Smart Energy Management: Supporting a Step Change in Local Authorities

Marouane Azennoud

Supervisors:

Prof. Mark Lemon
Prof. Richard Bull
Dr. Graeme Stuart
Dr. Darren Perry

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Institute of Energy and Sustainable Development (IESD), Faculty of Technology, De Montfort University (DMU), Leicester, UK

February 2019

Abstract

The concepts of Smart Cities in general and Smart Solutions in particular have emerged during the last decade. A review of the related literature to these concepts has come to the conclusion that ‘Smart’ is most of the time linked to technological solutions. This is why the Smart City focuses, in a first instance, on the use of technologies for facilitating the management of the different aspects of the city, one of which is energy. The latter is putting organisations under much pressure as on one hand prices are increasing, and on the other, these organisations are compelled to reduce their carbon emissions which can be achieved by decreasing their energy consumption. Hence, there is a great focus on energy management. This thesis focuses on one aspect of the Smart City which is energy management. It deals with the concept of Smart in a specific setting, Local Authorities (LAs), and for a specific aspect which is energy. It addresses the need to identify what Smart can mean in this setting, the change and associated transition it brings to these organisation and how it can improve energy management in order to identify what is meant by Smart Energy Management (SEM).

The thesis adopts a mixed methods approach to address the research aim and objectives. The data has been collected in two main phases and using different tools. The first phase consists mainly of interviewing heads of energy management or their representatives from each type of LAs in the UK, and when possible from outside of the country, to explore how the energy management practice is applied in their respective authorities and what additions ‘Smart’ technologies (like smart meters) are bringing. These data are analysed depending on a set of themes identified in the literature review. The results of this analysis inform the second phase of data collection which consists of an in-depth case analysis of the process of incorporating energy management into a Local Authority and identifies how smart technologies are used for facilitating the application of this practice. Two main data collection instruments are used. The first one is a set of semi-structured interviews with key energy management stakeholders such as heads of energy management, energy managers, building clerks, budget holders and Councillors. The second is a content analysis of corporate documents including the energy management system (EnMS) of the case study Local Authority, energy and metering contracts and periodic energy related reports. The researcher has also sent a questionnaire to the participants in the 1st phase to report and validate the findings with them.

The findings from this research support the development of a Smart Energy Management framework for Local Authorities and identify the different factors that can enable its embedding within these organisations. The first group of factors are at the macro level and include legislation & Central Government policy, Central Government financing opportunities, and how the public sector can lead by example. The second group is at the Meso level and includes the support and endorsement of top management of the organisation. The third one is at the Micro level and covers the availability of high-resolution energy data, highly qualified and motivated members of staff. The final group of factors is embedded in the organisation and includes cultural change.

The thesis concludes with recommendations for future research.

Papers Published

- Azennoud, M., Stuart, G., Bull, R., Lemon, M., and Perry, D. (2017) Smart Energy Management: How Does the Use of Smart Meters Help in Achieving Energy Savings: Case Studies from Two Local Authorities in the UK. *ECEEE Summer Study Conference Proceedings 2017*. pp 657-666

- Azennoud, M., Bull, R., Lemon, M., and Perry D (2017) How Can the Process of Adopting Energy Management in Organisations Inform Water Management Practice. *Journal of Clean Energy Technologies,* 5 (5). pp. 417–421.

- Bull, R. and Azennoud, M. (2016) Smart Participation- Social Learning: A Model of Participation. *Energy – Proceedings of the Institution of Civil Engineers,* 169 (8). pp. 93-101.

Awards

The collaboration between De Montfort University and Northamptonshire County Council which formed part of this research received a Green Apple Award.

Acknowledgements

This research was conducted at the Institute of Energy and Sustainable Development at De Montfort University, Leicester, UK, in collaboration with the Energy & Carbon Management Team, at Northamptonshire County Council, Northampton, UK.

First, I would like to pay my deepest gratitude and express my greatest appreciation to my supervisors: Prof. Mark Lemon, Prof. Richard Bull, Dr. Graeme Stuart and Dr. Darren Perry. I thank them for their dedication, guidance and belief in my abilities. It has been four years full of challenges and they were always there to assist me with my research. I thank them for making it an enjoyable experience for me. Special thanks go to Prof. Mark Lemon for assisting me and encouraging me in very difficult moments.

Second, I would like to dedicate this thesis to two of the most important people in my life; my beloved parents: Prof. Abderrahman Azennoud and Ms. Anissa Benmoussa. They have both provided me with unconditional encouragement, support, love and guidance. I thank them for them prayers and long nights reading and correcting this thesis. My gratitude goes also to my dearest three brothers: Bilal, Khalil and Yassine for their continuous support and love and to the rest of my family for their encouragements.

Third, I would like to thank a person close to my heart, Dr. Darren Perry. He has been like a second father to me, a mentor, a manager and a supervisor. I thank him for all the support and guidance since day one in this country. This work couldn't have been accomplished without his tremendous help.

Fourth, my gratitude goes to the people who participated in the interviews and questionnaires for this research. It required a lot of time and efforts from their part.

Fifth, thanks and appreciations go to Northamptonshire County Council which was home to my research including my colleagues: Aiden G, Paul T, Aiman S, Eamonn B, Philip G, Phil J, Laura B, Laura D, Ru R, Jasper F, and many others for their continuous support.

Finally, special thanks go to my dearest friends for their generosity, constant encouragement and energy.

Table of Contents

Table of Figures

List of Tables

I	Chapter Aim	Activities
	General Introduction	
	To locate the research within the new concept of 'Smart' and link it to Energy Management	- Concepts overview and scene setting - Research aim, objective, question & structure

Chapter I: General Introduction

This chapter is devoted to exploring the concept of Smart Cities and linking it to energy in general and to the practice of energy management in particular. First, the chapter defines the notion of 'City' and the changes it went through until it reached the current state which is 'Smart Cities'. The researcher then gives the rationale behind including this concept showing its relevance to the research. The concept of Smart City is introduced and explained in this chapter to give an overview and to position the research in the current innovation environment despite the fact that 'Smart City' is not the focus of this study. The main concepts of this study, i.e. energy management in Local Authorities and the use of high-resolution energy data, are later introduced and explored in the following chapters.

1.1. Introduction

According to the United Nations, cities in 2014 were home to half of the earth's population (i.e. around 54%) and is expected to rise to 66% in 2050 (the United Nations, 2015). Cities are home to large energy consumers such us buildings. The energy consumption of buildings was estimated at 20.1% of the world's consumption and is expected to increase by 1.5% yearly between 2012 and 2040 (Energy Information Administration, 2016). This shows that there should be a focus on energy management of buildings be it for a small setting like a school or a large one like a

Local Authority or a city. In the United Kingdom (UK), a Local Authority is a local government responsible

> "*for a range of vital services for people and businesses in defined areas. Among them are well known functions such as social care, schools, housing and planning and waste collection, but also lesser known ones such as licensing, business support, registrar services*" (Local Government Association, n.d.)

This chapter is devoted to defining one of the biggest systems and grouping of buildings which is a city, introducing the different city management strategies and concepts and focusing on the ones which highlight the importance of sustainability and energy management in a complex environment. Then, the chapter introduces the concept of 'Smart Cities', which is one of the latest developments for this system, and explains how this influences energy management and energy building management. Finally, the research focus, question, objectives and approach are detailed. This is summarised in Figure 1:

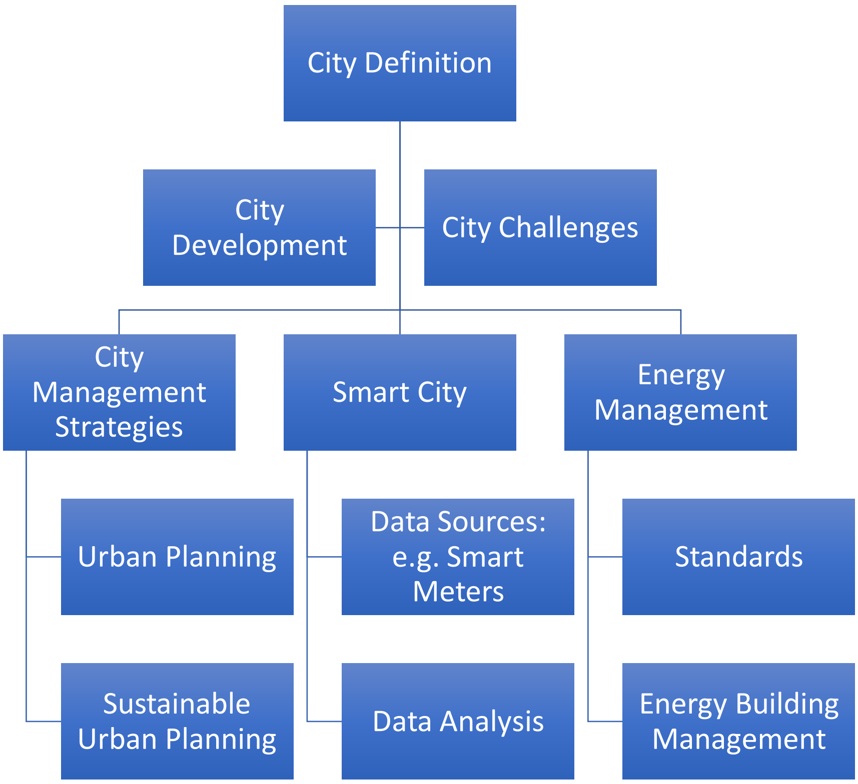


Figure 1: Chapter Structure and Main Topics

1.2. Introductory Perspective

1.2.1. Brief Overview of the Development of the City

The urban theorist Lewis Mumford defines the city as "a geographic plexus, an economic organization, an institutional process, a theatre of social action, and an aesthetic symbol of collective unity" (Mumford, 1937, p.94). This means that the city is a human settlement in a defined geographic/physical environment with some specificities and characteristics. The different interactions between humans, be they for social or economic reasons, form a society (collective unity) with its unique traditions, culture and most importantly with its social stability. This settlement is governed by the rule of law and its prosperity is dependent on the creativity and the manpower of its citizens. This being said, each city has its own characteristics (geographic, social, institutional and economic), and cities will always differ from each other (Duranton and Puga, 2013). This is why it is very important to approach each city as a specific/unique case when preparing plans for their managing.

Ancient cities were developed by the settlement of humans around sources of food (National Geographic, n.d.); the city's creation and development were influenced by economic factors such as the location of water sources namely rivers or lakes, agricultural lands, markets and the main routes of trades (Ellis, n.d.). Its buildings were organised in a way they were located around temples or palaces (Smith, 2007).Though, historians have always debated about characterizing ancient settlements as villages or cities. In 1950, The archaeologist Vere Gordon Childe defined the criteria to distinguish ancient cities from ancient villages. These criteria are:

- The population of cities had to be larger than the population of previous settlements
- Not all citizens have to be peasants but should have different specialties (jobs)
- Payment of taxes goes to a king or an imaginary deity
- Construction of monumental public buildings is achieved from the collected taxes and the social surplus
- Citizens who do not grow their own food are supported by the king

- Adoption/creation of systems of recording
- Adoption of systems of writing
- Art development
- Importation of raw materials for local industries
- Foreign craftsman can belong politically and economically to the city

Cities are undergoing continuous evolution and today they look very different from the ancient ones. However, their different roles have not changed and the characteristics of ancient cities are still retained today. Cities are still seen as centres of business, trade, labour and culture, but with time, they started turning into places of innovation (living labs as an example): "the city is a core paradigm for the mankind, where trade, technology, art and culture converge in designing and building the solutions to the civilization risks" (Andone et al., 2014, p.1). With the evolution of cities, urban life started creating pressure and presenting many challenges for both the administrators of the city and its residents, challenges evolving from different sectors which have as a primary role to serve the citizens and make their life easier. Cities, nowadays, are providing a variety of services to its citizens; these range from jobs, transport, and health care to food, waste management, leisure centres and education. Each one of these services needs an authority which will have to manage the system put in place to deliver the required service. Having different authorities and management systems creates difficulties since each authority has its own agenda that might not serve another authority's agenda; these difficulties can be a challenge to the Local Authorities in their day to day service delivery and in their duty of keeping the city functioning as it is supposed to be. This is known as silos and the issue is that they cause managers or employees to focus insularly on the agenda of their authority/team/department (Pattison, 2006). Cities can have different governing bodies and can be labelled as a municipality, a borough council or any other type of local authorities depending on the constitution of the country and its legislation. This will be examined in detail in Chapter IV. One way to overcome these silo structures or silo thinking in governments or municipalities or any public agency is through the development of cross functional projects which require different departments or services to work together to achieve the intended project goals (Van der Wadlt, 2007).

The pressures put on the different authorities will keep growing since the population of cities is rising with time and authorities should look for new ways to generate resources other than taxes.

1.2.2. Challenges Facing Cities as Complex Systems

A complex system is “literally one in which there are multiple interactions between many different components” (Rind, 1999, p.105). The growing population, migration and changing social structures are not the only major challenges facing the senior management of cities. There is another challenge which is also related to or can be a direct impact of the growing population of the city. This challenge is the increase in the use of resources like fossil fuels. As an example, the population of cities which is 50% of the earth’s population consumes 75% of the generated resources (Aoun, 2013). Additionally,

> “*The growth and operation of cities and urbanized areas absorbs roughly three-quarters of the world's fossil fuel production. This is a staggering amount given that fossil fuels supply 85% of total global commercial energy use – and their use is increasing at a rapid rate*” (Droege, 2002, p.87).

This urban growth is having a negative impact on the environment: “the city in its current form is the outcome of an era marked by the seemingly inexhaustible availability of cheap fossil fuels” (Huber & Mayer, 2015, p. 817). Knowing that the world reserves of these fuels are decreasing and their prices are fluctuating leads authorities to face a budgeting challenge which is mainly about securing the availability of these resources at a reasonable price without putting pressure on the annual budget of managing the cities. This also includes plans to use these energies (resources) in an efficient way. Therefore, there is a need for new economic models to be adopted or adapted by the cities to finance new methods for resource management (encouraging efficiency and recycling, etc.) and this can be facilitated by mandating national policies which promote and support such business models (The Organisation for Economic Co-operation and Development, 2012).

One advantage of living in a complex system is that these economic, environmental and social challenges make the city a place where different solutions can be tested in order to create systems/strategies which will enhance its management. Throughout history, the cities "have served as centres of innovation, advancement, civilization, and as facilitators of the social interaction necessary for the progress of humankind" (Aoun, 2013, p. 2). However, how do these solutions interact with the strategies and plans which will be or are under development for controlling the growth of the cities and ensuring their survival and prosperity? Additionally, what types of controlled growth are sought for cities?

All the strategies designed to help cities overcome the challenges facing them fall under urban planning and Local Authorities need to have a master plan to manage their cities effectively and efficiently;

> *"A successful city cannot operate efficiently in isolation from its environment. It must balance social, economic and environmental needs. A successful city must offer investors security, infrastructure and efficiency and should also put the needs of its citizens at the forefront of all its planning activities"* (City of Cape Town, 2009, p.54)

1.3. Urban Planning

Urban planning is defined as the "core set of activities that city and local governments undertake to ensure the efficient functioning of urban places to support citizens, communities, and economic activities" (Dodman et al., 2013, p.7). From this definition, it can be inferred that an urban plan takes into consideration all the important sectors and systems which are live in a city. When urban planning fails in delivering its defined goals and solving the issues - facing the city - for which it was designed, then the situation will be aggravated, and the city will face more complex problems; hence, it is very important to take time to understand the real problems and challenges and produce an efficient and effective urban plan.

> *"Poor urban planning and management can have grave results for the urban economy, the environment and society. Poorly managed urban settlements will*

> *be unable to keep pace with urban expansion, and unserved slums will proliferate, bringing with them poor health, poverty, social unrest and economic inefficiency"*(City of Cape Town, 2009, p.54).

Therefore, an urban plan can be described as a holistic view or approach and a solution to lead and manage the city. This holistic approach is widely adopted by local authorities and the governments that oversee them since it is more efficient than sectorial approaches and during these last years, these urban plans are turning into long term strategies (Rapp & Rat-Fischer, 2012) to ensure the sustainability and the continuity of the impacts of the solutions. In other words, urban development should be steered by a sustainable management vision. This has led to the rise of the concept of sustainable urban planning.

1.3.1. Sustainable Urban Planning

The Brundtland Commission states that sustainable development is

> *"first and foremost about ensuring that everybody—both in poor and rich countries, and today as well as in future generations—can have their basic needs met. This must be obtained without jeopardizing the natural systems on which life on earth is dependent. Furthermore, the decision processes leading to such a result must be democratic and legitimate" (Naess, 2001, p.504).*

Aoun from Schneider Electric, which is an international corporation that specialises in energy management and automation solutions, defines sustainability for communities as "one which reduces the environmental consequences of urban life and is often an output of efforts to make the city more efficient and liveable" (Aoun, 2013, p. 4); a community can include from few to millions of persons.

From the above definitions, sustainable urban planning can be described as a long-term plan with a goal to serve the inhabitants of the city by solving their problems and providing the necessary resources to guarantee their well-being and at the same time protecting the environment and the future of coming generations by not overusing the available natural resources. Providing the necessary resources for the success of a sustainable urban plan is also about getting the necessary political and the social support because the solutions proposed by such plans are not always cheap and demand a lot of effort and courage. These plans ensure that the issues facing the city are dealt with in an effective way to avoid delaying their effects or shifting them to nearby local authorities. Thus, a sustainable urban plan can be viewed as another challenge which will make the work of local authorities more complex since they will have to look for innovative ways to be efficient in delivering their services and in their quest to mainly use sustainable resources. It can also be seen as an opportunity to decrease future pressures on the city when the quantity of resources available is diminishing and their prices are increasing. Sustainable urban planning suggests many solutions like providing multimodal transport and encouraging public transport, using renewable resources to generate electricity and different fuels, recycling waste, designing efficient buildings that are in harmony with the surrounding ecosystem, using efficient appliances, reusing urban lands, avoiding going beyond the borders of the city, etc. A sustainable urban plan should emphasize the following five elements (Naess, 2001, p.506):

- Reduction of the energy use and emissions per capita in the area (city, municipality, or region) down to a level compatible with the ecological and distributional criteria for sustainable development at a global level.
- Minimizing the conversion of and encroachments on natural areas, ecosystems and soil resources for food production.
- Minimizing the consumption of environmentally harmful construction materials.
- Replacement of open-ended flows, where natural resources are transformed into waste, with closed loops relying to a higher extent on local resources.
- Sound environment for the city's inhabitants, without pollution and noise damaging the inhabitants' health, and with sufficient green areas to give opportunities for the population to experience and become emotionally related to nature.

Urban planning in general and sustainable urban planning in particular also require communicative and collaborative planning meaning that both the inhabitants and the local population should take part in the planning process. Communicative planning can "transform conflicts of interests into situations where both sides win, and that it is possible by means of decentralized and broad planning processes to arrive at mutual understanding and agreement" (Naess, 2001, p.514). A bottom-up management approach would be best of use to inform the top of the management chain (leaders of the local authorities) of the needs of the bottom of the chain (the inhabitants). Additionally, the local populations are the most concerned about the effectiveness of these plans since this will affect their future and influence their day to day life and the growth of their communities (Mahmudi and Saremi, 2015). Citizens might be the ones who know best their problems and could be the right ones to describe them to the leaders of the authorities. Moreover, the inhabitants will have the power and the right to question the public authorities about their plans for solving the issues facing the city. This bottom-up approach can also be linked to participatory management or participatory democracy where there is equality in decision making meaning that the citizen participation is not only bound to voting to elect their representatives but expands "to wider forms of political expression and to more areas of social life" (Schiller, 2007, p.53).

The obstacle that might be facing the implementation of sustainable urban plans is that Local Authorities' leaders are elected for a defined period and these plans demand more capital and efforts and their outcomes are long term ones, which means that the results might be perceived after the end of the mandate of their leaders. In addition, local authorities -especially in the UK- are facing budget cuts and such plans might not be the top priority as there is a tendency to focus on achieving and fulfilling statutory duties and provide the statutory services (Cf. 5.1.3 for an overview of these statutory duties) to the residents of the region (Morse KCB, 2014). That is why urban planners have to convince the leaders of the authorities about the sustainable solutions they design, and this can be done through focusing on the image the authority wants to promote and the values it wants to share within its legislative boundary. Urban planners are bound to present solutions which have the best value for the territory they are managing even if it will take time to start feeling the benefits of the change.

Planners can also have recourse to existing national plans and targets to back up their choice for sustainable solutions (Naess, 2001, p.517).

1.4. Smart Cities

The rise of the Smart City concept is a continuity of different management strategies used to burst the bubble of challenges facing and surrounding the cities of the world. City management (Angelidou, 2015; Söderström et al., 2014) has evolved over time in order to cope with the daily necessities of the citizens and to face continuous challenges in order to ensure the survival of the cities. There were and are different visions for the cities created and developed to ensure their continuity. These visions have been inspired by the needs of the citizens and/or the development of the industry: they "connect the future of cities with a lavish utopia of a forthcoming mechanized age, inspired by the latest developments in science and industry" (Angelidou, 2015, p.96). Some of these visions or concepts are: Healthy & Functional City (1898), Industrial City (1904), New City (1913), Contemporary City (1922), Walking City, Plug-in-City, Transactional Cities, Wired Cities/Cyber Cities/Information Cities/Digital Cities/Virtual Cities, Knowledge City (Angelidou, 2015).

As there are visions for the cities, there are also management strategies. As an example, Sustainable Urban Planning emphasizes the sustainable growth and development of the city, be it economic, technological, or any other growth and the well-being of the inhabitants. The Smart City concept has emerged to tackle mainly the growing economic and resource management challenges facing the cities through displacing "traditional delivery vehicles for physical and social resources, potentially providing cost effective and innovative delivery channels" (British Standards Institute, 2014, p.1).

1.4.1. The Smart City Concept: Source of Ambiguity

"In contrast to other city concepts such as Green Cities, Eco Cities or Low-Carbon cities, Smart Cities seem to lack a clear and exclusive conceptual content idea" (Huber & Mayer, 2015, p.818). The concept itself is still evolving and, in parallel, a plethora of concepts related to urban planning is being developed, leading to a wide range of definitions which sometimes are not the same but fall under the same group or are connected and linked to each other. On one hand, Smart City is fuzzy: a very broad and vaguely defined concept with different perspectives owing to its multi-disciplinarity. There is no agreed upon conclusive or standard definition (Murray, Minevich & Abdullaev, 2011; Morvaj et al., 2011; Chourabi et al., 2011; Lekamge & Marasinghe, 2013; Vanolo, 2013; Burte, 2014; Manville et al., 2014; Angelidou, 2015; Huber & Mayer, 2015). Hence, there is an attempt "to understand the 'actually existing smart city', rather than the idealised but unrealised vision that often dominates the social imaginary and critique of what a technologically-mediated city might look like in the 21st century" (Shelton et al., 2015). On the other hand, some of the definitions focus on one aspect, ICT as an example, rather than a group of aspects which can include economy, environment, etc. (Höjer & Wangel, 2014). This can be explained by the recent interest of academia and urban planners in the concept:

> *"Little is actually known about the more fundamental principles and ideas underlying the smart city as a model – i.e. as a generic solution to the problems of urban development and management– beyond the self-advertisement of IT companies and municipalities. Until recently the existing literature was also lacking in critical engagement with the exception of an early text by Hollands (2008). However, since 2011, a series of contributions has more critically scrutinized the phenomenon from different viewpoints: political economy, science and technology studies, governmentality studies, and ideological critique, moving research away from the self celebratory climate around smart cities."*(Söderström et al., 2014, p.4).

