, but some energy suppliers are currently pursuing trials in this respect. One energy supplier has performed a customer trial of smart refrigerators that are able respond to signals from the National Grid. Effectively, they shut down for short periods when electricity demand is at its highest, theoretically, with no effect on performance or changes in food hygiene. This is beneficial in aiding continuation of electric lighting for all consumers and can keep costs down, because less new generation and distribution equipment (substations, cables, overhead lines) would be required. As aforementioned, this would only occur with consumer consent.

3) Smart technologies (of which smart meters are one aspect) and possible future uses of appliance control may (in future) make it possible for energy suppliers to control the quantity of electricity flows to certain appliances in households (i.e. refrigerators, air conditioning, pool pumps, etc.). Suppliers may offer less expensive deals or special appliances to consumers willing to allow those suppliers to switch off or reduce the quantity of electricity that appliances use, when high energy demands pervade the Grid. However, solely a smart meter is insufficient for this to occur and any decision rests with the consumer on decisions to sign up for these kinds of deals. With such offers, the benefit to consumers is that it helps them to reduce their energy use without changing their lifestyle; which might lead to lower bills, and offers of a cheaper deal or cash incentives from suppliers may ensue from this control.

4) Some suppliers are also running trials on customer appliance control (i.e. consumers may be able to remotely turn off and on their heating systems when they vacate their property by using their mobile phone, but requires additional equipment, or controls fitted to the heating system.

5) In what follows is some advice for consumers with respect to appliance control trials:

These types of trials are offered on a strictly opt-in basis and are not yet widely available in Great Britain. There are, currently, no specific consumer protections with respect to these types of offers, hence, before signing-up for a trial, interested consumers must get the following information from the energy supplier:

a) Is there a charge for the smart appliance or smart plug, and, if so, how much is it?

b) What happens if the consumer wishes to end the contract, or does not appreciate the deal? Will they face a penalty fee to exit, and if so, how much is it?

c) When and how often are suppliers most likely to expect to control consumer appliances?

d) How this system function? Will consumers notice any difference? Remote control of some appliances, such as refrigerators may not be noticeable to the consumer, whereas control of tumble dryers would be.

e) Will consumers be able to override the energy supplier's control and use the appliance if they wish to?

f) If a consumer overrides the control – how will this operate? Will they face a penalty fee or a higher charge, and if so, how much?

g) If consumers have problems or questions, where do they look for help and is there a 24 hours help line facility?

h) What happens if the appliance is switched off longer than normal and this results in problems (spoiling of refrigerated food)? What compensation will consumers receive?

i) Who is responsible if there are problems – the consumer's energy supplier or the manufacturer of the appliance?

The response to all of these points (a-i) is that, if the supplier is supplying the new appliance, then consumers must verify its size and whether they will need to perform installation work in their household.

Smart meters and old people

With respect to smart meter technology and people over 60 years of age, one might question how they might be affected, in that, perhaps they cannot understand nor can they use this new system. Also, many old people might, surely, be very cautious and frugal upon the realisation that using any particular energy commodity could be accounted for in terms of their home economics. Maybe, upon realising the cost of using a heating radiator in their home for 30mins, perhaps they would stop using their heating system during the colder winter period and then increase the risk of contracting hyperthermia. The smart meters to measure gas and electricity use may disadvantage poor and elderly people, because it would become easier for utilities to cut off a consumer's gas and electricity supplies without entering the property. Proper legal safeguards need to be implemented in order to ensure that there are regulations

in place to protect the vulnerable, elderly and the impoverished, to ensure they benefit from the new system (Morales and Airlie, 2012).

In North America, where teething troubles of smart meters have already been seen, a handicapped woman in western Ohio refused to allow the local power company to install a "smart meter" on her property. It was winter time and, as a result, she had no power for heating, until her old analogue meter was restored (after media and municipal intervention). The woman had originally wanted written confirmation from the electricity company that the electrical signals from the new meter would not interfere with her pacemaker, but she never received the guarantee, because the company was unable to assure this (Opelka, 2013).

Awareness in the UK and smart meters - statistics

In the UK in late 2012, fifty per cent of the general public are still unaware of what smart meters are, according to a survey commissioned by the Department of Energy and Climate Change (DECC). UK public support for smart meters also remains unchanged, with 29 per cent still in favour of the nationwide roll-out, while 19 per cent of respondents in the survey oppose it. Interest in smart meter installation is four in every ten people. However, interest has increased in those wishing to obtain information on smart meters. Fifty per cent of the people in the survey expressed that there was a paucity of information (compared to a third in the previous survey). Also, younger and larger households in the survey tended towards support of smart meters and expressed more interest in them. However, the older generation had lower level of engagement (Utility Week, 2013).

5.2 Potential benefits of smart meters

5.2.1 Smart meters and the UK carbon footprint

The introduction of metering technology will not be a general panacea for Britain's commitment to complying with its year 2050 carbon emission target; however, without smart meters, the target might not be met at all. In this respect, Lord Stern (Stern, 2006) reported on the economics of Climate Change, warning that we will be too late to repair the damage of former periods of environmental negligence (Umbach, 2008). Smart meters are an important portal for energy suppliers and can improve market operations via improved paths for energy management and finding new retail opportunities. Smart meters are also good for small and medium enterprises (SMEs) and domestic households in order to economise on energy consumption via ameliorated feedback on energy consumption and outgoings (economic) (Owen and Ward, 2006: 4; Energy Review, 2006; OFGEM, 2011; Department of Energy & Climate Change, 2013).

Addressing Consumer Protection Issues

A Consumer Protection programme is set up for users of smart meters which begin to roll out in 2014. Consumer Protection will safeguard early installers against the smart metering programme being undermined by poor foresight and a weak consumer protection framework.

It will also monitor any poor performance of suppliers in sales, marketing and information provision in energy supply to check on trustworthiness for the future (OFGEM, 2011b).

Consumer savings by having a smart meter

Installation of a smart meter is not an immediate guarantee of economising on expenditure, but depends upon the motivation and habits of each consumer and careful use of information the smart meter or energy display, in order to calculate where one is able to make reductions in energy use with respect to fuel bills. People who are already conscientious about energy efficiency might find it more difficult to make savings using a smart meter. Other methods to save money on energy bills will be via energy efficiency measures, changing the energy supplier, or by changing to a cheaper payment method. Certainly, it will be less expensive to pay monthly (direct debit) rather every quarter by cash or by cheque. Also, suppliers of smart meter are obliged, even now, to provide free energy efficiency advice to clients. This may come in the form of an offer of a cheaper tariff or free energy efficiency help with measures (insulation, for example) (Citizens Advice Consumer Service, 2013).

Does having a smart meter make it easier to switch me to a prepayment meter (PPM)?

Starting in year 2014, smart meters will facilitate switching between credit and prepayment modes. Hence, if one wants to change from a 'credit meter' to a 'prepayment meter' then the meter does not need replacing; this can be performed remotely by the energy supplier. The energy regulator, OFGEM, must publish new regulations to ensure customers are only given a PPM if it is pertinent for them.

Are smart meters convenient?

Energy suppliers now have to make sure it is safe and practical for a customer to use a prepayment meter; the energy supplier must put themselves in the consumer's shoes. Hence, OFGEM says that suppliers must check, for instance, the following points:

i) That consumers understand and can operate PPM and add more credit via top-up points (i.e are they physically or mentally disabled?);

ii) That consumers live close to or far from any top-up outlets;

iii) Whether consumers require a continuous supply for health reasons, such as dependency on medical equipment requiring an electricity supply?

iv) Whether the PPM is situated in an unreachable position (i.e: high on a wall) that means the consumer could not operate it?

v) Whether the PPM has to be located at the exterior, or in a room that the household has non continuous access to;

If a change in the consumer's circumstances means that it is no longer safe and reasonably practicable for them to use a PPM, the supplier must then: re-locate the PPM to a position where it is safe and practicable; Or offer the consumer another payment method (ie. a credit meter);

7. Conclusions

To generate and then distribute energy (power) in an increasingly efficient way, with great reliability and transparency, energy suppliers (utilities) are currently looking for more control over electric grids and power demands. Suppliers also wish to provide consumers with information that helps them to make decisions energy saving (Glória, 2010).

Smart meters are being introduced globally, despite objections. The UK is expecting to complete the installation of about 27 million domestic electricity smart meters by 2020. The primary aim of the UK in introducing smart meters is to provide energy consumption and electricity price information to consumers so that they would volunteer to reduce demand or shift demand to a period where the price is low. This information will be presented to the consumers through an 'In Home Display'.

Smart meters are aimed at aiding power system operations and control. During power system emergencies, domestic appliances will be controlled remotely using Direct Load Control (DLC) commands transmitted by an energy supplier or the demand-response aggregators. Within a property, the DLC commands will be transmitted to the appliances via a Home Area Network created by the smart meter and appliances in each property (Samarakoon, 2012).

A Home Area Network (HAN) is necessary to manage the energy utilisation in the household. A Consolation Entity is necessary, too, in order to fairly distribute and manage (using collaboration) available grid energy. These elements would be important when more renewable sources would be introduced in greater abundance in the future, such as wind, wave and solar power, because these elements have a variable availability (Bean, 2010: ii).

8. Recommendations

In light of the results obtained from data analysis and conclusion, the following recommendations are formulated to enhance awareness regarding smart meters, their benefits, effective utilisation, consumers' concerns and benefits of these meters for the UK population.

In order to enhance the effect of potential benefits of smart meters for the energy consumers, the meters should be installed in limited numbers and their efficiency for the proposed benefits should be empirically tested. It will allow the government to enhance the effect of a smart metering rollout promotion program that consistently emphasises upon the potential benefits for the consumers.

There is a need to educate people regarding the smart meters, their purpose and working principles. The government should take steps to increase awareness regarding smart meters and their benefits on a national level.

The concerns of the consumers should be addressed before complete implementation of a smart metering rollout in the UK. The primary concerns are regarding the privacy issues due to the transfer of utility data and energy consumption patterns along with the impact of smart meters on energy consumption and people's lifestyles.

Moreover, it is also recommended that the government review its carbon emission reduction goals as set in the present smart metering rollout because the results of the study indicate that the UK population is not convinced that these meters will contribute towards carbon footprints.

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