This leads to the conclusion that "compared to other city concepts, Smart Cities lack a specific content perspective and rather make a difference with regard to change processes" (Huber & Mayer, 2015, p.818). In other words, the Smart City is still a vision or a broad idea that needs to evolve into a structured system with a core universal definition and agenda. Additionally, Smart cities can still focus on utilising ICT; however, the key is to shape the cities using both technology and human initiatives for social purposes (Husar et al., 2017).

1.5. Energy Management

> *"A smart city is a sustainable and efficient urban centre that provides a high quality of life to its inhabitants through optimal management of its resources. Energy management is one of the most demanding issues within such urban centres owing to the complexity of the energy systems and their vital role"* (Cavillo et al., 2016, p. 273)

A smart city manages different aspects that its inhabitants interact with in their day to day activities. These aspects can be as an example and not exclusively, energies like water, gas, electricity and oil or they can be services like transportation, public health, etc. Succeeding in managing energy effectively is crucial for a smart city for the simple reason that all the components of the city rely on the availability of energies; if this is unavailable, the smart city will fail and cease delivering its services. A smart city, and in the sake of managing all its components effectively, should gather all the necessary data and information using different infrastructure and one of them is the smart meter.

1.5.1. The Rise of the Concept of Energy Management

It is difficult to find a definition of Energy Management without linking it to Management Systems which are either developed based on technologies like building management systems or standards like ISO50001:2011. Most of the academic papers found on online databases like IEEE, Scopus or Science Direct and which were examined as part of this study explain Energy Management as a part of the standard ISO50001:2011 or through the control technologies used to command the flow of energies within the boundaries of a system be it a house or a factory or a line of production, etc. This leads Energy Management to appear like a technical skill (Oung, 2013) rather than a managerial skill.

Energy management is a vast concept; it includes energy production, balancing the energy produced and energy consumed in a closed network, energy use and energy saving, etc. In simple terms, Energy Management is about decreasing the cost of energies and minimising the carbon emissions of a company or an organisation (Smith & Parmenter, 2016).

One of the key drivers behind Energy Management in general and energy efficiency in particular is economic (O'Rielly & Jeswiet, 2015) and is achieved through energy savings or procurement of energy at cheap prices. Energy costs are the second highest for some organisations after the staff salaries, and in some instances, it can be the highest cost for energy intensive companies (Carbon Trust, 2012). The other drivers are environmental ones when a company is obliged to report or decrease its emissions for multiple motives such us conforming with government regulations – as an example, the Carbon Reduction Commitment (CRC) - or enhancing the image of the organisation under the Corporate Social Responsibility (CSR), etc. In chapters V, VI & VII, some examples of how local authorities in the UK adopted emissions reduction programmes are presented.

There would clearly be no willingness to spend money on unnecessary energy usage or polluting the environment by organisations but the lack of knowledge and expertise on how to optimise the use of energy can lead to this which makes the role of energy manager a crucial one.

Energy Management has recently become a matter of interest in organisational management even though Energy Management Systems have been comprehensively studied for around 40 years **(**Lee & Cheng, 2016), since oil prices have peaked and new environmental policies have been adopted by many countries encouraging organisations to reduce their emissions and lower the operating costs in order to survive in highly competitive markets. Organisations cannot control energy prices or the global economy, but they can control how they use energy (Bird, 2011). There are many factors which have made energy management become an important component of organisational culture:

> *"Energy is part of everyday talk and experience in organizational life. It clearly is associated with people's motivation and willingness to exert effort,*

and it is tightly linked to progress in organizations — initiatives that are described as having energy are usually the ones moving forward. Yet energy is also an abstract idea with little clarity regarding how it might be created or how it influences outcomes" (Cross, Baker & Parker, 2003, p.53).

Energy Management can differ from one organisational environment to another since the stakeholders will change, the processes are not the same, and so are the sources of energies used, raw materials, systems, technologies, laws, prices, and so on. Hence, it has become a necessity to design a universal system for Energy Management.

1.5.2. Energy Management Systems (EnMS) as part of ISO50001:2011

An EnMS is used to measure, monitor, control, and optimise the flow of energy by regulating the energy management practices inside an organisation. With the increasing climate change problems, the United Nations Industrial Development Organization, in March 2007, "hosted the first meeting proposing the concept of an energy management standard. UNIDO sent a request to ISO on behalf of the participants. The ISO Secretariat accepted the request" **(**Risser, n.d.). The proposed standard is called ISO 50001:2011- Energy Management System which

> *"Requires an organization to establish, implement, maintain, and improve an energy management system, enabling systematic achievement of continual improvement in energy performance, energy efficiency, and energy conservation"* **(**Risser, n.d., p.7).

Most importantly, this standard gives organisations the freedom to set their own targets, design their own action plans and choose their own performance criteria. However, it stresses the continual improvement of the process since it is an iterative one. The standard has a manual with a set of guidelines and clauses that should be met by the organisations to help them design their own Energy Management system, draft the Energy Management manual and set the energy policy before being audited and certified with ISO5001: 2011.

The benefits of the Energy Management System are multiple and diversified. First of all, and as it was previously stated in the Risser's (n.d.) definition, it is a systematic approach which helps in adopting energy conservation and energy efficiency inside an organisation. Second, it helps in being statutory compliant since organisations are bound to identify and abide by the national laws and regulations related to their domain of activity. It also applies to international laws and regulations for the case of organisations with international activities. Third, it helps in actively reducing the energy use, emissions and the related costs without negative impact on the operations and activities. Fourth, it opens new markets for the organisation and gives it a competitive advantage.

1.5.3. The Interaction between Energy Management and Information and Communication Technologies

An Energy Manager can also decide to use computer-based systems (a.k.a Smart systems) to control the flow of energy. These are known as Energy Management Systems (EMS). There are EMS for boilers, lighting systems, HVAC, buildings (known as BMS), etc. These systems use different criteria and rules (e.g. turning down the boilers during the weekends) and rely on different factors (e.g. external temperature) to optimise the flow of energy. The energy savings vary and can be achieved through complex or simple actions like turning off the lights when the sensor detects the absence of an individual in a room, decreasing the heating temperature of the building depending on the external weather, etc. Additionally, savings can vary depending on the adopted technological solution:

> *"From 1976 to 2014, management performance reported by 305 EMS cases (105 BEMS cases, 103 I/C/F EMS cases and 97 cases of EMS for equipment) is analysed to evaluate varied energy saving effects. Statistical results show that saving effects of BEMS increased from 11.39% to 16.22% yearly. Inversely, saving effects of I/C/F EMS decreased from 18.89% to 10.35%. Regarding to EMS for equipment, there's no obvious trend but only the averaged saving effects can be reported. EMS for artificial lighting systems has the highest saving effect up to 39.5% in average. For HVAC and other*

equipment, energy saving effects are around 14.07% and 16.66% respectively" (LEE & Cheng, 2016, p.760).

1.6. Research Focus, Aim, Objectives and Question

To summarise, the city has always been a place of settlement for humankind. Since their inception, cities have been managed in different ways. With time and technological developments, the needs of inhabitants have grown and city management strategies have to cope with them. Different concepts and management strategies have been adopted by city authorities; some of them failed and others succeeded. However, the cities of tomorrow are facing increasing pressures ranging from population growth, scarcity of resources to climate change. A new concept has emerged and suggests solving the challenges facing the cities. This concept is the 'Smart City' and relies on technological advances to provide the necessary information about the city and action based on them which can be seen as a data driven change.

As there is a Smart City, there is a Smart Village, a Smart Home, etc. The concept of 'Smart' can be associated with different types of systems and one of the goals of this thesis is to study the relation between the two concepts 'Smart' and 'Energy Management' in buildings. However, what does 'Smart' mean in the context of Smart Energy Management (SEM)? What makes a system or a process 'Smart'? Is it the data? Is it its users? Is it the technology and software deployed for its management and analysis? Or is it a combination of different aspects? Later, Chapter II will briefly review the literature relating to technology transitions management, technology assessment and technology transfer. Additionally, Chapter IV will include a literature review of smart metering, energy data analysis, energy monitoring and targeting will be presented. A smart meter can be viewed as one of the sensors (i.e. infrastructure) the smart city in particular and the city in general can rely on to collect data about specific subjects; in this case, it is the energy use of the buildings. Other sensors can be air quality monitors, speed cameras, weather sensors, etc. All of these sensors collect large amounts of data sets that can be used to inform decision making.

All in all, this thesis recognises the emergence of the Smart City concept, but it will focus on the concept of Smart and more precisely identifying what is Smart Energy Management and what it can mean for a Local Authority.

The aim of the research is to explore how Local Authorities can more effectively introduce Smart Energy Management into their internal governance.

The objectives of the research are:

- To review the latest developments and trends of energy management in UK Local Authorities (LAs).
- To identify the benefits and challenges for smart meters roll-out in UK LAs.
- To explore the current position regarding smart energy data management in UK LAs.
- To generate a Smart Energy Management framework for UK LAs.

Last, the research question is: What does smart energy management mean for a Local Authority and how can it support the day to day work of an energy manager?

1.6.1. Contribution to Knowledge

This research aims at generating knowledge through the exploration, on one hand, of how energy management has been introduced into Local Authorities and, on the other hand, how new energy metering technology and half hourly energy data is used by different local authorities to develop this practice within their organisations. The qualifying and the defining of the concept of "Smart" in a specific setting, which is energy management, will be also possible after addressing the objectives of this thesis. This research is novel and original in the way that it

- Produces new knowledge related to smart meters and half hourly energy data usage in a real-life setting facing a multitude of challenges like austerity
- Compares the academic literature and the real-life application of a specific event which is the smart meters roll out in buildings

- Explores how improvements in smart energy management can support Local Authority Smart City ambitions and defines what "Smart" can mean in this specific setting.

1.6.2. About the Researcher

The researcher is a full-time student at the Faculty of Technology in De Montfort University, Leicester. At the same time, he is a part time employee at the Northamptonshire County Council based in Northampton. During the period of the research, he has been tasked with many responsibilities within the local authority including managing the Energy Management System (EnMS) of the Council in accordance with the requirements of the international standard ISO50001:2011, the management of the energy and energy metering contracts for the Council's properties and schools and managing an internal recycling fund used to invest in energy efficiency measures. However, the main responsibility has been to assess the energy metering contracts and the smart meter roll-out programme. The purpose of this assessment is to find opportunities from using generated energy data to ensure financial and energy savings from NCC's decision to deploy smart meters in its property portfolio and in the schools which are part of its energy basket; this is an aggregation of electricity and gas consumers that chose to buy these commodities through the LA. This job responsibility aligns with the research main aim and has given the researcher the opportunity to have access to key members of staff within NCC and other LAs and organisations in addition to different key documents like energy and metering contracts, invoices, policies, etc.

1.6.3. Thesis Structure

Figure 2 summarises the thesis structure and chapters.

Chapter	Chapter Aim	Activities
I	**General Introduction**	
	To locate the research within the new concept of 'Smart' and link it to Energy Management	- Concepts overview and scene setting - Research aim, objective, question & structure
II	**Transition Management in Local Authorities**	
	To study how change can affect organisations and how to address it	- Introduce the concepts of Change Management, Transition Management with a focus on technology
III	**Methodology**	
	To chart the methodological considerations of the researcher	Selection of research methods, philosophy, approach and strategy in addition to the justification of the choices
IV	**Literature Review**	
	In-depth study of theoretical background of concepts used in research & identification of gaps in the knowledge	- Review of smart metering and energy data analysis, energy monitoring and targeting
V	**Energy Management, Metering, Monitoring & Targeting Practices in LAs**	
	To describe the roll-out programme and related legislation for LAs, in addition to explore their usage	- Semi-structured interviews with LAs energy managers - 1st phase research findings & themes
VI	**The Development of Energy Management in NCC**	
	Presentation of NCC's EnMS, how it was developed and how it is performing	- Case study of the energy management system of NCC
VII	**Smart Metering and use of Energy Data in NCC**	
	An in-depth study of the identified themes in the previous chapters and in a real-life setting	- Case study of the smart meters rollout in NCC - Discussion around central energy mgt
VIII	**Energy Data Management for shifting towards a Smart LA**	
	To discuss the findings and create a Smart Energy Management framework for LAs	- In-depth review and analysis of the findings - Researcher reflections
IX	**General Summary, Contributions and Future Work**	
	To reflect on the process of research and to summarise the findings and limitations	- Contribution to knowledge - Future research

Figure 2: Thesis Structure

II	Transition Management in Local Authorities	
	To study how change can affect organisations and how to address it	Introduce the concepts of Change Management, Transition Management with a focus on technology

Chapter II: Transition Management in Local Authorities

Section 1.2 argued that cities are complex systems that constantly evolve alongside different managerial concepts the latest of which is Smart Cities. The development of these managerial concepts has often been driven by technological development. This thesis will focus on one aspect of the Smart City which is energy management in the context of Local Authorities (LAs).

Under 1.5, it has been stated that the energy management practice is often linked to energy management systems which are either a set of technologies and software or fall under different international standards like the ISO50001:2011.

Energy managers in LAs are in the middle of the change and transition affecting energy management and driven by technology development. They often have to make decisions about which technologies and software upgrades they need to opt for or if they can accomplish their duties with the existing infrastructure and systems in their organisations. To shed more light on this dilemma, this chapter will look first at defining the concepts of change, transition & innovation management and technology assessment & transfer, and second at identifying what it means for an LA and more specifically for its energy management.

This chapter and in conjunction with Chapter IV and Part I of Chapter V will look at reviewing all the main concepts addressed by this research.

2.1.Introduction

> "In the wake of a rapidly changing world, societies need to cope with demographic changes (urban densification, aging population), climatic changes (more extreme events), economic changes (globalization), and technological changes (communication)" (Porter et al., 2014, p.525)

"Transition" is often associated with "Change" as both concepts complement each other. Change is the shift in an external situation and refers to the "thing" that has changed whereas Transition is the reorientation that needs to take place to address the Change (Bridges, 1991) and having a management plan for both is necessary for their implementation as this era is characterised by perpetual change (University of Victoria, n.d.).

Managing change and transition is essential for organisations to survive and the same applies to cities. Porter et al. (2014) qualify the current urban governance systems as having a limited capacity to foster adaptation and this had led to the stagnation of the development processes in cities and proved their inadequacy to address persistent problems that face them. This is why, according to the same authors, these systems need to be adaptive to absorb the change and deal adequately with its dynamics and variability.

2.2.Change Management

> "The ability to change is a key 'engine of success' the shift from strategy into capability demands leadership, action planning, the ability to cope with pressure and uncertainty and a willingness to learn. More analysis helps us in that it aids our understanding of where we are and how we came to get there – however, analysis alone will not create the future." (Carnall, 2007, p.44)

Change is an ever-present feature that will constantly have an effect on the organisation; it is the rule rather than the exception (Bridges, 1986). This is why organisational change needs to go hand in hand with organisational strategy (Bournes,

2004) and thus requires process and managerial skills that will lead to a culture change and allows an overall integration in organisation's culture in pursuit of progress (Senior, 2002; Carnall, 2007). The first step to address change is to identify its type and there are different theories that help with this task.

Senior (2002) divided change into three main categories; change characterised by the rate of occurrence, causality and scale. Each one of the three categories has its own sub-categories and different theories addressing them and are well explained and discussed in multiple pieces of literature. However, even if change management can be tracked back to the 40s and 50s of the last century; By et al. (2011) and By (2005) argue that there are different limitations of this concept that need to be addressed since they mostly lack empirical evidence. First, there is a lack of a valid and pragmatic framework that enables the successful implementation and management of organisational change and; to address this failure there needs to be exploratory studies around the nature of change. Second, the authors suggested that researchers themselves question if it is possible to meaningfully manage change due to the complexity of organisations and the properties of their systems. Third, change management often uses problem-centred approaches which is referred to as diagnostic change and which Bushe and Marshak (2009) compare to dialogic change which focuses on changing the mindset rather than the phenomena. By et al. (2011) add that the dialogic change is characterised by using techniques that can be described as improvised and unscripted to address change rather than engaging in established forms or techniques. This is why the authors suggest, once again, that this disjuncture in change management opens the doors for new research and provides opportunities for innovation around this concept.

However, and while waiting for the limitations highlighted above to be addressed, organisations can use a change management implementation strategy which was developed by Carnall (2007). This strategy relies on using diagnostic surveys and benchmarking techniques to formulate change through the data collected (C.f. Figure 3):

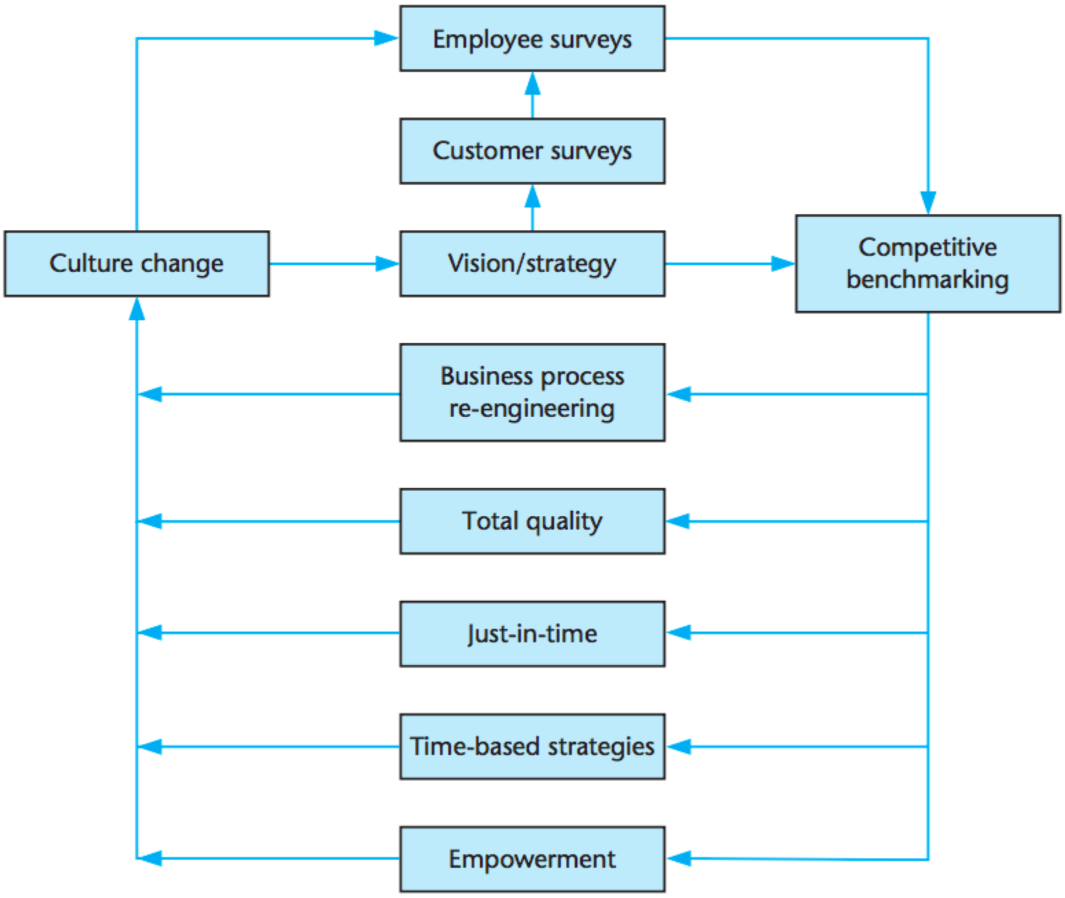


Figure 3: Implementation Strategy for Change Management in Organisations (Carnall, 2007, p.43)

Figure 3 shows that for a systematic change management, different techniques (e.g. surveys, competitive benchmarking) need to be employed and different stakeholders (e.g. employees at different levels of the organisation's hierarchy, customers) need to be part of the process so that this strategic diagnosis of the change can lead to an adapted company's vision, strategy and culture change.

2.3.Transition Management

Transition is a process that organisations go through while they orient to change; it is an internal process that takes place as a direct result of change which is seen as an external factor. Transition is what people (i.e. organisation's employees) go through, and this englobes their emotions, psychology, behaviour, etc. while the organisation is addressing the change; it is seen as a form of reorientation of the employees (the University of Adelaide, n.d.). Bridges (1991) states that it is not change that affects the organisation but the transition as the first one is an external factor and the second is an internal one. According to Bridges (1986), transition is a dynamic that goes through three main stages:

- The Ending Phase: also known as the Letting Go. It starts when change is presented and the organisation starts getting detached from a specific culture or a process or a vision of how things are done. This phase is complex as it is difficult for employees to detach themselves from how they have been working for a long time, and the organisation's management needs to acknowledge this difficulty and accept these emotions in order to put the right tools in place to help employees accept change and guide them through the different transition stages.
- The Neutral Zone: this phase is characterised by new systems and processes put in place, new responsibilities identified and assigned leading to a new work environment. This phase can be unsettling as employees are not used to this new setting and can still be attached to the old way of doing things while they learn to adapt to the new.
- New Beginnings: the transition was a learning process that the organisation has undergone. This is why this phase is about to address any difficulties faced while designing the new way of working and making any adjustments to finalise the transition. This does not mean that the organisation has changed what it does, it can be the case in some cases, but what it means is that it still does what it always did but in a different way. This is the last stage where the organisation embraces the change initiative.

Researchers from the Centre for Excellence in Learning at the University of Victoria combined this model for transition management developed by William Bridges and other work by Elizbeth Kubler-Ross (i.e. The Kubler Ross Change Curve) and Cynthia Scott to design a more elaborated model (C.f. Figure 4). This can be used to anticipate how people will react and respond to change during the different stages of transition in order to define how the organisation's management can respond appropriately and also to how to identify opportunities from this change.

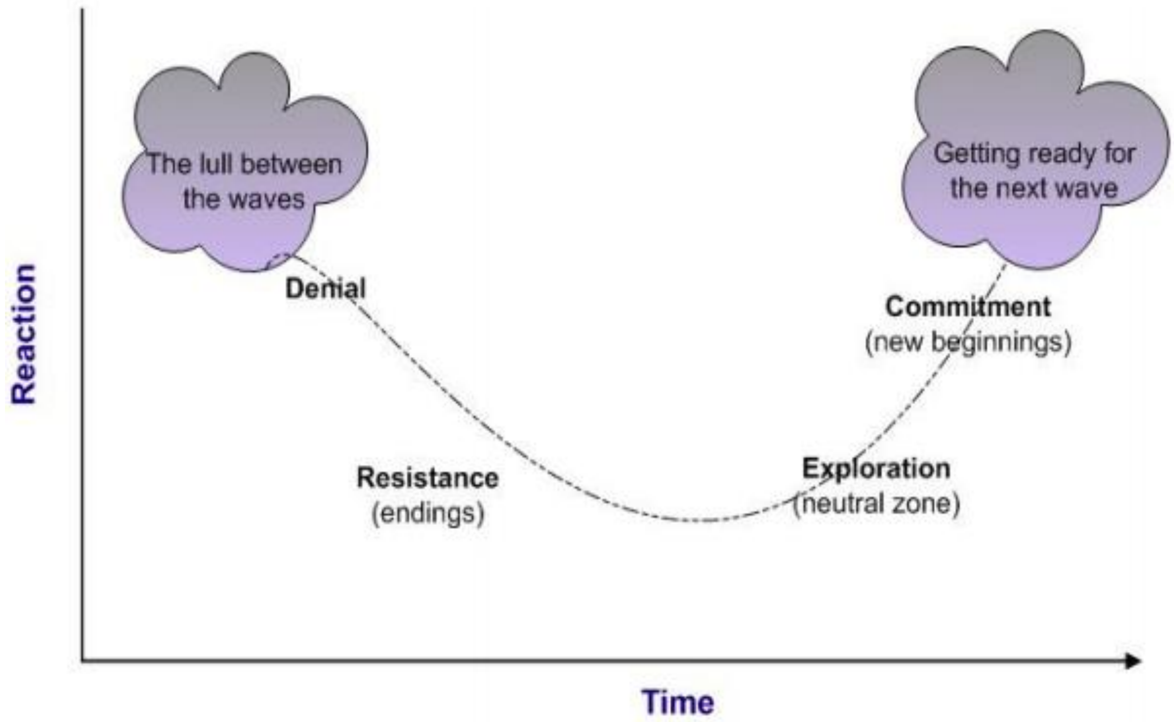


Figure 4: Elaborated Model for Transition Management (University of Victoria, n.d., p.10)

Figure 4 summarises the main emotions experienced by employees during the three main stages of transition management.

2.3.1. A Multi-Level Perspective for Transition

Transition management has undergone great development during the last decade especially in the field of applied management (Porter et al., 2014) and it can be studied from different perspectives e.g. socio-technical, sustainability, etc. From a socio-technical perspective, Geels (2002) describes transition through a multi-level perspective model (C.f. Figure 5) where it is perceived as a non-linear interaction between three levels of the social system.

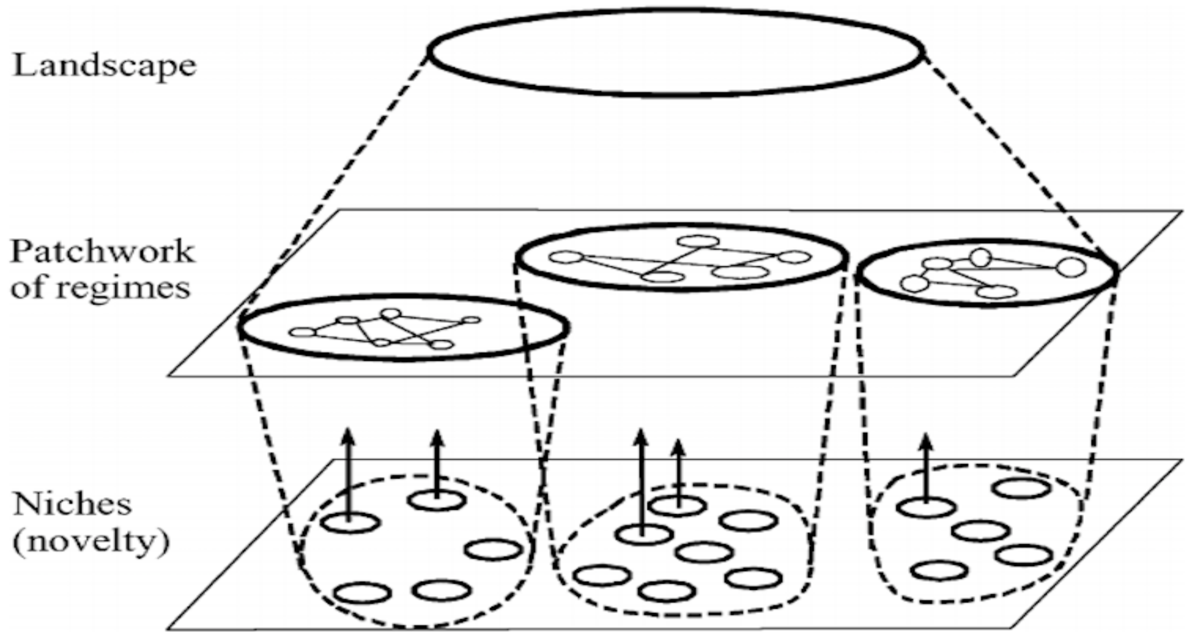


Figure 5: Multi Level Perspective for Transition (Geels, 2002, p.1261)

The three levels are:

- The landscape at the macro level which refers to a specific societal environment or system with defined boundaries and which can denote to a society with defined long-term and large-scale developments.
- The regimes at the meso-level which denotes the dominant culture or structure or practice in the landscape.
- The niches at the micro-level and these are defined as societal subsystems that exist within the regime and which can provide the perfect environment for experimenting new practices and consequently allow for innovation - which have social goals - to develop, grow and replace some of the practices within the regime (Porter et al., 2014).

It is the dynamics of the productive combination and alignment of the developments of all these levels, i.e. the creating and growth of processes within the niches and which are reinforced and influenced by changes at both the meso and macro levels, that leads to transition (Kemp et al., 2001). This is further explained in Figure 6:

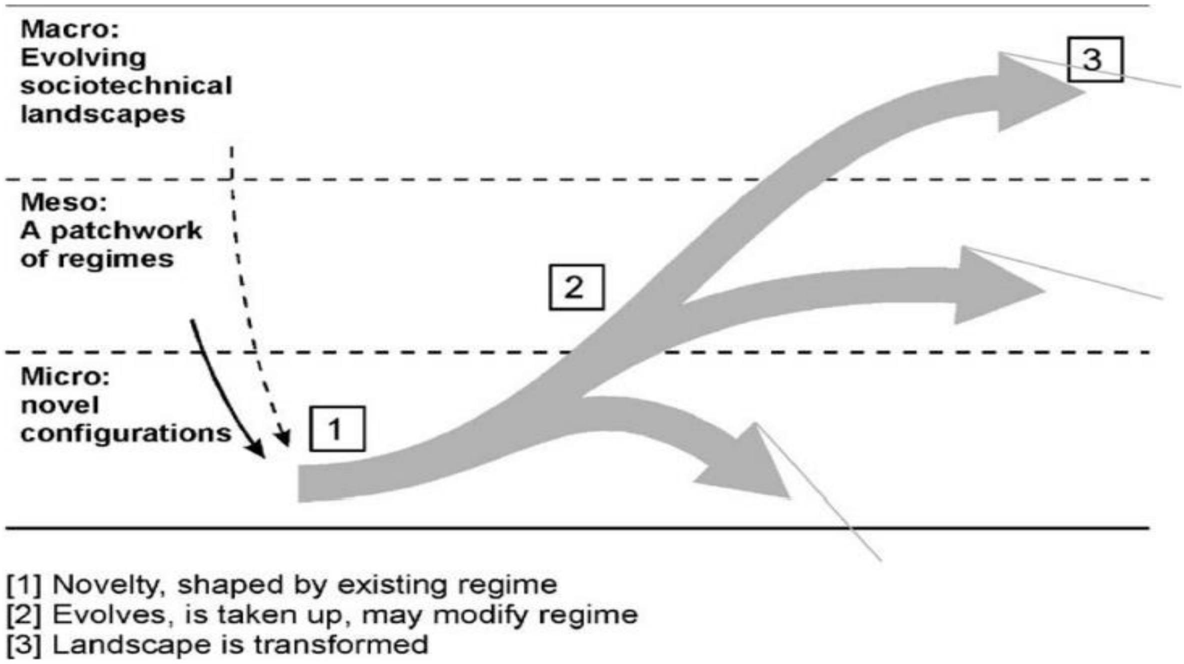


Figure 6: The Dynamics of Socio-Technical Change (Kemp et al., 2001, p. 227)

Finally, and as mentioned under 2.1, change management and transition management go hand in hand as, first, change is inevitable and the success of a company depends on how well it adapts to it and uses it as a catalyst for its development. Second, change drives transition which is a key feature that needs to be managed thoroughly since it is related to the employees' state of mind within it as it goes through the change. The focus on employees is an expected choice for they form the base of the organisation and the source of its success. Based on the works of Ackerman around steps for managing change and the model of transition management developed by Bridges, researchers from the Centre for Excellence in Learning at the University of Victoria created a model for managing change (Cf. Figure 7). This model shows that change management can be a systematic process which takes into consideration transition management and which break change management into different steps that depend on tools that organise master or have used in the past like developing plans and strategies, impact analysis, etc.

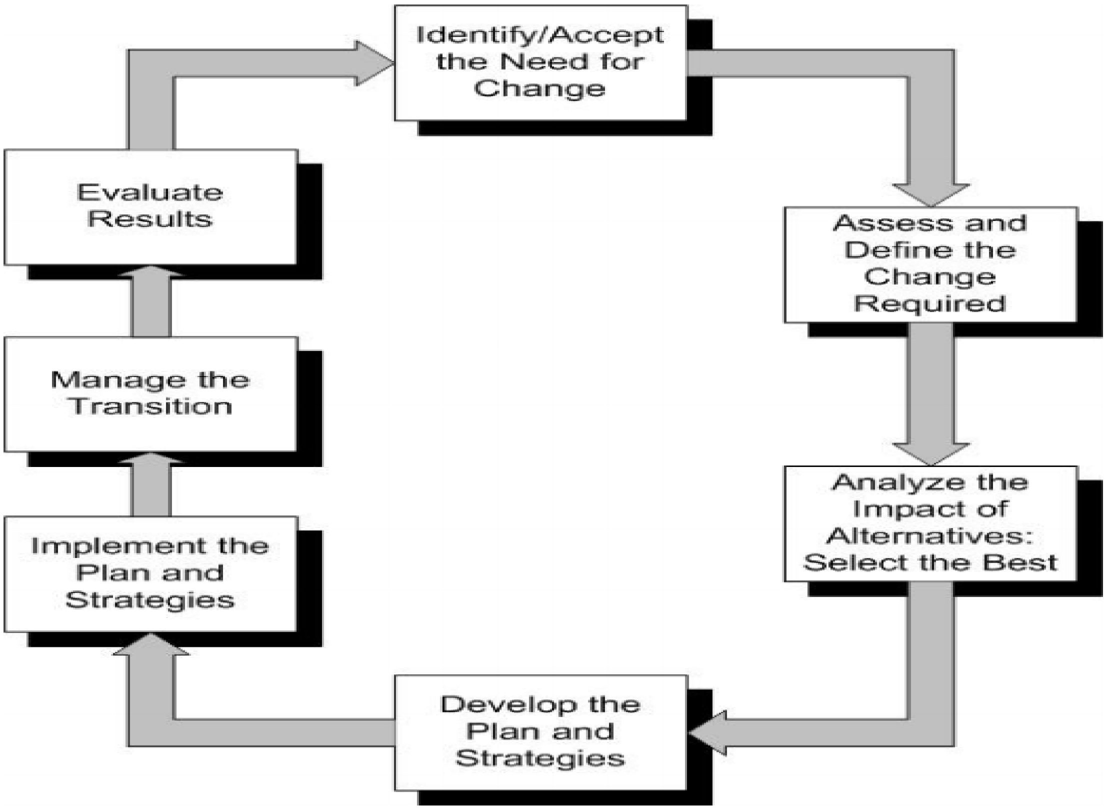


Figure 7: Steps for Managing Change (University of Victoria, n.d., p.7)

2.3.2. Sustainability and Transition Management

It has been stated in the previous section that, within the multi-level perspective model developed by Gills (2002), innovation takes place within niches as a result of experiments conducted in practice to address societal challenges, and according to Porter et al. (2014), this relates to the core notion of sustainable development that is based on searching, learning and experimenting. This transition experimentation can support and lead to a sustainable transition and transition toward sustainability; in fact, transition can be seen "as a deliberative process to influence governance activities in such a way that they lead to accelerated change directed towards sustainability ambitions" (Loorbach and Rotman, 2010, p.239); this will be discussed in detail under the first part of Chapter V where governance will be linked to sustainability and energy management. The sustainability aspect of transition management can be reinforced thanks to three mechanisms which can also be related to Geels multi-level perspective model and these are (Porter et al., 2014):

- Deepening: the learning process that takes place in niches through the transition experimenting.
- Broadening: repeating this transition experimenting in different environments in order to broaden and link it to other factors of other domains.
- Scaling up: the embedding of the deviant structure, practices and culture that have been used in the transition experiment in the ways of thinking, doing and organizing of a society which will lead to a fundamental change.

The similarity with Geels's model is that we start from experimenting and studying a specific phenomenon in a very precise system to move to a large system. Therefore, thanks to its ability for adaptation, transition management has become a generic governance approach with its own practical tools and instruments (Loorbach and Rotman, 2010). For instance, the multi-level perspective model can be used in environments of different scales (e.g. company, city, etc.)

The transition towards sustainability is known as sustainability transition, and according to (Geels, 2011), it is different from other types of transitions in a number of ways:

- It is purposive or goal oriented whereas the other historical transitions were emergent (Smith et al., 2005). It is focused on addressing environmental problems, and the civil society and public authorities are best placed to address this.
- It focuses on the collective good and the solutions, it provides, demand important changes that have an effect on different domains and sectors like economy, policy, etc. which lead to politics and power struggles.
- It is needed more in specific domains like agri-food, energy and transport which is an environment witnessing the existence of big actors (e.g. big companies) who are pioneers and capable of environmental related innovation that can boost sustainability transition.

This makes sustainability transition about "interactions between technology, policy/power/politics, economics/business/markets, and culture/discourse/public opinion" (Geels, 2011, p.25). This is why according to the same author, researchers need to look in depth at the multi-dimensionality of this type of transition and the dynamics of its structural change which is characterised by having existing systems, that are often unsustainable, and stabilised through lock-in mechanisms which can be, for example, investments in machines or scale economies, infrastructures, institutional commitments, competencies and shared beliefs.

Since this thesis is looking at exploring the role of technological advancement in improving energy management in Local Authorities, the sections below will introduce innovation management, technological transition and energy transition concepts.

2.3.3. Technological Transition Management

It has been stated under 2.3.2 that technology is one of the principle aspects that sustainability transition seeks to manage. This can be for different reasons:

- Technology can be a solution that addresses a sustainability issue. In the energy management practice, for example, technology innovation helps in saving energy and reducing carbon emissions.
- Technology can cause resistance to change and transition since, on some occasions, it requires important capital investment and organisations might not have the financial capability to keep investing in newer technology every time there is a new release.
- Technology can help in solving a problem, but it might not be the solution as there needs to be a combination of factors to make a change e.g. competence, training, etc.
- Technology can be the direct result of innovation that can lead transition within an organisation. Geels (2002) claims that changes at the landscape level of the multi-level perspective model may put pressure on the regime and create openings for new technologies.

However, the modern world is witnessing technological innovation every day. So, how should organisations interact with technological change and transition? To answer this question, two challenges need to be addressed in order to allow for a better understanding of technological transition by analysing the factors that facilitate or inhibit the adoption of specific technologies (Genus and Coles, 2008). The two challenges are:

- Improving individuals' understanding of long-term technological change.
- The creation and adaptation tools and mechanisms for the analysis of technological change, and for informing interventions in the governance and management of technological change in real life.

Research into technological transition is not new. Nelson and Winter (1977) proposed the terminology "technological regime" which referred to the designs and mechanisms that direct developers in firms to select and develop ideas and technologies that are feasible and will be of best use for the organisation from different available solutions. Since then, the concept has been elaborated and today there is a reliance on the Geels' multi-level perspective to analyse technological change and transition in socio-technical systems which led to a rebranding of the concept under the terminology of "socio-technical regimes" by Geels; the latter concept incorporates techniques from sociology to explain the relationship between organisations, rules and technology development and adoption (Genus and Coles, 2008).

There are many concepts and tools created and developed for technology assessment and which can be combined with Geels's multi-level perspective model for facilitating technological transition. Some of these tools, for example, are the Constructive Technology Assessment (CTA) and the Social Construction of Technology (SCOT) which fall under constructionist approaches and both infer that the genuine focus "on co-construction of technology as a complementary method of (re)creation of technology in society could be employed, thus informing and potentially bridging transition theory and social constructionist approaches" (Genus and Coles, 2008, p.1443). The CTA looks at the inter-relationship between the social and technical; there should be a variety of actors, especially social ones, in order to address the social problems surrounding technology deployment (Rip et al, 1997). The SCOT which was developed by Bijiker (1987) and which was about understanding how the sociology of technology and the sociology of science can benefit each other; in other words, it is a sociotechnical process that shapes all forms of technology. The latter shapes the world, but individuals are the ones who are behind its creation and development, which means that human actions shape technology and not the other way around. This is why it is important to understand how technology can be embedded in a societal context so as to define how it can be used. Another concept, Actor Network Theory (ANT), focuses on technological change at the niche level (Genus and Coles, 2008) which leads to linking network and transition theories to study the new sustainable technologies (Steward et al, 2004). The ANT studies the link between human and non-human factors in a network and tries to explain the gradual progression of new technology to describe the movement from one passage to another (Callon, 1987).

2.4. Innovation Management in Organisations

The inability to cope with change can beset a company; this can be due to many factors like the lack of innovation within the organisation to address change or simply the failure in anticipating it. This is why Drucker (1999) sees innovation as an almost obligatory strategy for organisations' survival. Tidd et al. (2005) add that innovation has become a competitive advantage for organisations thanks to their mobilisation of experience, knowledge and technological skills to offer novelty and this can be verified through the strong correlation between market performance and the release of novel products which help in increasing profitability and retaining market share. Thus, there is a need for a supportive environment and culture (within the organisation) that provides relevant contextual systems to harvest and cultivate creative practices (Malaviya & Wadhwa, 2005).

Innovation is defined by Drucker (1998) as a form of change that leads to a new dimension of performance. In this case, change is not always a result of external factors but can be a result of internal ones such as the existence of an employee who feels a necessity for novelty and acts on it to create it. For a breakthrough innovation, the latter needs to be viewed as a process rather than a sporadic event that can transform the novel ideas into production (Malaviya& Wadhwa, 2005); this can be achieved by having three types of employees (Browne & Eisenhardt, 1998)

- Arrow shooters: employees who look for ideas in untapped areas by the organisation
- Path finders: employees who transform the idea to an early stage prototype to help explain it and uncover its potentials
- Road builders: employees who transform the prototype into a final product

From Section 2.3, it can be said that encouraging the culture of innovation can help in facilitating transition in reaction to change within an organisation as employees should be used to constant and continuous changes in their way of work, production processes or services delivery.

2.4.1. Types and Dimensions of Innovation

Tidd et al. (2005) stated that innovation in an organisation can take four broad forms known as the '4Ps': product innovation (change in things or services), process innovation (change in the way the product is created or the service is delivered), position innovation (change in the context where the product or the service is offered) and paradigm innovation (change in the mental or the business models that define what the organisation does).

Each one of the 4Ps can have different levels of change which reflects a degree of novelty; this is described as incremental change that can lead to radical change. To illustrate this, Tidd et al. (2005) gave the example of changing the style of a car (with a diesel or petrol engine) and producing a new car made of completely new composite materials and has an electric engine. Whereas both cars can be the result of change and creativity; the second car -back in 2005 – would have been qualified as a radical innovation. Additionally, according to the same authors, incremental innovation is less risky than radical innovation as the organisation starts from something that it masters and it changes it gradually through a series of improvements; this allows reducing uncertainty around the final product or service. This is why the authors relate innovation management to the ability of balancing uncertainties and transforming them into knowledge. The latter can be captured while developing the novel product or service.

Innovation management, as in the case of change or transition management, is complex as it is difficult to manage something that is uncertain, random and the organisation has no knowledge about it or in some instances just basic knowledge. The management terminology in this case translates the ability to create conditions (e.g. developing and refining new basic knowledge, convincing others to adopt and support the innovation, applying the new procedures, using new technologies, etc.) that will facilitate the resolution of different challenges caused by novelty, change and uncertainty (Tidd et al., 2005).

2.5. Sustainable Energy Transition and the Role of Local Authorities

This thesis is also exploring the shift of Local Authorities (LAs) towards more efficient and sustainable energy management; explaining this shift will help with identifying what smart energy management can mean. LAs are seen as key players when it comes to sustainable energy transition (Van Staden, 2017) thanks to their important role at the niche level when it comes to governmental and national energy governance strategies and plans (Fudge et al., 2016).

The UK and, as will be explained throughout Chapters IV and V, like many other countries of the world is expected to decrease its carbon emissions. Different national plans have been put in place to achieve the carbon reduction targets set for the years 2020, 2030 and 2050. Local governments play an important role in meeting these targets and they are increasingly engaging where “they have recognised the need and benefits of action. Energy conservation and using improved energy efficiency technologies are key action areas to reduce energy demand and save costs” (Van Staden, 2017, p.18).

However, why do Local Authorities (LAs) have a role in the sustainable energy transition? It has been seen in the previous sections that change often starts from the top, i.e. when the senior management of an organisation understand that they need to put strategies in place to address the change they are facing. Still, change cannot happen if the bottom layers of the organisation, i.e. staff members do not embrace it, and this is what transition management theories try to achieve. The same thing can apply to addressing the climate change problematic which can be seen as the essence for preparing sustainability agendas; there can be no solution to climate change if there is an absence of local energy and climate actions (Van Staden, 2017). Additionally, LAs have an important role in localism thanks to their political and legislative status and their function as a local public servant organisation which can stimulate a community-based approach to national climate change and energy agendas (Fudge and Peters, 2009; Fudge et al, 2013).

2.6. Research Aim and Objectives

As has been briefly mentioned under 0 and as will be explained under chapter IV and Part I of Chapter V, organisations in the UK including LAs have to put in place energy management structures to respond to various regulations, schemes, incentives and decrease their carbon emissions. These regulations and the introduction of the energy management practice into organisations lead to and require change to existing strategies and work culture. The aim of the research is to focus on this process and

> *explore how Local Authorities can more effectively introduce Smart Energy Management into their internal governance*.

The associated research objectives are:

- To review the latest developments and trends of energy management in UK Local Authorities (LAs).
- To identify the benefits and challenges for smart meters roll-out in UK LAs.
- To explore the current position regarding smart energy data management in UK LAs.
- To generate a Smart Energy Management framework for UK LAs.

2.7. Conclusion

This chapter has been devoted to theoretical concepts for assessing change and transition management with a focus on technologically driven change and its diffusion to organisations. Local Authorities (LAs) are facing this type of change and transition as any other organisation. Therefore, for a successful technological transition management, a technology assessment is necessary. Chapter IV will look at assessing a smart metering technology that has recently been introduced to energy management in LAs from an academic perspective, whereas the second part of Chapter V will look at how the technology has actually been diffused in these organisations.

LAs are often characterised by a long history of how things are done and are stabilised through lock-in systems like shared beliefs, institutional commitments, investment in infrastructure, policies and public governance. This is why it will be interesting to study how these organisations adapt to technological change. All of this will be studied with a goal to identify what Smart Energy Management means for an LA, how to make this practice more efficient in these organisations, how LAs' energy management teams adapt to technological transitions and how the latter affects the way they work.

III	Methodology	
	To chart the methodological considerations of the researcher	Selection of research methods, philosophy, approach and strategy in addition to the justification of the choices

Chapter III: Research Methodology

This chapter charts the methods and tools used for this research, the methodological considerations, and the reasons behind adopting them. It also presents the elaborated approach to set the perspective for the research and to structure the work to be carried out.

The chapter has two main goals: the first one is to give an overview of the tools, research approaches and methods available to the researcher, and the second one is to outline the methodological decisions taken to address the research question and objectives in addition to the rationale behind the adoption of the different approaches and tools and the consequent limitations facing the researcher.

3.1. Introduction

As discussed in Chapter I, the aim of this research is to explore how energy data management can support a Smart Local Authority and the initial idea the researcher has is to address this research through a series of comparative studies, surveys, interviews and case studies. However, to ensure that the research activities are not influenced by the work-related activities of the researcher who is at the same time a component of the system he is investigating, he needs to ensure objectivity, honesty, ethical and professional integrity when carrying out this study. Hence, the research methodology to be used should be valid both for academic research and for working outside the boundaries of academia. Later in the chapter, the researcher will explain how the adopted methodology deals with this matter.

3.2. Research Methods

It is fundamental to design a research method before carrying out research as it helps with shaping the researcher's choice and use of particular methods and linking them to the desired outcomes (Crotty, 1998) in addition to providing guidance for this process and sharing the rationale behind selecting different methods with the readers and other interested parties. In this way, the researcher minimises the risk of encountering complications raised by not developing a research design/strategy (Robinson, 2011). It is also important to ensure that this methodology goes through layers of quality checks, which are consulting with the supervisors and abiding by the research ethics, for instance, in order to guarantee that it is fit for purpose and it proves to the readers and assessors that there is a logic behind developing every step of the methodology rather than the researcher assuming that there is no alternative to their favoured approach as suggested by Robinson (2011).

3.2.1. Multi-Method Research and Mixed-Methods Research

Research can be carried through different methods or a combination of these methods using different techniques. A multi-method approach is defined as the type of approach where a combination of data collection techniques and analyses are used, and these tools should be either quantitative or qualitative (Tashakkori and Teddlie, 2003). However, a mixed-method approach is when qualitative and quantitative data collection and analysis techniques are used (Saunders et al., 2009). It is crucial to define and outline the philosophical assumptions and the approaches and methods to be used in the research as they will influence the results and conclusions drawn from the study (Denzin & Lincoln, 2000). However, the methods applied and developed strategies are influenced and sometimes defined by the research aim and questions. The availability of different approaches to carry out the research requires the researcher to systematically categorise the research according to dimensions like:

- *"Philosophy: positivist vs. interpretivist, analytical vs. design*
- *Approach: deductive vs. inductive*
- *Choice of Data: quantitative vs. qualitative*

- *Strategy: Survey vs. experiment vs. case study vs. …"* (Hinkelmann and Witschel, n.d., p.5)

Saunders et al. (2003) summarise these dimensions in a five-layers model known as the Research Onion (Figure 8). These layers represent the process that the researcher should follow to design the methodology of the research: the first one is naming and identifying the research philosophy, the second one is defining the research approaches, the third one is designing the strategy for conducting the research, the fourth one is establishing the time horizons and the last one is deciding on the methods to be used to collect the data.

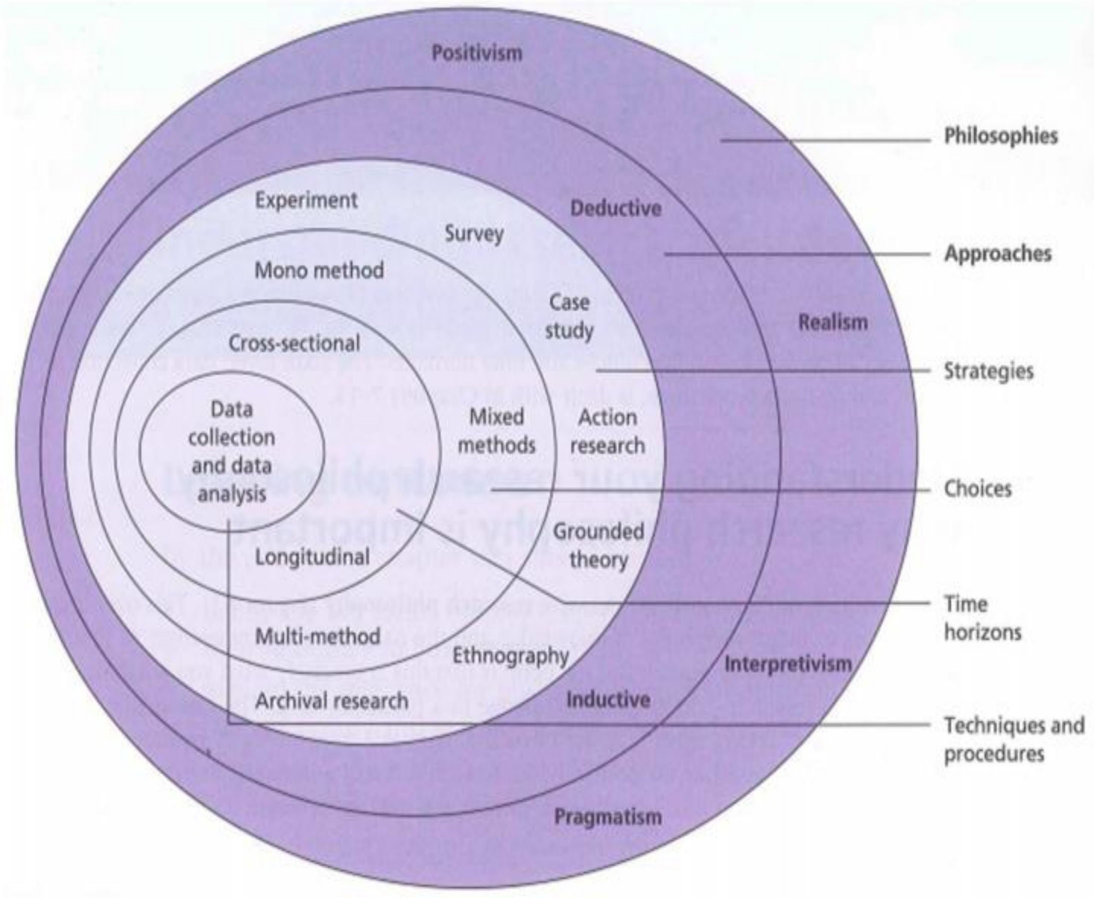


Figure 8: Research Onion (Saunders et al., 2009, p102)

3.2.2. Research Philosophy

The research philosophy to be adopted for this study broadly favours positivism over interpretivism. Table 1 summarises the differences between the two research philosophies. In positivism, the researcher can observe and describe the investigated phenomenon from an objective point, deriving theories and testing them (Hinkelmann and Witschel, n.d.). In addition, these observations should be repeatable. This philosophy relies on investigating tools and techniques such as observations, interviews, and surveys. This will have an effect or will justify the choice of the research methods for this thesis (4^{th} layer of the research onion).

Metatheoretical Assumptions About	**Positivism**	**Interpretivism**
Ontology	Person (researcher) and reality are separate.	Person (researcher) and reality are inseparable (life-world).
Epistemology	Objective reality exists beyond the human mind.	Knowledge of the world is intentionally constituted through a person ís lived experience.
Research Object	Research object has inherent qualities that exist independently of the researcher.	Research object is interpreted in light of meaning structure of personís (researcher ís) lived experience.
Method	Statistics, content analysis.	Hermeneutics, phenomenology, etc.
Theory of Truth	Correspondence theory of truth: one-to-one mapping between research statements and reality.	Truth as intentional fulfillment: interpretations of research object match lived experience of object.
Validity	Certainty: data truly measures reality.	Defensible knowledge claims.
Reliability	Replicability: research results can be reproduced.	Interpretive awareness: researchers recognize and

		address implications of their subjectivity.

Table 1: Comparison between Positivism and Interpretivism Research Philosophies (Weber, 2004, p IV)

3.2.3. Research Strategy Tools

The researcher will be adopting a mixed method approach where he will be using two research strategies to decipher the relationship between energy management and smart energy data. The reasons behind choosing these strategies are explained in this section.

Proposed Research Strategy One

The first research strategy to be embraced is the survey research. The latter is sometimes regarded as an easy approach with a chance to conduct a poor quality rather than a high-quality survey (Kelley et al., 2003). Therefore, it is important to have good knowledge about the investigated phenomenon and about the prospective respondents of the survey in order to set the context for the questions, ask the right ones and receive high quality responses. For example, in this study, the researcher will be running a survey across different types of LAs. However, before designing the survey, the researcher will have to learn about the different types of local authorities in the UK, how LAs work, investigate how decisions are taken within them, in addition to reading about smart meters and energy data which are the focus of this research. The reason behind having to learn about how local authorities work is to tailor the questions to fit with the environment the researcher is investigating.

Surveys provide a description of a phenomenon at a specific time (Denscombe, 1998) or a way to explore aspects of a specific situation or collect data for testing and explaining the research question (Kelley et al., 2003). The survey research employs different methods to enable the collection of data and these include questionnaires sent by post or email, face to face interviews and telephone interviews. The researcher will elaborate more (in 3.2.6) on which tools have been selected for this study and the rationale behind using them.

Proposed Research Strategy Two

The second strategy to be incorporated is the case study research which is “a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple sources of evidence” (Robson, 2002, p.178). The specificity of the case study is that it allows getting a rich understanding of the investigated phenomenon within its real context (Morris and Wood, 1991). The difference between the survey and the case study is that the latter allows observing the phenomenon investigated, interacting in real time with the employees, and having access to additional resources like documents, etc. The case study can also rely on different techniques like surveys, questionnaires and interviews with stakeholders, observations, etc. For this research, the case study will be the energy management system of Northamptonshire County Council. The reason behind selecting this local authority is that the researcher works within its Energy and Carbon Management Team, has good access to the stakeholders of its energy management system, energy related documentary and more importantly has the support of his manager who is at the same time the technical supervisor for this research. In addition, the researcher is acquainted with NCC’s energy management system and has good relations with his colleagues, which makes it easier for him and in this context to find information and answers than in the case of selecting an energy management system of another local authority as a case study.

The case study can be used for different types of research. Yin (2009) notes that there are three main types of research and these are exploratory, descriptive and explanatory. Stake (1995) and Yin (2009) define these three categories as follow:

- Exploratory research: the case study is used to learn more about a specific issue or theory, more often a new phenomenon.
- Descriptive research: the case study describes a phenomenon in its context or in a particular environment and portrays its specific attributes, properties and relations.

- Explanatory research: the case study is used to identify causes of a phenomenon and explain its outcomes in addition to understanding how one variable can affect another one.

For this research, the case study will be used for explaining a phenomenon. As it has been described previously, the researcher will run a set of interviews and questionnaires in order to explore how different types of local authorities use smart meters and their generated energy data in order to find patterns of common use of these systems. One of the reasons behind running a case study is to look at these potential common patterns in details. An example is that one LA representative stated that due to their usage of smart meters, the energy team is now saving on the cost of having to go around all their buildings to take meter readings or to enter them manually to the energy management software; in fact, this was seen as one of the main motives to accept the rollout of this technology in their portfolio of buildings (Cf. 7.2 for more details). The survey process did not allow quantifying these savings and checking the validity of this statement. Therefore, and as part of the case study, the researcher will try to quantify the savings achieved by NCC when it comes to using smart meters to record monthly meter reads.
The other reasons behind running a case study are to understand in detail the rationale behind the current usage of the half hourly energy data and why real-time or near/real time monitoring is still not adopted in NCC.

The researcher will review the literature relevant to this subject and should potentially have an idea about the theory of how smart meters work and how half hourly data should be used. However, through the case study, the researcher can also observe the advantages and the limitations of each concept while it is used in a real-life environment.

All in all, the surveys will be used for exploratory research in order to first collect information on the usage of smart meters and energy data in different types of Local authority and second to locate Northamptonshire County Council (NCC) in this mix. The case study will be explanatory for the previous stated reasons.

3.2.4. Time Horizons

There are two types of time horizons available to a researcher to consider when designing his/her methodology. The longitudinal study has the characteristic of being similar to a diary or a series of snapshots of a specific event (Saunders et al., 2009). In other words, this type of study gives the researcher the ability to study a phenomenon over a period of time and capture any changes or developments related to the phenomenon itself or to selected variables; the only condition is that the changes and developments should not be enacted by the research itself (Adams and Schvaneveldt, 2009); otherwise, it will be a kind of action research. This type of research does not mean that the researcher is bound with the duration of his/her study, but s/he has the possibility to use historical data that will enable the longitudinal assessment of the phenomenon or its selected variables.

The second type of time horizon is cross-sectional research which inspects a specific snapshot of an event. In other words, it is about the study of a phenomenon or some of its attributes at a specific period of time (Saunders et al., 2009). The survey strategy is often used for this type of study (Robson, 2002).

Proposed Time Horizon for this Study

For this research, both time horizons are to be used. On one hand, the cross-sectional study should be used in the survey when the researcher is investigating how the smart meters have been deployed in the different local authorities, the reasons behind enrolling them, what they are used for and how the energy managers in these LAs use their generated half hourly data. The researcher will be seeking to describe the incidence of smart meters roll-out in different types of LAs in addition to comparing how these LAs use the half hourly data. On the other hand, the NCC case study should be longitudinal as it will be looking at how energy management was adopted in the authority and under which form, how it has been developing with time, what additions the smart meter roll-out programme brought to energy management, how the energy data is used and the rationale behind deploying the smart meters and paying for different metering arrangements, etc.

3.2.5. Data Collection and Analysis

Approaches to data collection and analysis and to research in general are characterised by either being quantitative or qualitative. Bryman and Bell (2011) explain the quantitative method as a research strategy that focuses on quantification while collecting and analysing the data. Under the quantitative approach, data is used to study the investigated phenomenon in terms of quantity or numbers. Quantitative research also provides the possibility of statistically analysing large streams of collected data in a replicable and systematic method. However, one of the challenges with this type of research is that it sometimes assumes that the social world can be linked, explained/described or measured in numbers (Mc Queen and Knusson, 2002). The quantitative research has two key characteristics. First, the social reality is viewed as an independent objective reality (Bryman and Bell, 2011); hence, the use of large data sets to prove and confirm this objective reality. Second, it has the tendency to be linked to the deductive approach (Bryman, 2008) as the large data sets are used to test the theory and the hypothesis.

The qualitative research, in contrast, tends to focus more on observing and analysing actions rather than collecting and analysing large data sets (Creswell, 2013). This type of research is often based on social and behavioural studies and tends to have an in-depth investigative approach. In addition, the researcher gets the opportunity to personally interact with the study agents and thus can report data and results based on real time observations, discussions, etc. The key differences between these two types of research are summarised in Table 2:

Quantitative	**Qualitative**
Considered a hard science	Considered a soft science
Objective	Subjective/empathic understanding
Deductive reasoning	Inductive reasoning

The focus is concise and narrow	The Focus is complex and broad
Tests theories	Develops theories
Basis of knowing: cause and effect relationships	Basis of knowing: meaning, discovery
Data collection through surveys, testing and measuring	Data collection through unstructured interviews, case studies, observations, access to documents
Basis of analysis: numbers and statistical analysis	Basis of analysis: words, narrative
Single reality that can be measured and generalised	Multiple realities that can be continually changing with individual interpretation

Table 2: Key Differences between Qualitative and Quantitative Research (Keele, 2012, p. 36; Burns, 2000, p. 391)

From table 2, it can clearly be deduced that both methods are distinct and can be used for different purposes. However, they can be combined in the same research under three possibilities (Silverman, 2006) as a mixed methods approach:

- Adoption of the quantitative approach to establish a sample of themes related to a specific topic, then use of the qualitative approach to study the selected highlighted themes in depth.
- Use of the qualitative approach to gain a detailed insight of a specific topic before implementing the quantitative approach.
- The main approach is the qualitative one, but the quantitative approach can be used to locate or prove the results from the qualitative study in a broader context.

Proposed Approach for this Study

A mixed methods approach is deemed suitable for this research; still, the focus will be on using the qualitative approach since the researcher has good access to one local authority and can study in detail the use of smart meters and energy data for energy management in addition to locating the related energy decision making process within the organisational structure. The researcher will have recourse to one quantitative research tool for two main reasons. The first one is to explore how different types of LAs use smart meters and energy data and locate NCC within this mix. The second is to define the main themes to focus on and study in-depth while using the qualitative approach.

3.2.6. Data Collection Tools

Different tools are available for the researcher to collect data that will help answer the research question. These tools can either be quantitative or qualitative and some are observations.

Observations can be effective when researching about what people do. Saunders et al. (2009) argue that an observation is a systematic approach that involves recording and observing people's behaviour and then interpret it and analyse it. The same authors divide observations into two categories.

The first one is participant observation. Gill and Johnson (2002) explain this as when the researcher becomes a member of the group s/he investigates and enables him/her to not only observe but also to feel what is happening. This means that the researcher will be immersed in the research setting. In addition, and depending on how the researcher observes, Gill and Johnson (2002) developed four roles that a participant observer can adopt:

- Complete observer: the researcher does not reveal the purpose of the observation to the subjects. The researcher's role is to only observe the different activities performed by the subjects.
- Complete participant: the researcher becomes a member of the investigated group but does not reveal the purpose of the observation.
- Participant as observer: the purpose of the observation is revealed to the investigated group. This role allows the researcher to interact with the investigated group, ask questions, etc.

- Observer as participant: here the purpose of the observation is also revealed to the investigated group but the researcher does not participate in any activity performed by the subjects.

These four roles are summarised in the participant observation roles matrix in Figure 9:

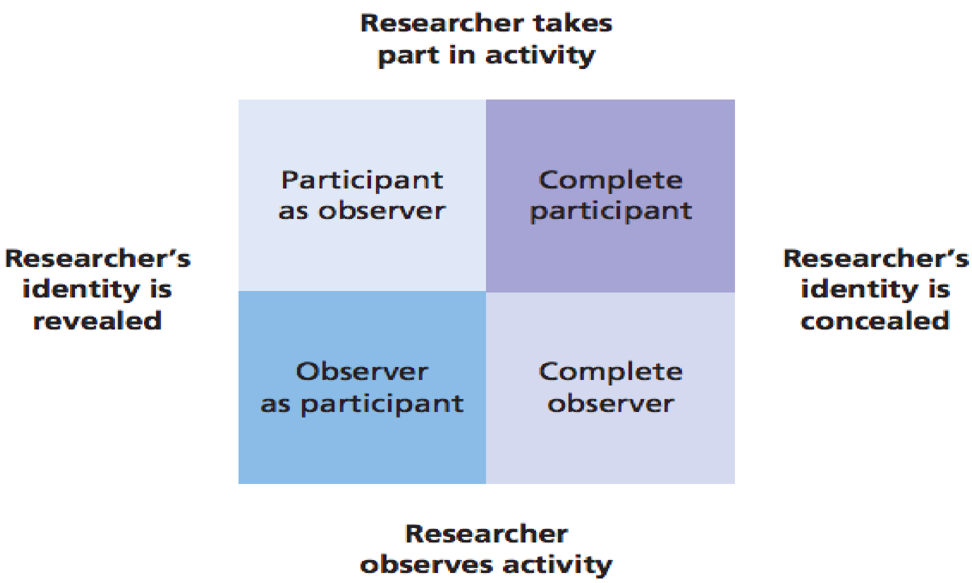


Figure 9: Typology of Participant Observer Research Roles (Saunders et al., 2009, p. 293)

For participant observation, the data collection process can be made of informal interviews, asking questions, observations of key participants and of the physical setting, etc. The generated data can be categorised into three types (Delbridge and Kirkpatrick, 1994):

- Primary observations: keeping notes of events and statements and recording them at the time they took place.
- Secondary observations: observer's interpretation to events and statements of subjects.
- Experiential data: observer's feelings and perceptions towards the process being researched.

The second observations category is structured. This type of observation is more systematic and has a more structured approach compared to participant observation. The purpose of using it for data collection is to quantify the behaviour rather than understanding why it took place (Saunders et al., 2009). The structured observation uses a tool called an 'off-shelf' coding schedule. This tool is applied when having meetings with the subjects or interviews and is used to observe the frequency of events and the relationships between them. However, the researcher can develop his/her own coding schedule if the 'off-shelf' one is not suitable.

Both categories of observations have some disadvantages. For instance, in the participatory observation, there are threats to reliability and validity (Cf. 3.3.1 for more details) of the conclusions drawn from this activity if the observer cannot manage to control or limit his/her bias. This is why it is important that the observer puts aside his/her life experiences and common knowledge when interpreting the observations (Delbridge and Kirkpatrick, 1994). For the second category which is the structured observation, there are three threats to reliability and validity of the conclusions (Saunders et al., 2009):

- Time error: the selection of time for observations should not be incomparable to the rest of the time of the research period.
- Subject error: the subject being observed should be working in normal conditions.
- Observer effect: the observer should make sure that the subject is acting normally and that the observations are not affecting his/her behaviour.

Proposed Observation Tool

For this research, the participant observation is deemed appropriate. The researcher works within the setting he is investigating, and his colleagues are aware of it. However, in this case, the researcher is focusing on observing how the energy management system performs rather than observing how individuals work. The researcher does not participate in the activities of energy monitoring and targeting and therefore can be identified as an 'observer as participant'.

The data collection tools which can be used by the researcher are:

a. Interviews

Kvale (1996) defines interviews as a method to gather descriptions of the investigated phenomena in the live words of the interviewee. The interviews are useful when the goal is to understand the story behind the interviewee's experience. Gill et al. (2008) argue that there are three types of interviews:

- Structured interviews: these are characterised by being verbally administrated questionnaires. In other words, the interviewer is asking a set of predetermined questions and rarely asks follow up questions. This type of interview is easy and simple in a way the interviewer only has to stick to the script (list of questions) and focus on understanding the responses of the interviewee.
- Semi-structured interviews: for this type of interview, the interviewer has a list of key questions that will direct the discussion and highlight the areas to be explored. These interviews give the interviewer the opportunity to ask additional questions or follow up questions and adjust his/her list of questions based on the responses of the interviewee and to pursue an answer in more details. This approach allows the interviewer to discover and learn more about a subject that s/he did know about.
- Unstructured interviews: these are characterised as being difficult to manage and time consuming as the interviewer does not have a list of questions or at least key questions that will provide a setting for the interview and direct the discussion. These interviews are run with little or no organisation. The interviewer might have recourse to this tool if s/he does not have any knowledge about the subject and the solution is to ask the interviewee exploratory questions to start learning about the subject. These exploratory questions are often characterised by being open questions.

Interviews allow for exploring beliefs, motivations, views and experiences of the subjects in relation to the investigated phenomenon (Gill et al., 2008). Moreover, they are far more personal than collecting data through questionnaires as an example. In addition, they give the researcher the opportunity to ask follow up questions. However, interviews are resource intensive and time consuming. For this study, the researcher had to travel to different regions of England to meet with his interviewees in other LAs; for example, for an hour interview, the researcher will have to spend five hours travelling in one occasion.

Interviews can be run face to face, by phone or through a video conference facility. Both telephone and video conference interviews enable the interviewer to collect data rapidly. However, in telephone interviews, the interviewer cannot see the facial expressions of the interviewee when s/he is answering the questions and this latter might get bored if the interview is too long while s/he is sitting alone in a room responding to a list of questions.

Ethical Considerations

It is important to highlight that there are some ethical issues to take into consideration when running interviews. This is also relevant for other data collection tools. Allmark et al. (2009) suggested five themes to classify the ethical issues for interviews and these are:

- Privacy and confidentiality: interviews can cover some aspects which are private and need to be kept private. Additionally, interviews need to respect the confidentiality of the elements discussed in an interview. When quoting the interviewee, his/her identity should be kept confidential and one way to refer to him/her is by using a job title, a code, etc.
- Informed consent: the interviewee should consent to take part in the interview and share information that can be used in the research. However, the interviewee should be aware that s/he can drop out whenever s/he wants. Additionally, the interviewee should be granted

the right to ask the interviewer not to use some or all of the information s/he provided.

- Harm: some interviews can be sensitive and harmful to both the interviewer and the interviewee especially when discussing sensitive subjects. The researcher should be aware and make a difference between his/her role as an interviewer or a therapeutic during the interview. In other words, the interviewer should let his/her feelings aside when taking notes and reporting the findings in order to guarantee objectivity.
- Dual role and over involvement: this theme is related to the previous one. The interviewer might play a therapeutic role and give a positive interpretation of the events presented by the interviewee or push the latter to give more information about the events. The interviewer should always focus on his/her role as a researcher without getting emotionally involved.
- Politics and power: sometimes the interviewee and interviewer know each other, and the interviewee might feel obliged to take part in the interview; for example, because the researcher/interviewer is senior. It is important to make it clear to interviewees that their participation is voluntary, and they are not obliged to answer all questions if they do not feel comfortable. Additionally, if there is a relation of power, the interviewer should take into consideration that the answers provided by the interviewee might be influenced by this factor.

Proposed Interviews Structure for this Study

For this study, the researcher has decided to run semi-structured interviews with energy managers from different local authorities. The choice of this type of interviews can be explained by the need to explore how the energy managers use the smart meters and their energy data. The interviewer has experience with energy management in one of the LAs of the UK and with how smart meters and energy data is used and for which purposes. Hence, the researcher has identified the key themes he wants to discuss with the interviewees and prepared a list of questions that he will be using to direct the interviews (Cf. Appendix B to view the list of questions to be used in the interview).

Many universities have a set of ethics rules that researchers should follow when doing their research and when collecting data. De Montfort University, for instance, has a set of ethical guidelines that the researcher needs to take into consideration. These are made available to the researcher online (i.e. DMU's website, blackboard, etc.). In addition, every researcher needs to gain ethical approval before starting their research. Last, the researcher should present to the interviewee their rights and obtain their consent before starting the interview.

The researcher has sought ethical approval before starting his research. As part of the ethical approval application, the researcher presented an information sheet which gives an overview of the research and the goal behind conducting this interview in addition to an example of a consent form (Cf. Appendix A and Appendix B). These two documents will be shared with the interviewee before the start of the interview and sometimes weeks before by email. The reason behind sending these documents beforehand to the interviewees is to get them acquainted with the interview questions, seek approval from their directors to participate in this study if needed, and break the ice through a series of emails/calls exchanges to introduce the interviewer and his research and answer their questions. Both the interviewer and the interviewee will sign the consent form before the start of the interview and both of them should keep a copy of it.

b. Questionnaires

Depending on the nature of questions asked, questionnaires can be categorised as a quantitative or a qualitative data collection approach. Both questionnaires and interviews are used mainly in the survey strategy but can also be used in the case study strategy. Questionnaires have different definitions, but the one used in this research is when the subjects are recording their own answers (Saunders et al., 2009) without the presence of the interviewer/researcher. These are also known as self-administrated questionnaires as opposed to interviewer-administrated questionnaires and which were discussed in the previous section.

Questionnaires are widely used to collect data from large samples as respondents answer the same set of questions and it is easier to compare the provided responses. However, Oppenheim (2000) claims that it is very hard to design a good questionnaire with precise questions and this should be the researcher's goal as it is difficult to have another chance to ask the same respondents to answer another questionnaire. This data collection tool is used mostly for descriptive or explorative research (Saunders et al. 2009). There are three types of self-administrated questionnaires:

- Internet/intranet mediated questionnaires: these are questionnaires that are prepared using online survey tools and the researcher has only to share the link with the subjects, or the researcher can send the questionnaires by email.
- Mail questionnaires: the researcher posts the questionnaires to the subjects often with a prepaid stamped envelope.
- In-house/delivery-collection survey: this involves visiting the subjects' place of work or home and handing them the questionnaire.

Each of these has advantages and disadvantages and the researcher needs to decide the one that best suits his/her needs and take into consideration the cost, time, sample size, etc. to be associated with his/her decision to address the research question. As an example, if the sample size is large and the researcher decides to run delivery-collection questionnaire, then this might be a time, efforts and money intensive choice whereas Internet-mediated questionnaires might be easier and cheaper. However, the researcher might get a higher response rate if the questionnaire is to be delivered and collected. Nevertheless, questionnaires have the advantage that they give the chance to subjects to answer the questionnaires in their own time and look for data to back up their responses.

Cases When Questionnaires Will be Used in this Study

In this study, the researcher will seek to have face to face or telephone interviews whenever it is possible. However, if the interviewees prefer to have a questionnaire, then the researcher will provide them with the list of questions by email. The researcher is aware that there are instances when the interviewees will choose this tool for reasons such as being safe and ensuring that their responses will not be altered as it will be written or if they need to seek their manager's or organisation approval for their responses and, in this case, they will need to write it down.

3.2.7. Content Analysis

This data collection approach is defined as a "research technique that uses a set of procedures to make valid inferences from text" (Weber, 1990, p .9). It is a qualitative tool used to determine the presence of specific terms or concepts in recorded communication (Stan, 2009). It is also used to make valid inferences, obtain documentary evidences, and draw on the textual analysis of the sender, the message and the receiver. Krippendorf (1980) has suggested 6 considerations to follow when using content analysis:

- Unit of analysis: Which data are analysed?
- Definition of terms: How are data defined?
- Unit of sampling: What is the population or unit from which the sampling data are drawn?
- Context analysis: What is the context relative to which data are analysed?
- Definition of boundaries: What are the boundaries of the analysis?
- Definition of inferences: What is the target of inference?

Content analysis has specific advantages like its need for logic and skills to code open-ended questionnaires ans summarise interviews and data analysis (Woodrum, 1984). The disadvantage of this approach is that it can be subject to researcher's bias, like any other qualitative approach. However, thanks to the availability of original texts, documents, or recordings, findings can be checked by external assessors.

Content Analysis in this Study

For this research, content analysis will be used for analysing interviews and the questionnaires and for extracting data from energy contracts, metering contracts and related communications with suppliers. The researcher has chosen not to transcribe the interviews as he is not interested in applying a discourse analysis of the responses but rather interested in collecting thematic data on processes. However, the recordings of the interviews will be kept safe for any future usage. In fact, the number of interviewed LAs is small and the researcher will be listening many times to the interviews to summarise them (Cf. Appendix E) and to analyse them (Cf. Appendix F) based on the identified themes in the literature review and extract the main findings. Additionally, the researcher will often quote the interviewees in order to share an un-interpreted version of their views and to support some of the researcher's ideas.

3.3. Quality of the Research

This research uses different data collection techniques which should shed some light on the trustworthiness of findings. The researcher will, for example, use a case study approach to collect data and validate some findings. The trustworthiness of findings from such an approach or other qualitative data collection approaches has been a source of debate (Robson, 2002). However, the quality and credibility of the research can be evaluated by the validity, reliability and generalisability of research findings and how the supporting evidence is presented and linked to these findings (Robson, 2002; Yin, 2003).

3.3.1. Validity, Reliability and Generalisability

Validity of the finding depends on checking the appropriateness of the tools, processes and data used; the researcher needs to check the validity of (Leung, 2015):

- The research question in regard to the desired outcome.
- The choice of methodology in regard to the research question.
- The choice of the strategy in regard to the methodology
- Whether the sampling and data analysis is appropriate

- The results in regard to the sample, data used and context of the research.

In a broader sense, validity is related to the ability of the researcher to explain, defend and demonstrate the rationale behind every decision made and which had an effect on the findings in addition to eliminate any bias when reporting the results. The use of different sources of evidence and different data collection approaches, which is also known as data triangulation, helps in decreasing the bias (Yin, 2003)

Reliability refers to the replicability of the research processes to end up with stable and consistent results (Leung, 2015). However, it is deemed difficult to ensure replicability in qualitative research for different reasons (Robson, 2002) since it "is characterized by feelings and personal reports, it is believed that the approach cannot give reliable and consistent data when compared to using quantifiable figures" (Eyisi, 2016, p.94 cited Atkins & Wallac, 2012). Therefore, Silverman (2001) interprets reliability as the degree of consistency when applying research methods or data collection approaches on a specific subject in different occasions.

Generalisability is to check whether the research findings can be applied to other settings. In a broad sense, qualitative studies are meant to investigate a phenomenon in a specific setting; this is why the generalisability of the findings is not expected (Leung, 2015) and some researchers suggest applying analytical generalisation (Kvale and Brinkmann, 2009) which means exploring whether the findings can be generalised to another one with similar setting.

Validation of the Findings of this Study

For this research, a findings validation questionnaire will be sent to the energy management key personnel who represented their LAs in this study for two main reasons: first, as a way to thank them for participating in this study and to share with them the findings and second, to explore if they agree with the findings or not and if this is something that can be applied in their LAs. A copy of the questionnaire can be found in Appendix I.

3.4. Methodology for Addressing Research Objectives

This chapter has presented and addressed the methodological considerations that the researcher can use to conduct the study, with a focus on the methods and the tools that will be used. These are outlined in the methodology (below) for addressing the research objectives.

3.4.1. Objective 1: Reviewing the Latest Developments and Trends of Energy Management in UK Local Authorities (LAs)

The researcher will first study literature around LAs in the UK in order to understand how they work, how they are managed and what their roles and statutory requirements are. This will help in creating an overview of their governance model. Second, the researcher will examine the literature about energy management in general to identify developments related to this practice. Third, the researcher will locate energy management within the governance model of LAs by studying different literatures around energy management in public buildings in general and in Local authorities in particular.

3.4.2. Objective 2: Identifying the Benefits and Challenges for Smart Meters Roll-out in UK LAs

This will be accomplished in two main steps. First, a review of academic and technical literature related to smart metering will be completed to identify the general benefits and challenges of rolling out smart meters in the UK. Second, the researcher will use interviews, and a case study which includes documents analysis such us contracts, observations and informal chats with the energy stakeholders of one LA to define the specific benefits and challenges of rolling out this technology in LAs in the UK. A detailed description of the tools used is presented in section 3.5.

3.4.3. Objective 3: Exploring the Current Position Regarding Smart Energy Data Management in UK LAs

This will be achieved through interviewing energy managers in LAs and conducting a case study to define and analyse how the energy data (i.e. half hourly meter reads) automatically generated from smart meters is currently used and for which purposes. A detailed description of the tools used is presented in section 3.5.

3.4.4. Objective 4: Generating a Smart Energy Management Framework for UK LAs

The review of the literature and the analysis of the data collected through the interviews and the case study will help in generating a Smart Energy Management (SEM) framework for the UK LAs. This framework aims at developing the current energy management practice in these organisations and suggests solutions for a better usage of smart meters and high-resolution energy data for the case of an LA.

3.5. Summary of the Application of the Methodological Considerations

The collection of data for this research will be carried out in two phases. The first phase will consist of conducting semi-structured interviews and sending questionnaires to key personnel in Local Authorities (LAs) who are responsible for managing energy; these can be heads of energy management, heads of property management, energy contracts managers, etc. The set of questions to be asked in these interviews can be found in Appendix C and Appendix D (the latter encloses the list of the questions to the Councillor which had different questions than the other stakeholders since s/he represents senior management and has an important role in defining LA strategies). The researcher has a preference to conduct face to face interviews to be able to interact directly with the interviewees, to see their facial expressions and to define the best time for when to interact, intervene and ask follow-up questions during the interview. However, when it is not possible to conduct face to face interviews either because the interviewee prefers another type of interview or the LA is in a distant location, the researcher will conduct phone interviews since they still give him a chance to interact with the interviewees. In other instances, the interviewees might prefer to answer the questions in a written way because they will need the approval of their managers or to keep a record of their replies.

The choice of LAs to take part in this study will first depend on the type of LAs and second on the access to their energy managers. As it will be discussed under 5.1.1, there are different types of LAs in the UK; for example unitary and two-tier authorities, etc. and the goal is to interview one authority from each type. Additionally, as the researcher is a member of the Energy & Carbon Management Team in Northamptonshire County Council, he has the ability to use the address book of the team and get in contact with energy managers from other LAs. This phase does not include a quantitative study but rather an exploratory one. Each interview will be summarised and analysed and the conclusions drawn will be fed into the second phase which is a case study of buildings' energy management in Northamptonshire County Council.

The case study will present NCC and its operational model in order to explain the reasons behind adopting energy management within the local authority and how it has been implemented. In this phase, semi-structured interviews with different energy management stakeholders will be conducted but the focus this time is to explore and analyse how different energy managers within the same organisation interact with energy data and how open they are to new ways of using it in order to generate additional energy savings. Moreover, the case study will look at quantifying savings from past use of energy data to check whether they cover the cost for collecting half hourly (HH) data or not. These energy managers can be budget holders, building clerks, councillors, school bursars, etc.

The researcher will also use various documents like contracts and the energy management software to collect data for this phase. The researcher will use some of the questions of Appendix B and will add others which are informed by the findings from the first phase. In order words, the focus is not only to understand how the interviewee performs his/her duties but also to suggest different methods of exploiting the energy data which are used by the other Local Authorities, and check if the interviewee believes or how s/he is open to duplicate this methodology within his department, building, etc. in order to help in saving energy without any negative financial implications (i.e. the energy savings are greater than the cost of using the energy data).

3.6. Conclusion

Following the introduction of the subjects of “smart”, smart meters and energy management in Chapter I, this chapter has presented the different research philosophies, methods, strategies, designs and data collection instruments which can direct the researcher while conducting the study. Additionally, this chapter has outlined the methodological considerations and decisions to be taken by the researcher, summarised the process for data collection and the reasons or justifications for choosing each approach. The researcher presented the research onion of Saunders et al. (2009) and used it to first explain the focus of each layer and second to present how the research aligns with each layer. Based on the main aim of this study, which is to explore how energy data from smart meters can support a smart LA, the two-phase research methodology has been explained. This study will adopt a qualitative approach for data collection with the use of exploratory semi-structured interviews to investigate and compare how different types of LAs use HH energy data. Moreover, this chapter has introduced the researcher and his job role and how it fits within the research. To complement the views and ideas to be collected through the interviews, a case study will be implemented to enable an in-depth analysis of the findings in a real-world setting. Finally, this chapter has presented how a good quality of research is sought and how the researcher is addressing the validity, reliability and generalisability of the findings. The diagram on Figure 10 summarises the research methodology for this study:

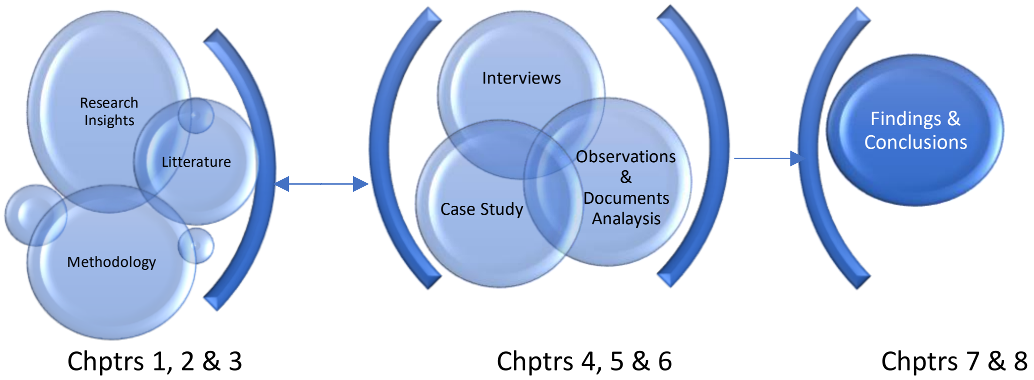


Figure 10: Research Methodology

IV	Literature Review	
	In-depth study of theoretical background of concepts used in research & identification of gaps in the knowledge	Review of smart metering and energy data analysis, energy monitoring and targeting

Chapter IV: Energy Metering, Monitoring and Targeting

In this chapter, some concepts which are essential for this study are defined. It starts by exploring the sources of energy data and will focus on smart meters as they are becoming the norm when it comes to energy metering in the UK. The researcher will then present the Smart Meter Rollout programme and the electricity markets in order to explore its impact on non-domestic users. This first part of the chapter mostly includes the literature related to policy and public organisation strategies. The second part deals with the academic literature related to the high-resolution data and their potential use in non-domestic buildings.

In the next chapter, the researcher will introduce the concept of energy management, its application in Local Authorities and how the approaches for using energy data which are presented in this chapter can lead to an effective implementation of this practice

Part I: Developments Related to Energy Metering

4.1. Introduction

The changes in living and working lifestyle has led to an increase in the emissions from residential and commercial buildings due to energy use for hot water, heating, cooling, lighting, etc. For instance, buildings are the largest energy consumers in the European Union accounting for 40% of the total energy consumption; in the UK the CO2 emissions of the building sector represented half of the total CO2 emissions of the country in 2013 (Ahmad et al, 2016). This is why the EU's Horizon 2020 work programme has focused on significantly decreasing the energy consumption of the building and transport sectors by 2020 through its "Secure, Clean & Energy Efficient" societal challenge (Molina-Solana et al., 2017).

Interest in energy efficiency emerged following the Oil Crisis and the Yom Kippur War in the 1970's which led to a spread of energy efficiency applications in the building sector in Western Europe around the second half of the seventies (Copiello, 2017). Energy efficiency (EE) has since developed to include practices and solutions that take into consideration continuous technological advances. As an example, in the following sections, the researcher will describe the impact of innovation on energy metering and how it makes energy more visible for building users and ignites the need for EE. The International Energy Agency (n.d.) describes energy efficiency as an important way to meet the economic, security and environmental challenges as it is one of the abundant energy resources that every country has. Energy efficiency in simple terms means using less energy to provide a service or a product with the same or a better quality (Department of Energy & Climate Change, 2012). This can be achieved by simple actions like controlling the working patterns/hours of a boiler and programming it to turn off when a building is not used, or by more complex actions which demand significant investments like upgrading the boiler to a more efficient one. The energy manager should be well informed in order to identify and select the appropriate energy efficiency improvement measures for a building. The collection of energy data to monitor the energy flow or energy consumption of the building and its appliances can be integral to this process. The process of collecting data has witnessed a major transformation or advancement with the inclusion of computer aided systems connected to different technologies. In the field of building energy management, the computer aided system can be a building management system (BMS) connected to sensors or smart meters or advanced meters, etc., which are also known as Internet of Things (IoT) technologies (Shrouf & Miragliotta, 2015). The Internet of Things refers to

> "*A type of network to connect anything with the Internet based on stipulated protocols through information sensing equipments to conduct information exchange and communications in order to achieve smart recognitions, positioning, tracing, monitoring, and administration*" (Patel et al., 2016, p. 6122).

The BMS can have different roles ranging from controlling the heating systems to controlling the luminosity levels based on pre-configured software programmes. Different data can be collected from different streams which can support the BMS to act accordingly when controlling the building energy systems thanks to the software programmes it is equipped with. These data can be related to internal factors like a building's ambient temperature, number of occupants, light levels (luminance), CO2 levels, etc., and to external factors like outside temperature, levels of visibility, etc. Both internal and external factors can have an impact on the building energy management. One example is when the weather is cold and there is a low level of visibility meaning that lights and heaters should be switched on. Another example is when a large number of people are present in a room leading to a high concentration of CO2 which will trigger the ventilation system to start or the windows to open leading to an increase or a drop in the room's temperature depending on the external temperature. This means that either the heating or cooling system will have to operate to bring the room's temperature back to the selected value by its users. In a building, every action might have an effect on energy consumption.

The integration of these new systems has made energy management both easier and more complex; easier in the way that many processes are automated and complex in the way that energy managers have now many systems to manage and different streams of data to analyse in order to find energy saving opportunities in conjunction with the factors that can influence it. In addition, the use of Smart and IoT technologies can give access to instantaneous and real-time energy consumption figures which can provide a high-resolution tempo-spatial data – i.e. detailed data like half hourly data which can include time, temperature, luminosity levels, etc. - for which different methods and systems need to be deployed in order to analyse the energy consumption and the impact of the measures taken to reduce it. The next section will explore the available sources of energy data and what the latter can be used for.

4.2. Sources of Building Energy Data

An organisation cannot manage and improve what it does not measure. This is why collecting and gathering energy data is one of the first tasks to be undertaken once an organisation has decided upon energy management (Carbon Trust, 2012). There are different methods and technologies which can be used to collect building energy data.

4.2.1. Energy Surveys and Energy Audits

Energy surveys have historically helped to map out the monthly energy consumption and to define areas for energy efficiency improvements (Brown & Wright, 2007). The benefits from carrying out energy surveys are different since the goal is not only to collect energy data and energy consumption figures but also to understand the flow of energy and define and understand the factors which might influence it. In other words, it is a systematic review of how energy is used within the surveyed system, which includes carrying out physical inspections of the setting in order to establish an overall picture and a list of the buildings, machinery and processes which consume energy so as to find practical opportunities to save energy, carbon and money (Carbon Trust, 2011). An energy survey is itself a source of building energy data and at the same time can depend on other sources; some of them are listed in the sections below. The energy survey helps in collecting data about all the factors affecting energy use of a building such as its size, the materials used in its construction, the types of insulation, the different uses of the building, the operating hours and the number of people working in it.

Alternatively, an energy audit can be part of an energy survey (Carbon Trust, 2011) and includes an analysis of the energy use of a system, its cost, and a list of recommendations that emerges from the analysis of the collected data for improving the energy related practices (Atikol, n.d.).

Both energy surveys and energy audits collect energy related data for the purpose of drawing energy efficiency measures or for establishing the actual energy consumption map of a building. The areas identified as the biggest energy consumers might be the ones where the most energy savings can be made as per the Pareto Principle where 80% of energy waste practices can be in 20% of activities (Croner, 2017).

Display Energy Certificates and Advisory Reports as Examples of Energy Surveys

In the UK, energy surveys are used to produce Display Energy Certificates (DEC) and Advisory Reports (AR) for public sector buildings with a gross internal area of 250 m^2 or more. They are also used as part of the Energy Saving Opportunity Scheme (ESOS) which is considered to be the private sector equivalent of DECs (Azennoud et al., 2017). The DEC, AR and ESOS help in visualising the energy use to the organisation's management by providing it with an overview of their energy consumption and a list of energy efficiency measures. In addition, these certificates can be used to create an energy consumption database. Another example from the UK is the requirement to carry out energy surveys to both collect energy data and locate wastage in public buildings in order to prepare a feasibility study as a condition for receiving free interest capital from SALIX, a government funded organisation, which will help with funding and deploying energy efficiency measures and technologies. Energy surveys can contribute to financial and carbon savings through reducing energy waste as explained in Figure 11:

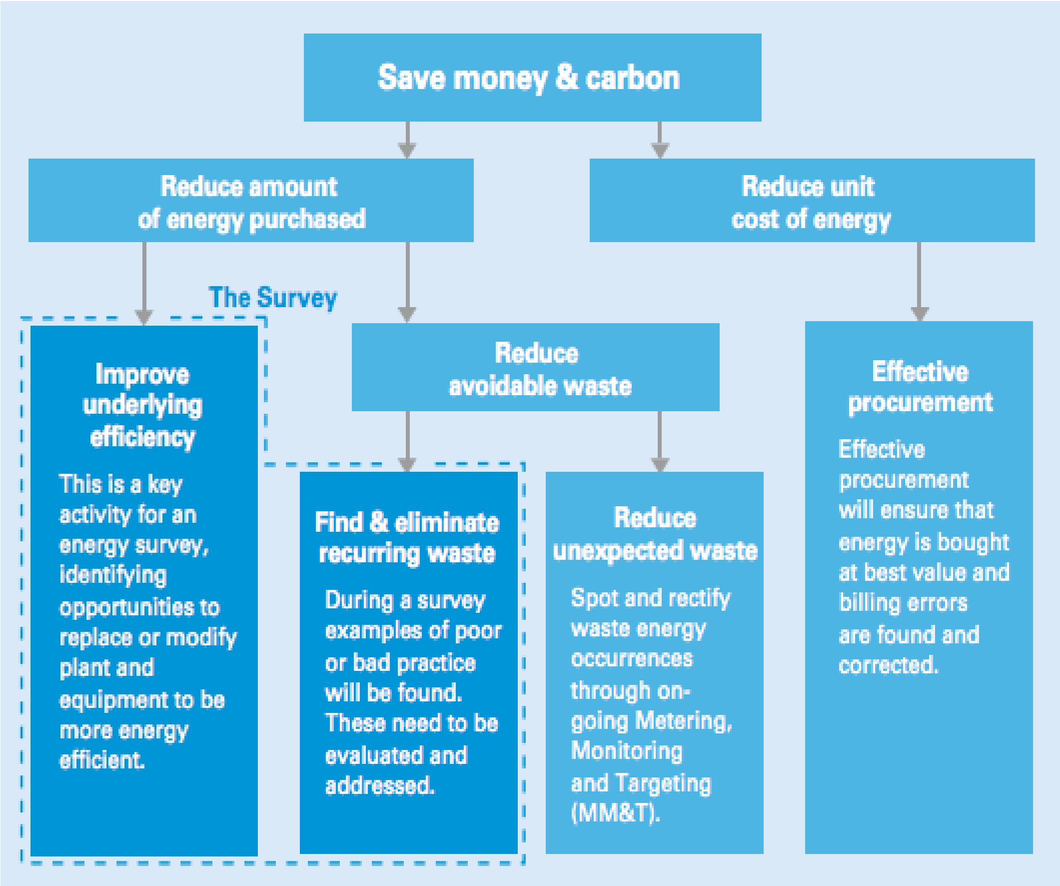


Figure 11: Energy Surveys Contribution to Saving Energy and Carbon (Carbon Trust, 2011)

Energy surveys and audits start by identifying the energies consumed in a system, then look at defining their flow within it and quantifying it. The information can be collected by looking at energy bills, meters and similar technology and by interviewing energy stakeholders like building's care takers and energy managers.

4.2.2. Energy Data Loggers

Data loggers (Cf. Figure 12) are used for different purposes and in different sectors and industries, but their main role is to generate frequent data about a process. For example, they can be used to collect data related to pollution levels in the air in a specific zone in order to see if air quality standards and regulations are met, or to collect temperature data in a storage facility to ensure that food is stored safely. For the energy industry, data loggers are installed for a wide range of applications. As an example, a data logger can be installed to collect the energy consumption data of an appliance. The researcher came across a case where a local authority, in the South Midlands of England, uses water data loggers to ensure that their water supplier is invoicing them correctly. Water meters are sometimes installed in locations which are difficult to access, and the water supplier has to estimate the consumption. Therefore, the local authority installs data loggers on the main pipes/supplies to collect water consumption data of its buildings. A data logger is one of the technologies used to remotely monitor the energy consumption of a system (device, process, etc.) thanks to its ability to record and store energy data periodically and feed it to an online system that can be accessed remotely and which can be used for different purposes such as energy surveys or energy monitoring and targeting.

Figure 12: Electricity Data Logger (Fluke, n.d.)

4.2.3. Energy Bills and Developments in Energy Metering

Quantifying energy consumption, at a building level or a group of buildings or for a service or process, is fundamental to understand and solve energy related challenges (Burgoon, 2012). Insufficient energy consumption data and energy metering constitute an obstacle for understanding, verifying and analysing the real energy performance of a building (Cao and Pietiläinen, 2013). Tracking energy consumption can be achieved via the use of meters and sub-meters. An energy meter is a measuring device which is used to record the energy consumed (i.e. the flow of energy into a building be it a home, facility, etc.) at any time in terms of units (SSI, 2013), whereas a sub-meter is used to provide energy related data of a process, a system, etc. (Rao et al., 2017) within a specific building, facility, etc. The ability to meter energy enables the shift from energy being an abstract idea to an accessible and quantifiable resource or commodity which can be readily manipulated and managed to achieve financial savings as it will be explained in Chapters IV and VI.

Energy metering has undergone significant changes over the past 200 years as it will be described in the following section. In the past, electricity utilities used to sell lighting rather than electricity. To measure the electricity consumption, the suppliers used to bill their customers monthly on the basis of 'bulb evening' or depending on the number of light fixtures installed in a building (Willis and Philipson, 2015). However, when the utilities started selling electric power rather than lighting in the second half of the 19th century (Matsumoto, n.d.), a new measurement method had to be put in place to measure the current and the voltage; hence, the invention of the electric meter. In 1886, Weston invented the first portable meter which is known as the DC Ammeter and aimed at inventing an AC meter.

Since then, important advances have occurred as detailed below (MSEI, 2006). As an example, in 1981, Thomas Edison used the electrochemical effect of electric current to quantify the electricity consumption using an electrolytic meter. In 1884, Hermann Aaron constructed the pendulum meter where the flow of the current makes two pendulums to rotate in opposite directions and these movements served as a basis for metering the electricity use. However, since this meter was expensive and could only meter DC current, it was replaced by the motor meter invented by Elihu Thomson in 1889. The principle of work was similar to the one of a motor; the stator was excited by the current while the rotor was excited by the voltage and the driving torque was the product of the voltage and the current, whereas a magnet supplied the braking torque to balance the load. This meter was used only on DC current. With the invention of transformers in 1885, the AC current replaced the DC since this latter could not be converted to high or low voltages. Therefore, there was a need to meter the AC current. In 1889, the first induction meter was patented by Otto Titusz Blathy; this meter (Cf Figure 13) has two magnets with a phase shift causing a cylinder to rotate.

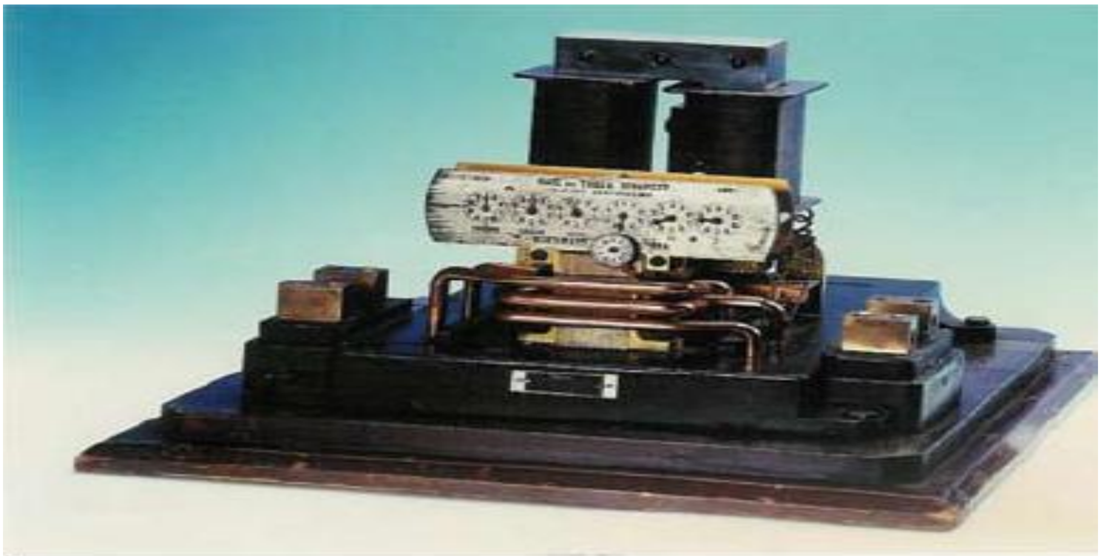


Figure 13: Blathy Induction Meter (MSEI, 2006)

The induction meter was further developed by different inventors and scientists leading to a considerable decrease in its weight and dimensions and a more precise metering of electricity (e.g. the Ferraris meter in Figure 14).

Figure 14: Latest Version of Induction Meters (Raman, 2012)

Nowadays, new generations of meters are being rolled out in households and commercial buildings around the globe; these are known as Automatic Meter Readings (AMRs) and smart meters and are discussed in the following section. Both meters enable remote metering like data loggers; one of the main differences is that the first ones can be used as fiscal meters, whereas the data generated from data loggers cannot be used in the UK for issuing bills.

To sum up, developments in energy metering were a direct result of technological advances and changes in the use of electricity. Thomas Edison once stated that electricity should be sold like gas (MSEI, 2006) instead of selling lighting. In other words, there was a will to meter electricity more precisely and learn from the usage of the same technology to meter another commodity.

This thesis will focus on use of AMRs and Smart Meters in Local Authorities. The step change in energy metering and the move from traditional meters like the Ferraris meters to AMRs and then smart meters. This has led to some benefits, for example, a site visit is necessary to collect the meter readings to calculate energy consumption in the case of traditional meters, whereas advanced and smart meters supply these data to both the energy supplier and to the building user automatically and remotely. It is important to highlight that the only difference between a smart meter and an AMR is that a smart meter enables two-way communication, whereas an AMR is a one-way communication device (Azennoud et al., 2017). A one-way communication meter can only send data (meter readings as an example) to the supplier, whereas a two-way communication device, in addition to sending energy meter reads, can receive information from the supplier like instantaneous energy prices, etc.

4.2.4. Smart Meters and their Usage

Smart meters have no universal definition but have some characteristics that distinguish them from other meters and these are (Carbon Trust, n.d.):

- Supporting and enabling a two-way communication
- Providing real time energy consumption to both the suppliers and the consumers
- Being able to store energy data
- Including the functionality of metering the energy export for micro energy producers like household with rooftop solar panels
- Having a display unit that can show energy consumption in different units like in kWh or in the country's currency, or to display historic energy consumption and produce consumption patterns to notify the consumers if their energy usage is higher or lower than their historic average household energy consumption, etc.

However, smart meters can be deployed for different reasons which are evident in the advantages of remote metering:

> *"Since the remote reading can also be made at short intervals, the user has to pay only the energy actually consumed [...] The knowledge of the consumption profiles in real-time, enables those who manage the energetic networks to create mechanisms of greater dynamism, flexibility, decentralization and interactivity in the management of the networks themselves (smart-grids); in addition, it also provides the user with the ability to have greater awareness of what is consuming. Also it is possible to implement numerous services of*

high added value as the automatic detachment of loads to reduce the consumption peaks... Higher frequency of detection of the readings can finally allow to easily identify both losses on the private network user downstream of the meter and losses related to failure of the measuring instrument, which would involve missed billings with economic losses for utilities" (Ferringo et al., 2013*).*

This will be discussed in detail in Part II of this chapter. The next section will look at the deployment of the Smart Meters in the UK to identify the advantages of this operation in addition to the challenges. This will also help to understand the electricity and gas settlement in the UK (Cf. 4.3 for more details around settlement).

4.3. Current Roll-out Programme of Smart Meters in the UK and Benefits Related to their Usage

4.3.1. Overview of Electricity Market in the UK

Organisations have the choice to upgrade their fiscal meters to smart ones or to install an additional meter or a data logger to collect energy data and improve the energy management practice (Carbon Trust, n.d.). In the UK, SMEs and households can request an upgrade to a smart meter for the gas and electricity commodities for free thanks to the UK's objectives of enrolling 50 million smart meters by 2020 which is a direct result of the enactment of sections 88-91 of the Energy Act 2008 that were extended in the Energy Act 2011 in 73 (Richards et al. 2014). However, in some cases, organisations might be obliged to change the fiscal meter to a smart one; this depends on its electricity load profile or profile class. In the UK, electricity suppliers are licensed to supply electricity to consumers under the governance of the Balancing and Settlement Code which is run by Elexon (Elexon, 2017). Suppliers are obliged to read the electricity fiscal meters only once every two years (Office of Gas and Electricity Markets, n.d.). This means that consumers will be receiving increased number of estimated bills and a reconciliation will have to be made once the meter is read. To avoid estimated billing, consumers are encouraged to supply their meter reads at least monthly to suppliers using online platforms, etc. However, for some load profiles or profile classes, the requirements are different. The historical manipulation of electricity demand and consumption data and their derivatives lead to design profile classes which

> *"Represent the pattern of electricity usage of a segment of supply market customers. A load profile gives the Half- Hourly (Settlement Period) pattern or 'shape' of usage across a day (Settlement Day), and the pattern across the Settlement year, for the average customer of each of the eight profile classes. It is the proportion of demand in each settlement period that is of interest to the Settlement System" (*Elexon, 2013*).*

The electricity market of the UK consists of nine profile classes, i.e. eight profile classes in addition to Profile Class 00; Profile Classes 1 & 2 are for domestic users and the remaining profiles classes are for non-domestic users. Profiles 5 to 8 are the customers who have meters that can measure the peak demand at a defined period and these customers are referred to as Maximum Demand customers. In addition, Profile Class 00 is for customers with a peak load usage above 100 kW, and for this profile class, a half hourly meter (AMR or smart meter) is required.

Settlement is defined as the "process for comparing contracted and metered positions and determining the charges to be paid for any imbalance" (Office of Gas and Electricity Markets, 2014). This is used and sought by energy providers to balance the energy they buy and sell. It is very difficult to predict the energy consumption of a site at a specific moment or for a specific period; also, when there is a group of customers with unknown annual energy consumptions, the uncertainty around the amount of energy that the supplier needs to buy to make it available to its customers is high. As an example, when the researcher wants to get a quote for an energy supply for one of the Local Authority properties, he is required to provide the annual energy consumption of the site. This is one of the ways the suppliers quantify how much energy should be bought and made available to customers. However, this piece of information is not always accurate and does not give any indication about the energy consumption pattern. Another challenge related to the electricity supply is how much energy should be produced and supplied at a specific moment of the day; this is also known as the grid balance. A surplus electricity generation can put a stress on the grid which might lead to blackouts, whereas an insufficiency of energy generation can cause service disruptions; to adjust the production, the grid operators have a short period – few minutes – to react (Chiu et al., 2012). In the event of a grid imbalance, National Grid – the UK's grid operator – can take three types of actions (National Audit Office, 2014):

- Amend the generation of power: National Grid has the right under different agreements to contact live power plants to either increase or decrease their generation. If these power plants have reached their maximum generation capacity, then the grid operator can have recourse to reserve generators which can switch on their power plants and start generating power in a few minutes.
- Reducing demand: National Grid has set mechanisms and agreements with large consumers to reduce their demand. These consumers allow the suppliers or the grid operator to decrease their supply or even interrupt it when there is an important stress on the grid in return for low energy tariffs.
- Voltage reduction: the grid operator can have recourse to slightly decreasing the voltage on the grid for a short period. The effects of this measure can be noticed when the lights are automatically dimmed. However, this measure can make an additional 6 GW generating capacity available.

These actions might fail, and it is important to stress that they are reactive. However, during recent years, a new solution that can decrease the need of having recourse to these actions has emerged thanks to the roll-out of smart meters. Smart meters provide the grid operator with an instantaneous view of the demand side of the electrical grid and their generated data can help with predicting what the consumption will be in each hour of the day based on historical half hourly meter reads:

> *"Smart meters bring benefits for customers by giving us new ways to optimise use of demand and micro generation, as well as more cost-effective choices for balancing the grid and reducing the need for network investment"* (Marland, 2014).

Additionally, one of the benefits sought by the Central Government of the UK, represented by its Department for Business, Energy & Industrial Strategy (BEIS), from the UK's Smart Meter Rollout programme is the potentials that smart meters provide, for grid operators, which are (BEIS, 2016):

- Ability to resolve network failures more efficiently
- More informed investment decisions
- Load shifting once Time of Use pricing is applied
- Savings from distribution and generation capacity investment

4.3.2. Rollout of Half Hourly Metering Technology in the UK

Many countries have designed programmes to rollout smart meters and the European countries were urged by the European Union to look at the use of this technology to address some of the issues related to climate change and to develop the energy supply system (Azennoud et al., 2017; Smart Energy GB, n.d.). For instance, Directive 2009/72/EC has set a target for European Union countries stating that at least 80% of consumers should be equipped with intelligent metering systems by 2020 in the case of a positive assessment of smart meter roll-out programmes. Other directives like 2006/32/EC and 2012/27/EU encouraged the roll-out of the meters which are capable of automatically supplying meter reads to the energy providers to initiate energy efficiency in buildings. In the EU zone, the UK and Spain have already developed rollout programmes with a set of targets and started implementing them. France has finalised its programme which is expected to run between 2017 and 2022, whereas countries like Sweden, Denmark and Italy are described as front runners since each one of them has already installed millions of smart meters with Italy in the lead with 36 million meters (CBI, 2013).

The UK's smart meter rollout programme has been developed by Central Government primarily:

- as part of a plan to upgrade the ageing energy infrastructure (Smart Energy GB, n.d.) and smart meters will be part of a smart power system in the UK (CAS, 2016)

- as a help to the Kingdom to meet its greenhouse gas emissions reduction targets for 2020, 2030 and 2050 (CAS, 2016).

One might question why the UK's smart meter rollout programme targets the installation of 50 million meters in homes and smaller non-domestic sites only. In other words, why are large and medium non-domestic sites not targeted as well? Through the examination of the nine profile classes (Cf. 4.3.1 for more details about profile classes), the answer to this question becomes clear. For instance, profile 00 groups the large electricity users who have a peak load usage above 100 kW whose sites are already equipped with meters which automatically supply half hourly meter reads to the suppliers. This is part of the Half Hourly Settlement. Moreover, during recent years and following changes to the Balancing and Settlement Code (BSC), more profile classes have been included in the Half Hourly Settlement meaning that more electricity users other than the large users are required to use advanced or smart meters to automatically supply half hourly meter readings. The change to the BSC is known as P272 and requires that energy suppliers should upgrade the meters of their customers under profiles 05-08 to meters capable of automatically supplying half hourly meter readings like AMRs and smart meters. P272 was proposed by Smartest Energy – a private company – in May 2011 but was rejected by a BSC panel in 2012 for three main reasons (Office of Gas and Electricity Markets, 2014):

- The cost of the P272 programme will be more than the savings
- It is more efficient to roll out the half hourly metering technology to all customers than target profile classes 05-08
- The customers belonging to those profiles will incur more cost when the programme is implemented.

However, Office of Gas and Electricity Markets (Ofgem) carried out an impact assessment of the programme and launched a consultation; based on the responses it got, Ofgem proposed a P272 Alternative programme which

> *"Will promote competition in the supply of electricity to larger non-domestic consumers by incentivising suppliers to offer a wider range of offers for customers. This will help to create a market that delivers better outcomes for*

these consumers, for example through more competitive pricing and improved customer service." (Office of Gas and Electricity Markets, 2014, p.3)

Therefore, Ofgem mandated P272 in October 2014 and the implementation starting date was 1st April 2016. By the end of March 2017, all meters belonging to those profile classes should have been upgraded to HH metering systems unless it was technically not feasible.
A closer look at profile classes 05 to 08 shows that it groups Non-Domestic Maximum Demand customers with a Peak Load Factor of less than 20% to over 40% and profile class 00 groups the very largest electricity users, whereas profile classes 01 to 04 group domestic and small non-domestic users. This means that by the end of the Smart Meter Roll-out programme, all electricity users will be equipped with half hourly metering capable infrastructure since profile classes 00 and 05 to 08 already have smart meters and AMRs and profile classes 01 to 04 fall under the scope of the smart meter roll-out programme.

The researcher tried to investigate the process for HH settlement for the gas and water commodities but couldn't find as detailed information as for HH electricity settlement process. However, he was aware from previous discussions with the Portfolio & Analysis Manager for a large UK public sector energy buying group that there was a requirement for big gas consumers to supply meter readings on a daily basis. Following this conversation, the researcher found that gas consumers are divided into two types: daily & non-daily metered customers. For instance, the Uniform Network Code (UNC) requires any supply point with an annual consumption quantity (AQ) of gas above 58.6 GWh to be mandatory daily metered (DM) (Office of Gas and Electricity Markets, 2015). Large gas consumers who are below the DM threshold can also choose voluntarily to be daily metered (DMV) (Office of Gas and Electricity Markets, 2015). The UNC is "the hub around which the competitive gas industry revolves, comprising a legal and contractual framework to supply and transport gas […] It governs processes, such as the balancing of the gas system, network planning, and the allocation of network capacity" (Office of Gas and Electricity Markets, n.d.). However, Ofgem decided to make some changes to the UNC a few years ago: this modification is known as Project NEXUS. Both DM & DMV provide data daily to the gas transporters (GT) for various reasons; some of them are to help with balancing the network and with accurately determining the AQ for each supply point. In the past, the GTs provided the necessary equipment for supplying the daily meter reads. Nevertheless, GTs claimed that it is not a requirement, or efficient for them, to provide DMVs with such equipment and led to the raise of UCN345 and its approval by the authorities. UCN345 mandated the phase out of DMVs by the end of 2013. Yet, no substitute to DMVs was suggested and UCN441 was implemented and mandated that the phase out of DMVs should coincide with the implementation date of Project Nexus (Office of Gas and Electricity Markets, 2015).

The gas Supply Point Administration is undertaken by Xoserve; this is a company owned by the National Grid and five major gas distribution companies and its role is to manage the data related to all gas supply point of the different types of gas consumers in the UK. Project Nexus is jointly managed by Ofgem and PWC and is aiming to update the system used by Xoserve for gas settlement in order to "facilitate faster switching for customers, support smart metering and allow for improved supplier cost allocation" (Crown Gas & Power, 2012). The project's support for the smart meter rollout programme resides in increasing the ability of the system to store more meter reads supplied by smart meters or AMRs. Once Project Nexus is implemented, the gas AQ will be more accurate and four gas settlement products will be available to gas shippers; these are:

"• Product 1 – DM. Time critical, with reads required by 10am. This is mandatory for supply points with an AQ above 58.6MWh only;

• Product 2 – 'DM-lite', submission of reads is not time critical and can be submitted at any time of day. Available to any supply point;

• Product 3 – daily readings submitted in batches. Available to any supply point;

• Product 4 – periodic meter readings, with existing standards for read submission and timing. Available to any supply point." (Office of Gas and Electricity Markets, 2015, p. 2)

This will open the way for a wide use of automated meter reading practices. In fact, the researcher, from his work-related experience, is aware that there are programmes underway for upgrading the gas meters into AMRs or smart meters for domestic and small non-domestic users. These programmes fall under the smart meter roll out project. For instance, NCC and other LAs had developed schedules with their gas suppliers to upgrade their gas meters. However, the researcher is not aware of any similar programme for the water supply. The water supply market is not as developed as electricity and gas supply markets and there is no requirement for water suppliers to install AMRs or smart meters for domestic or commercial consumers whose main business activity is not water intensive (Azennoud et al., 2017). For instance, it has been reported in one of the reports published by the House of Commons (2016) that the Department for Environment, Food & Rural Affairs (DEFRA) claimed in their Water for Life White Paper (DEFRA, 2011) that at that time, a blanket policy for smart water metering cannot be economically justified.

4.4. Conclusion about Metering Developments

This chapter has highlighted that Meter developments have been linked to technological changes. Though, metering was not the only practice benefiting from these advances, energy management is also affected with digitalised processes. Energy managers nowadays have access to large databases and modern energy management systems. However, how can they benefit from smart meters and their generated half hourly energy data? This will be considered throughout the next part of the chapter and in Chapters V, VII and VIII.

Also, it is clear that the recent changes made to the Balancing & Settlement Code and to the Uniform Network Code will make the integration of smart meters into the existing grid, and network management, easier and will allow an improved flow of energy data that can be used by all stakeholders of energy management.

The first part of this chapter has focused on:

- Explaining the available metering technology for both suppliers and customers

- Presenting the different energy settlement codes used by the regulators in the UK
- Investigating the recent changes/upgrades to the metering technologies and regulatory frameworks and presented the reasons behind these changes
- Explaining the metering market in the UK.

The second part will explore how the non-domestic consumers can use these technologies to benefit of energy management. For some subjects, and in the absence of academic literature related to non-domestic users, the researcher will present studies related to domestic consumers.

Part II: Energy Monitoring and Targeting (M&T)

4.5. Introduction

> *"An effective 'smart' system is one that brings together every day human intelligence and action with technical ingenuity: it does not attempt to vest all the smartness in the technology and edit humans out of the picture"* (Darby, 2016).

In the first part of this chapter, it has been argued that smart meters can bring a lot of benefits to its users. It can also add a lot of complexity to the systems managers as large amounts of data are flowing and should be analysed to detect any energy wastage or energy efficiency/improvement schemes. Smart meters, through their generated energy data, can make energy more visible to users. However, visibility alone is not enough as energy managers need mechanisms to assess the energy use through analysing the continuously fed energy data. The bigger the portfolio of buildings, the harder the job will be as more meters will be supplying energy data. Moreover, analysing the energy consumption and drawing a list of actions to enhance the efficiency of the system is also not enough as there should be an additional analysis of the resulting actions and their impacts to see whether the intended outcomes have been achieved or not. This feedback loop is important for the success of energy management as it allows energy managers to learn about their systems and learn from their mistakes. However, this will not be possible if there is no clear plan or methodology to use and assess the energy data generated by smart meters. Nowadays, and thanks to the technologies presented in the first part of this chapter, collecting energy data with high resolution has become very simple, analysing the data to extract information that can lead to energy savings is the challenge. The activity of analysing energy data in order to detect areas for improving energy management systems is known as energy targeting and monitoring.

Targeting and monitoring is a disciplined approach to energy management which allows the use of captured energy data and links it to related drivers like weather or other energy related measures as a basis to minimise energy wastage and improve energy efficiency and existing operating procedures (Bhattacharjee, 2014; Carbon Trust, n.d.; Gotel & Hale, 1989). For instance, this approach is regarded as the first step towards identifying energy efficiency improvement strategies, understanding the energy behaviours of systems and evaluating energy savings; it even became a crucial step as energy management systems are nowadays based on continuous improvement and the need to identify the standard performance and energy behaviour of the system in order to detect any divergence from the set energy baseline (Benedetti et al., 2017).

Additionally, in the earlier part of this chapter, it has been explained that the resolution of energy data depends on the metering technology used. As an example, data generated by smart meters or AMRs is not the same as the data generated by traditional meters. The first can be half hourly, whereas the second depends on when it is manually read. It is true that it is possible to get half meter readings from traditional meters, but this will be a resource intensive activity as there will be a need to manually take the meter readings half hourly all day and all year round. Though, the accuracy and the usefulness of the monitoring activity depend on the quality of the collected energy data.

4.6. Different Types of Energy Data Available for Energy Management

Currently, energy managers can use three types of energy data: billing data, direct data and profile data. The first type is provided by energy invoices. In the UK, electricity and gas suppliers bill their customers on a monthly or a quarterly basis; this billing frequency is dependent on their annual consumption. The second type of data is when a direct meter reading is taken. These can be produced as frequently as desired by energy managers. However, meter reads are often produced on a monthly basis when a site manager or a care taker chooses to provide the suppliers with meter readings to avoid estimated billing. The final data type is related to the meter readings which are automatically generated by AMRs, smart meters or similar technologies that are capable of generating sets of half hourly/short intervals or daily or monthly or any other periodic basis.

All these types of data have advantages and disadvantages: billing data, for example, cost nothing to the energy manager as they are provided by the supplier. However, these data are not always accurate as the supplier is mandated to take meter readings only once every two years (Office of Gas and Electricity Markets, n.d.). Direct data can be collected by taking meter readings and is often one of the tasks of a site manager or a caretaker. Nonetheless, there might be a risk related to the accuracy of direct data as these are subject to human error while reading and recording the meter reads. Profile data can be the most accurate as these are supplied automatically and do not need any human intervention after the set-up of the system, but this can be an expensive solution compared to the other two.

In the past, organisations were advised to use utilities bills to extract energy consumption for monitoring and energy management by the UK authorities (Department of the Environment, Transport and the Regions, 1998; Carbon Trust, 2005). With the recent developments in metering technologies, organisations are encouraged to use short intervals meter reads for monitoring and targeting as they can serve to produce energy consumption patterns and support analysis of energy performance at a greater depth (Carbon Trust, 2010). Relying on financial data (i.e. utilities bills) for the M&T activity can be risky as there is a chance those bills do not reflect the real consumption of a building. As mentioned in the previous paragraph, energy suppliers have to read the meters only once every two years, and if the consumers do not submit the meter reads on a monthly basis, then the bills will be estimated. Estimated meter reads can be of no use to M&T activities as they do not reflect the actual consumption and performance of buildings. On the other hand, short interval meter reads can be described as fine-grained data and can give a detailed energy performance of a building at a specific time of a day. This means that the energy manager can easily detect when the building is consuming energy at high rate and try to define the variables that lead to such building behaviour.

Shrouf & Miragliotta (2015) classify the methods adopted for quantifying and forecasting the expected energy consumption - to derive energy budgets - into two main categories. The first one is based on historic data. The second one is more related to any planned activities which will have an effect on energy consumption. These two categories complement each other. However, according to the same writers, both categories have their weaknesses depending on the type of data, abnormal past energy consumption patterns, etc.; hence, the importance of accurate and timely energy data.

While high resolution energy consumption data is very common today among energy consumers thanks to the roll-out of automatic meter reading technologies, the question to ask is whether all these consumers have access to their half hourly generated meter reads. Access to this type of data is not free and the cost varies from one supplier to another. Customers belonging to profiles 00 and 05 to 08 can have access to their HH meter reads and the cost for this service is already included in the utility bills, whereas non-domestic customers who fall under the other profiles need to pay an additional price to have access to the HH meter reads generated by the AMRs or smart meters installed on their premises (Azennoud et al., 2017).

Energy Sub-metering

Having access to high resolution energy data of a building like HH meter reads can sometimes be of little help especially in the case of large buildings with energy intensive systems like pumps, chillers, etc. The meter reads reflect only the actual consumption of the whole building, and it is difficult to quantify the energy consumption of the different systems installed in the building; hence, there is a need for sub-metering (Azennoud et al., 2017). Rohdin and Thollander (2006) highlighted that the lack of energy sub-metering is one of the main barriers to developing energy efficiency schemes in non-energy intensive manufacturing facilities. In the UK, part L2 of the Building Regulations calls for the use of sub-meters in non-domestic buildings with a floor area above 500 m^2 and 90% of the estimated annual energy consumption should be assigned to the various end-use categories (heating, lighting etc.) through sub-metering (HM Government, 2013; Carbon Trust, 2012). The goal of the building regulation in general and of part L2 in specific is to allow the buildings' stakeholders to understand where energy is used and where it is wasted in order to define where economies can be made (Pitt, 2013). Part L2A only gives an overview to the requirements for metering, but it refers to another document produced by CIBSE which is the TM39: Building Energy Metering. This document presents guidance on how to address the metering and sub-metering requirements.

4.7. Role of Smart Meters in Monitoring & Targeting

The first part of this chapter has been devoted to show that one of the goals to install smart metering is to promote energy efficiency at customers' premises thanks to giving energy information to the consumers to make them aware of their energy use. Still, it is important to highlight that smart meters will not achieve energy reduction or promote energy efficiency by themselves. The only role of smart meters in energy management is to generate and visualise energy consumption. The act of analysing energy data can lead to detecting energy wastage, then energy savings can be achieved.

Smart meters generate large amounts of short interval data which is not necessarily related to energy but can include information about the meter. Different data is collected through smart meters like energy consumption and demographic information of the user which includes the meter number, the name of the costumer, a phone number and an address. All these data are stored in databases before being processed by Meter Data Management Systems (MDMS). This is

> *"A host system that receives, stores, and analyzes measured data for billing, time of use, time of day, peak load management, etc. MDMS has the capabilities like remote connect/disconnect of remote meters, power status verification and on demand reading of meters. Meter data management system has long term data storage and it is managing the volume of data transmitted by the smart meters" (*Khan et al., 2014, p.2*).*

The frequency of data collection varies from one meter to another; data can be collected on a quarterly or on a monthly basis: it depends on the decision of the customer and the legislative requirements. These large amounts of generated data require large databases to store them.

A study entitled by McHann (2013) run on 50.000 meters shows how much storage space is needed. For this study, dial up meters have been used. These have 5 dials and provide the user with their consumption at a specific point of time; one dial is equivalent to one byte. The size of this information is 5 bytes. Table 3 summarises the storage needed to save the data collected:

Time Interval	Number of Meters	Data	Amount of Data
1 Day	50K	5 Bytes	24MB
1 Month	50K	5 Bytes	720MB
1 Year	50K	5 Bytes	8.76GB

Table 3: Size of Data Supplied by Smart Meters (McHann, 2013, p.2)

The data collected includes only the energy consumption (5 digits). Nevertheless, the size will increase significantly if the number of the meter, the name of the consumer, his/her address and phone number are included. Big databases will be needed to collect all these data.

According to the same study, the city of Austin in Texas is collecting data from 500 000 meters on a 15-min basis; 200 terabytes is needed to store this amount of data and powerful processers, which means more memory space is needed to process these big amounts of information. If the data is collected at a 5 minutes interval, the size of the database will jump to 800 terabytes. Moreover, backups are more often stored, leading to at least doubling the size of the data.

4.7.1. Automatic Monitoring & Targeting (AM&T)

The developments in automatic meter reading technologies have supported the automation of M&T. AM&T has the same functions of M&T such as visualising the energy consumption and identifying areas of energy wastage. The only difference is that AM&T does not require any human intervention which leads to minimising the possibility of human error (Carbon Trust, 2014) when producing energy data, analysing it and generating different types of report. Energy management software, which is capable of capturing short interval energy data, can allow both M&T and AM&T as the user can choose to run reports manually or can set up rules and alerts to generate periodic reports.

4.7.2. Benefits of Smart Meters and M&T

The activity of M&T using the accurate energy data generated by smart meters and similar technologies can have different benefits. Shrouf & Miragliotta (2015) claim that this technology and activity can bring five sets of benefits to manufacturing facilities:

- Reducing energy consumption by limiting energy wastage which can be detected in three ways. The first is to compare the product output to the energy consumption of the process. The second is to compare the energy performance of different processes and enhance the energy performance of the least performing process. The third is to use the collected energy data of the different machinery to calculate how much they consume when they are on but not working. The results of this analysis should help in creating a machinery switch-off policy.

- Reducing energy consumption cost by:
    - Implementing the time of use principle and decreasing energy use in peak times.
    - Load balancing as the energy data will show the capacity used by the factory and the energy manager can decide to decrease or increase the factory's registered capacity
    - Saving on energy prices by using different suppliers at different times of the day
    - A better estimation of the yearly annual quantity to be purchased
- Improving maintenance management as energy managers will have access to historic and current data to analyse the effect of maintenance activities on energy consumption.
- The company will benefit from a good corporate social responsibility (CSR) image thanks to its efforts at decreasing energy use and thus decreasing the carbon footprint. The energy data and the results of M&T activities constitute a large database of company's energy information that will facilitate the process of obtaining certificates like ISO50001:2011.
- Continuous improvements in energy consumption by continuously assessing energy use and by making energy consumption visible to the buildings' users.

In addition to these benefits, Shrouf & Miragliotta (2015) and Molina-Solana et al. (2017) present additional practices that might also benefit companies or other non-domestic-users:

- Power quality monitoring to detect any power oscillations that can be harmful to some industrial processes and reporting them to suppliers.
- Fault detection prevention: an abnormal energy consumption (low or high) can help in detecting a fault in equipment or in a building.
- Production and operation cost management as real time energy data enables the cost of energy consumed per production process in real time to be determined. Davis et al. (2012) report that, for many industries, energy is the

second highest operation cost. Therefore, an accurate estimation of this cost will lead to a more accurate estimation of production cost.

- An increase in energy-aware design by including the energy factor when designing new products.
- Reduction of energy costs by obtaining real time energy prices and adjusting consumption accordingly
- Energy fraud detection thanks to the use of own metering systems that can allow for the comparison of energy consumption of buildings against the energy consumption billed by suppliers
- Improving economics of self-generated power through the maximisation of the use of generated energy by matching the machinery operations hours with the energy generation hours.

4.7.3. Monitoring Campaigns and Dimensions

Monitoring campaigns, with a clear strategy and set of targets, need to be planned to ensure the identification of any energy wastage. For example, if a specific building is to be monitored, a strategy needs to be developed in order to first identify the different energies used in the building, the machinery or systems consuming these energies, metering technologies to quantify energy consumption either at building level or device level, clear objectives, etc. Bolchini et al. (2017) have identified these dimensions of a monitoring campaign as:

- Objectives: primary goal of the monitoring campaign.
- Type: single phase or multiple phases, i.e. is the campaign carried out in one phase or different phases? This can be affected for example by the data collection frequency for different processes, or it can be related to the objectives. If there are objectives which are not linked, then the campaign might be divided into different phases.
- Data temporal usage: depends on how the energy data is made available to the campaign managers and if it is fed in real time or in a batch.
- Sampling strategy: data driven or event driven or a mix of both.

- Analysis’ time granularity: this is about defining how often data will be analysed (daily, weekly, monthly, etc.)
- Aggregation operator: to summarise the collected data and remove any redundancies.
- Segmentation strategy: how data will be segmented? Is it on an hourly basis, daily, weekly, etc.? Would the non-working hours and non-working days be discarded?
- Campaign time span: is it continuous or periodic? A periodic campaign might be useful if the objective is to detect if there is a specific factor that influences the consumption. For example, what will be the effect of weather on energy consumption?
- Instrumented spaces: definition of the boundaries of the monitoring campaign. Is it a whole building, a whole industrial process, etc.?
- Redundancy: there is a need to remove any redundant data especially when there are sensors that collect data about the same area even if they are put in different locations.
- Outlier detection: there should be a strategy to detect and clean/correct erroneous and/or inaccurate values.
- Missing value imputation: a strategy needs to be developed to deal with missing values or missing chunks of data. A missing value can’t cause a big distortion in data analysis unlike when a large segment of data is missing.

Bolchini et al. (2017) summarised these dimensions in Figure 15:

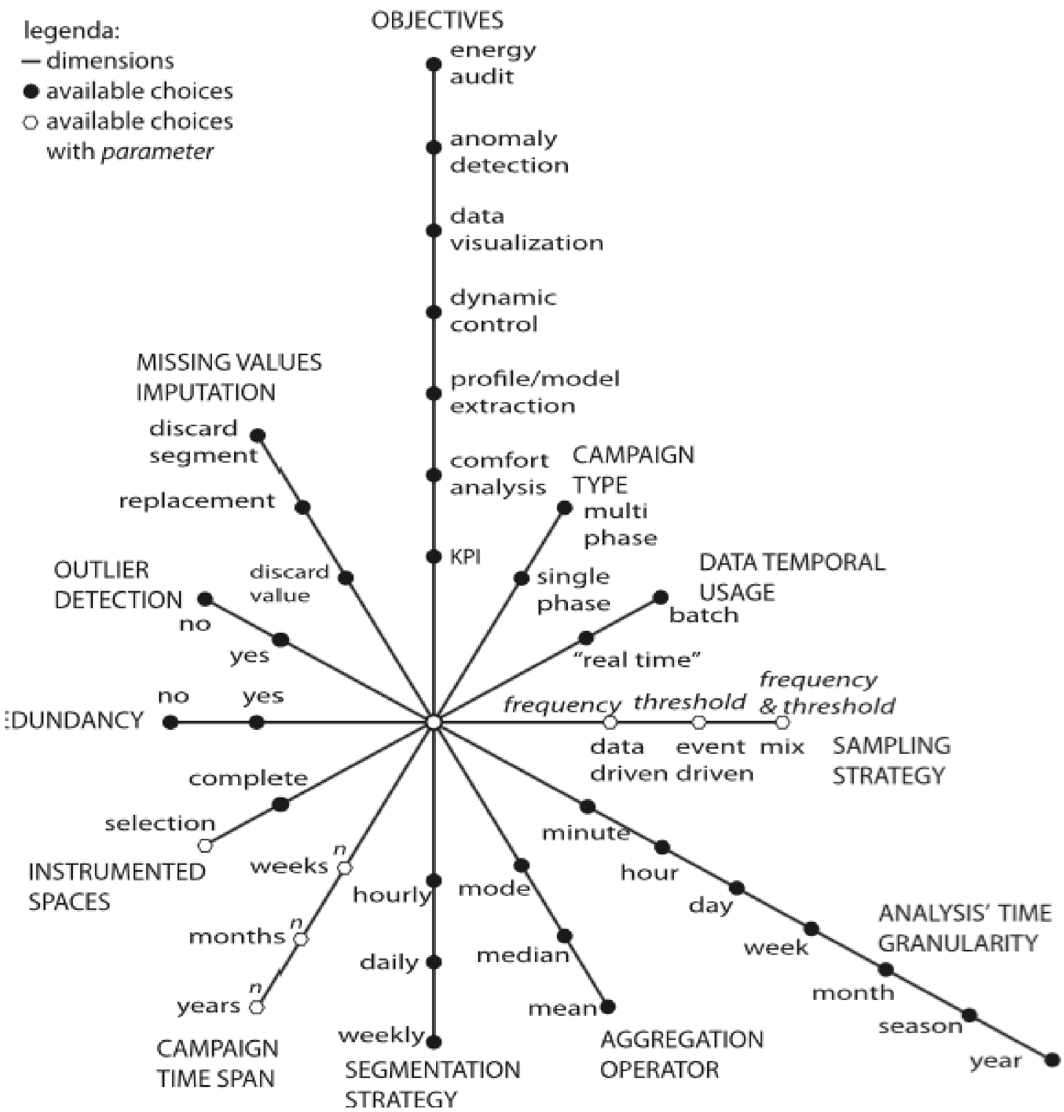


Figure 15: Monitoring Campaign Dimensions (Bolchini et al., 2017, p. 97)

The monitoring and targeting campaign can be a cyclic process in the way that every new campaign will learn from previous ones and the objectives will keep changing even if the campaign boundaries (i.e. instrumented spaces) are the same. Another case will be that the first campaign might fail in achieving its objectives, and this will entail the setting of new parameters or adding new data sources to address the failure. This is why it is important to review the analysis reports to detect how they can be improved and what role data play in this process. Figure 16 summarises this cyclic process:

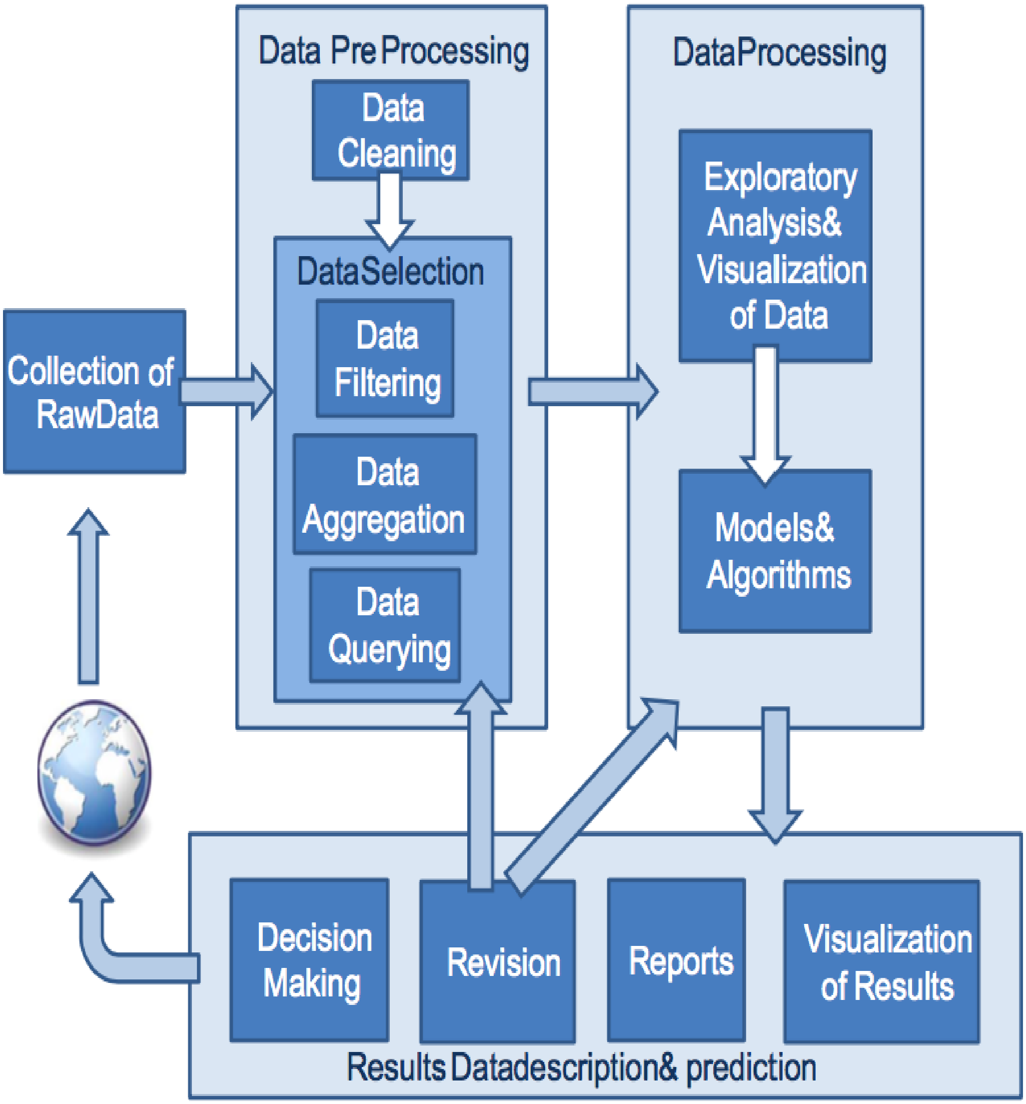


Figure 16: Data Processing for Monitoring Activities (Molina-Solana et al., 2017, p.600)

4.8. Energy Consumption Visibility and Awareness

Another benefit of Smart Meters that can be used for energy M&T for both domestic and non-domestic buildings is the ability to connect them to a visual display and make the buildings' managers and users aware of their energy consumption. It will be wrong to assume that the use of a display to show energy consumption has been developed thanks to recent advancement in energy metering. However, displays can now show a more detailed and realistic consumption as they are receiving more dynamic data on a short interval or real-time basis and are equipped with software that transform meter reads into significant information (i.e. feedback) to users.

4.8.1. Different Types and Forms of Feedback

Ehrhardt-Martinez defines energy feedback as a description of

> *"The situation when output information associated with an event or action in the past will influence an occurrence or performance of the same event or action in the present or future.*
> *In the case of energy consumption, feedback provides energy consumers with information about their energy use after they have consumed some amount of energy with the expectation that this information will change consumers' energy use practices in response to the information."* (Ehrhardt-Martinez, 2011, p. 4)

Feedback makes the users aware of their energy consumption and can even induce behavioural change (Faruqui et al., 2009) unlike when energy is invisible and out of users' minds as is in the case of monthly bills when users only know about their energy consumption or energy cost at the end of the month. Ehrhardt-Martinez (2011) compares this practice to a customer who goes to a store for grocery shopping where the prices of the products are not displayed and will have to estimate the price based on the product's weight, look, previous purchases, etc. The customer will have no idea about the cost of the grocery and consequently will not know if the household monthly budget is spent prudently.

This form of feedback is described as a direct one since the users are viewing their energy consumption instantaneously or near real-time as opposed to indirect feedback; for this type, energy meter reads are processed before being communicated to the users in the form of a bill as example, or a study, etc. Indirect feedback can be a more effective energy visualisation channel as it indicates changes in energy consumption patterns of a household and the long-term factors affecting it in addition to the impact of the adoption of energy efficiency measures, whereas direct feedback can be more effective when considering the impact of smaller end uses on energy consumption such as switching on a kettle (Darby, 2006). Indirect feedback can be linked to the energy measurement and verification M&V which has as a primary goal to quantify the effects of an energy efficiency intervention (Kissock & Eger, 2008; Efficiency Valuation Organisation, 2007).

Neenan (2009) suggests that there are different forms of feedback which all fall under the two main categories: direct and indirect. Some of these forms are cheap and others are expensive. The ERPI feedback in Figure 17:

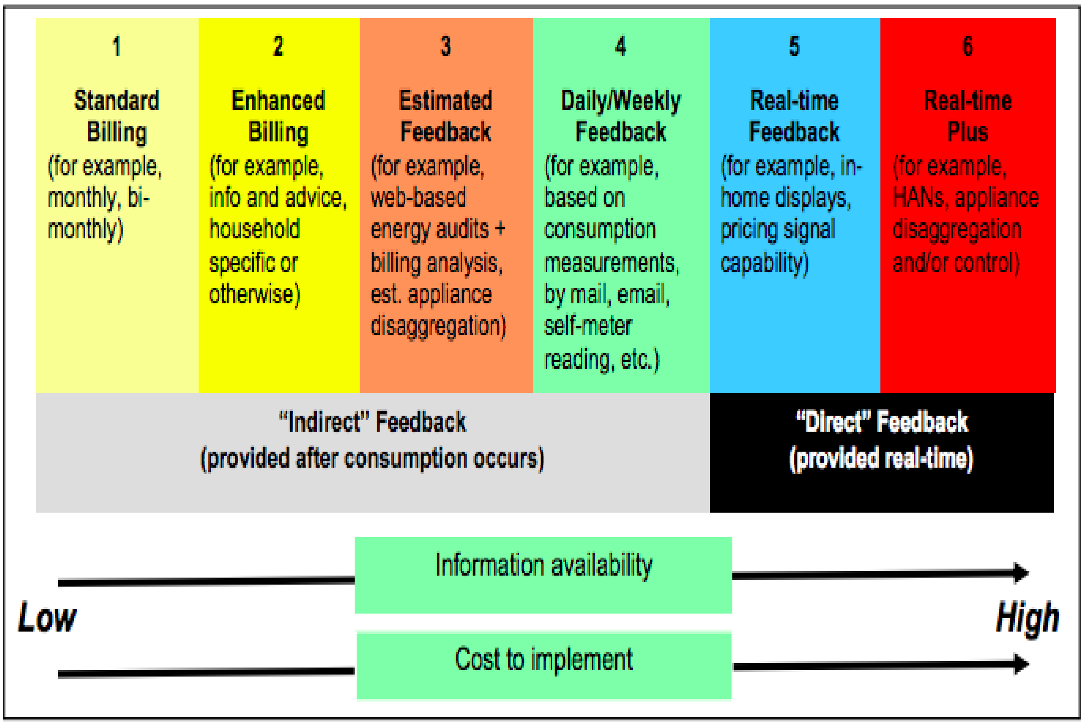


Figure 17: Feedback Delivery Mechanism Spectrum (Neenan, 2009, p. 10)

4.8.2. Making Feedback Meaningful

Energy is abstract, and displaying consumption could be meaningless in the case of ordinary users who have no notion of electricity units, i.e. kWh. Most of the displays or the In-Home Displays (IHDs) can show the energy consumption in the form of a cost in the currency of the user. However, both the energy consumption in kWh and the cost in currency are just a number for ordinary customers. This is why different research projects suggest that energy feedback should be combined with different forms of intervention like goal setting for energy conservation in order for it to be effective and achieve continuous energy saving (Ehrhardt-Martinez, 2011; Van Dam et al., 2010; McCalley and Midden, 2002).

The goal to be set should be realistic and ambitious in order to encourage users to reduce their energy consumption. Abrahamse et al. (2005) included a study run by Becker (1981) in their review of intervention studies aimed at household energy conservation; Becker selected a group of households and divided it into two. One sub-group was given a difficult goal of reducing their individual electricity consumption by 20% while the second sub-group was given a target of 2%. All households were provided with information about which appliances consume most electricity. Some of the homes belonging to both sub-groups received energy feedback three times a week. As a result, households which were provided with the difficult goal and feedback achieved an average 15.1% energy saving. Abrahamse et al. (2005) concluded that feedback is necessary for the achievement of such a 'difficult' goal while an 'easy' goal is not an effective strategy for saving energy since users might perceive it as not being worth the effort. Darby (2010) shares the same view and stresses that feedback can be effective if combined with advice. Therefore, (Ehrhardt-Martinez, 2011) suggests that there is a need to link the feedback-induced energy savings into energy conservation programmes that users are interested in so as to design programmes with persistent energy savings.

4.8.3. Feedback and Users Engagement

One of the goals of making energy visible to users is to engage them in reducing their energy consumption; this is why Bull et al. (2015) argue that there is a need to move beyond feedback towards user engagement. This is not to say that "savings cannot be made through visualisation tools, or that they cannot be useful tools for more effective management of energy within organisations" (Azennoud et al., 2017, p. 660) but to emphasise the role of users in energy conservation. Few research projects focus on the role of users on energy reduction in non-domestic buildings; however, Niamh et al. (2013) believe that domestic research projects in the domestic sector can be used to shed light on the role of users in energy reduction. Becker's (1981) study presented the effect of user engagement on achieving energy savings; the users who were in regular contact – 3 times per week- with the experiment managers achieved far more savings than the users who only received a saving target and a list of high energy consuming appliances in their households. Two studies confirm this claim. The first one included 52 participants over two weeks; these participants were provided with energy visualisation technology and they confirmed their awareness of their energy consumption after using these technologies but no energy reductions were achieved (Kim et al., 2010).

The second study was run by the Carbon Trust between 2004 and 2006 in order to evaluate the effect of advanced metering on energy management in SMEs. All the sites were provided with advanced metering technologies but with different types of services. These ranged between providing the sites with their energy data only, or energy data and advice or personal contact. The study concluded that advanced metering brings some energy savings into SMEs, but the savings vary depending on different factors (Carbon Trust, 2007):

- SMEs which have energy management expertise can use the energy data to identify energy savings. However, SMEs with no expertise need some advice to analyse their energy data for identifying energy savings opportunities.
- More energy savings have been achieved by sites which benefited from the advice or personal contact service.

However, how long should the engagement and communication with the users take place to ensure the continuity of energy savings? A report prepared by AECOM and Ofgem in 2011 covered four trials to assess the effect of energy visualisation and feedback on energy consumption and included households from four different energy suppliers; one of the trials, and which was the only one that measured how often the consumers accessed their energy data, found that less than half of the participants checked their energy data more than twice during the trial period (Niamh et al., 2013). Additionally, different studies found that consumers' response to energy feedback decreases with time. Another project that aimed at deploying an information system that facilitates an energy feedback loop between the stakeholders of one local authority's buildings in the UK found out that one of the biggest challenges facing these types of systems is to have active users:

> *"Access data show that after an initial flurry of activity, the system settled down to a consistent number of sessions per quarter. This dropped again after the project finished. Retention of active users is one of the biggest issues facing such systems"* (Graeme et al., 2016, p. 11).

Another study by Ueno et al. (2006) found that the persistency of some energy-saving activities performed by households drop with time even if residents are continuously provided with information on actual domestic energy consumption of the house as a whole and of the different appliances used in it. Ueno et al. (2006) came to a conclusion that people choose to perform energy-saving actions which do not affect their comfort. Energy consumers in households might be more concerned about energy feedback than office users, for any energy reduction will benefit the household consumer as it will lead to saving money unlike office users who will not benefit financially from their efforts to interact with energy feedback to reduce energy consumption in the workplace (Niamh et al., 2013). Hargreaves et al. (2010) further confirm the concern that the interest in visual display monitors drops almost to nothing after an initial period of intense interest. In one of the studies by Hargreaves et al. (2010), the participants admitted that they were very interested in exploring these new technologies and visualising the effect of their actions on home energy consumption patterns; this is why they were consulting the In-Home Displays (IHDs) frequently during the initial period. Later in the trial, the participants still accessed the IHDs on a regular basis but less frequently. Darby (2016) rejects the idea that IHDs become ineffective after some time of using them in households and finds that the critics of this technology are exaggerating. According to her, it is true that the interaction becomes less frequent but IHDs are used regularly to check usage over time, to budget energy expenditure or to detect any peaks in energy usage.

In summary, IHDs and other visualisation technologies provide a mechanism for feedback on energy usage. Visualisation of energy consumption alone might not be helpful, but there is a need to explain it and associate it with energy reduction targets and measures to achieve energy savings. Energy visualisation and feedback can be one of the first steps of energy M&T. However, combining this activity with energy data analysis and development of programmes activities to reduce energy consumption will make M&T complete. Programmes can include behavioural change measures, upgrade to more efficient appliances, change time of use of energy, etc. M&T might not lead to energy savings unless organisations action the developed programmes and assess their effectiveness as part of M&V.

4.9. Conclusion

This section will first be summarising the second part of this chapter. Second, it will include a summary discussion the whole chapter. Third, it will define the gaps in knowledge.

4.9.1. About Smart Meters and Energy Saving

The second part of this chapter has presented how smart meters (or similar technology) and their generated data can be used to assess energy consumption in order to identify areas for energy savings. It has been stated that one of the most direct results of adopting smart meters is to make energy visible. It has also been argued that energy visibility alone might not lead to achieving energy consumption reduction, but it is the first step on this journey. Energy visibility needs to be combined with energy conservation programmes and actions especially when dealing with consumers who have no knowledge of energy management. Clear goals, achievable targets and a set of actions need to be communicated to consumers in order to empower their decision making in relation to the energy management of their households or work place. This user engagement activity, as presented in the second part of the chapter, might become less useful with time as there is need for constant or regular communication with consumers.

Monitoring and targeting can build on this possible failure in non-domestic sites since it is characterised by being a cyclic and a regular activity. Monitoring & targeting (M&T) not only makes energy visible but also analyses energy data in order to study the energy flow in a system and identify any energy wastage. The goal of this chapter and this thesis is not to study how energy data is analysed as there are software in the market which are capable of analysing the periodic meter reads and prepare different sorts of reports but to identify how smart technologies can improve energy management in local authorities. This is why, in this chapter, the focus has been on explaining M&T and presenting its benefits.

The deployment of smart meters has shed light on different advantages for energy stakeholders, i.e. producers, suppliers, transporters and consumers. The literature presented in this chapter has summarised the advantages for the non-domestic consumers in the following themes:

- Financial:
    - Energy consumption reduction or energy savings will lead to financial savings
    - Ease of verification and validation of bills and fraud or discrepancies minimisation
    - Reduction of energy related charges cost (i.e. capacity charges, etc.) by adopting time of use strategies
    - Accurate annual energy quantities to buy in advance
- Technical:
    - Ease of access to real/near-real time and historic energy data of portfolios of buildings
    - Faults prevention or early detection
    - More informed energy related maintenance activities
    - Availability of energy data for feasibility studies and renewable integration into the energy mix
- Environmental and marketing: decrease of energy consumption will lead to decrease in emissions, which gives a good image of the organisation
- Legal requirements: roll-out of smart meters will help organisation in addressing the legal requirements for their half hourly supplies.

In chapters V and VIII, the researcher will explore how local authorities in the UK use smart meters in the context of these themes

4.9.2. Summary Discussion and Gaps in Knowledge

The first part of this chapter focused on exploring the available energy metering technologies and their development. The focus was on smart meters which represent the latest generation of energy meters. The researcher presented the reasons for their deployment in the UK from a statutory point. The second part of the chapter focused on exploring the academic literature that explain the reasons why organisations should and have opted for rolling out this technology and what their generated data (i.e. high-resolution meter reads) can be used for.

The UK's government low carbon agenda plays a key role in introducing different energy related schemes and concepts to organisations like carbon savings, energy efficiency and energy visibility under different forms which can be regulations, external funding, etc. In some cases, these organisations do not have a choice other than accepting the roll-out of specific technologies (like smart meters) especially when it becomes a statutory requirement. In other words, organisations do not study what impact these technologies will have on their performance. The roll out of smart meters is one example. There are very few academic papers studying the actual impact of rolling out this technology and using its generated high-resolution energy data on energy consumption. Additionally, the researcher did not come across any academic paper where the roll-out of this technology by organisations is part of a strategic decision especially in Local Authorities (LAs). This is why this study is going to identify why LAs in the UK are using this technology and how they are actually using it. The goal is to enrich academic research with empirical findings.

The same thing applies to energy management; even though there are many papers that explain why organisations opt for this practice and how they perceive its benefits and challenges, few papers actually present the strategic decisions behind its implementing and how it was embedded in the organisation. Therefore, this study will look at addressing this gas through the research's aim and objectives.

V	Energy Management, Metering, Monitoring & Targeting Practices in LAs	
	To describe the roll-out programme and related legislation for LAs, in addition to explore their usage	- Semi-structures interviews with LAs energy managers - 1st phase research findings & themes

Chapter V: Energy Management and Energy metering, Monitoring & Targeting Practices in Local Authorities

In Chapter IV, the researcher has set the regulatory scene for rolling out smart meters in organisations and presented the benefits and challenges of such a technology as identified by academic researchers. This chapter will present the rationale behind adopting this technology and by Local Authorities (LAs) through the analysis of interviews conducted as part of this research. In the first part of the chapter, the researcher will explain the regional political governance model in the UK and present governance and how it can be put into practice through energy management. In the second part, the findings of interviews with representatives of thirteen local authorities representing each type of LA will be presented.

The starting point for this chapter in particular and for this thesis in general is exploring the culture of energy management in different types of LA in the UK. The purpose of this study is to identify how different types of LAs use high-resolution, i.e. short-interval, energy data in their day to day energy management of buildings. The focus of this chapter will be on the different types of LA in the UK with their associated rules and functions and not the specific institutions themselves (i.e. legal defined organisations such as County Council, Borough Council, Parish Council, etc.).

Part I: Overview of Local Authorities in the UK and Governance Practices

5.1. Local Government Definition and Types

Even though local government has been a traditional form of decentralised power since the medieval era in England, their current guise owes much to the Local Government Act 1888, which heralded the creation of 66 county councils and the London Borough Council (Sandford, 2018). Since then, the structure of local government bodies (also known as local authorities (LAs)) has been changing. Nowadays, LAs are bound by statute and many of their functions are associated with statutory duties which have been fixed within various Acts of Parliament (Ministry of Housing, Communities & Local Government, 2011).

5.1.1. Types of Local Governments in the UK

Generally, Local Authorities in England operate under a one or two-tier system (gov.uk, n.d.). A one tier system provides all the services of the LA, whereas these services are divided between two local authorities for the two-tier system. In the two-tier system, County Councils are usually the upper tier, and district councils are the lower one. A one tier authority is a form of a unitary authority and can be found, for example, in cities, large towns and small counties, metropolitan districts or London boroughs. Such a system includes County Councils (upper tier) and District, Borough, City councils (lower tier) (a detailed definition of these organisations will be presented later in this section). The change from a two-tier authority to a one tier/unitary authority has been subject to the government policy or an initiative from the local government rather than being dependent on local identity, economy or geography (Sandford, 2018). In other words, the shift to a unitary authority is more dependent on the political agenda of Central Government or Local Authorities.

In some regions, there is a further – third - tier system which includes Parish, Community and Town Councils. These operate at a level below the Borough and District Council and are mainly found in the rural areas. In England, there are 353 LAs: 27 County Councils, 125 unitary authorities – including City of London, 32

London Boroughs, 36 Metropolitan Boroughs and Isles of Sicily- and 201 district councils in addition to some 10,000 parish and town parishes (Sandford, 2018).

All the LAs in Wales, Scotland and Northern Ireland are characterised by being one-tier/unitary organisations (gov.wales, 2015; Local Government and Communities Directorate, 2017; nidirect.gov.uk, n.d.).

There are 4 main types of LAs in England and these are (politics.co.uk, n.d.):

- County Councils: these cover the whole of the geographic area of a county and provide the majority of public services.
- District Councils: these are the lower tier of a two-tier system. They are below County Councils. They cover a smaller area and provide local services. They can also be called Borough or City Councils depending on the status of the district.
- Town and Parish Councils: these are responsible for very small local services like parks, community centres, war memorials, etc.
- Unitary Authorities: these cover large cities and towns and some small counties. They are responsible for most of the public services. One point to consider is that a County Council, City Council, or a Borough Council can be a Unitary Authority. As an example, Durham County Council and all London Borough Council are unitary authorities. There are two main types of unitary authorities:
    - London Boroughs: each London borough is a unitary authority and responsible for local public services whereas the Greater London Authority (GLA) governs the whole geographic area for London and shares responsibility for some public services. In a way, and even if GLA and London Borough Councils are unitary authorities, London can be viewed as a two-tier authority with GLA providing the shared and central services for the city, whereas London Boroughs provide the local services. In fact, the GLA and the Council governing the Isles Scilly are described as unique authorities (Sandford, 2018).

- Metropolitan Districts: These can be called Metropolitan City Councils, Borough Councils or District Councils.

For an overview of the statutory responsibilities of each type of LAs, refer to Table 4.

In some cases, different local authorities can decide to group under joint legal bodies that enable them to work together or form joint waste authorities following the enactment of the Local Democracy, Economic Development and Construction Act 2009 and the Environmental Protection Act 1990 (Sandford, 2018). One example is the West Midlands Combined Authority which is made of twelve LAs and three Local Enterprise Partnerships (LEPs). These latter are voluntary partnerships and are jointly managed by LAs and local businesses. They have a role to drive economic growth and decide on local economic priorities and were created to replace the Regional Development Agencies which were abolished in 2012 (Politics.co.uk, n.d.). There used to be 39 LEPs in England, but their number dropped to 38 following the merger of the Northamptonshire and South East Midlands LEPs in 2017(The Local Enterprise Partnership Network, 2013; South East Midlands Local Enterprise Partnership, 2016).

5.1.2. Operational Models for LAs:

Local Authorities can choose from four operational models which have been set out in the Local Government Act 2000 and these are (Ministry of Housing, Communities & Local Government, 2016):

- Leader and cabinet executive
- Mayor and cabinet executive
- Committee system
- Other operation model approved by the Secretary of State.

The councillors or members of the Council are the voice of the public; each councillor represents a geographical ward or division and its citizens and forms a link between them and the LA (Local Government Association, n.d.). Each ward can have a single councillor or multiple ones; the Local Government Boundary Commission for England is responsible for reviewing wards' boundaries and the number of representatives and cabinet councillors (Sandford, 2018). Councillors have many duties, but the main ones are developing and approving Council policies, strategies, budgets and communicating with their ward's inhabitants.

5.1.3. Responsibilities of Local Authorities

LAs do not provide all public services in their regions but different types of local governments have different statutory requirements. Additionally, there are some services delivered by other national public bodies. As an example, health services are delivered by the National Health Service (NHS), but some types of LAs do have a health-related duty known as "Public Health"; this was transferred from the NHS and is more related to improve the lives of residents (Department of Health, n.d.).

Table 4 summarises the responsibilities of the LAs in UK depending on which tier they fall under:

	Shire Areas			Metropolitan Areas	London	
	Unitaries	County Councils	District Councils	Metropolitan Districts	London Boroughs	GLA
Education	✓	✓		✓	✓	
Highways	✓	✓		✓	✓	✓
Transport planning	✓	✓		✓	✓	✓
Passenger transport	✓	✓		✓		✓
Social care	✓	✓		✓	✓	
Housing	✓		✓	✓	✓	
Libraries	✓	✓		✓	✓	
Leisure and recreation	✓		✓	✓	✓	
Environmental health	✓		✓	✓	✓	
Waste collection	✓		✓	✓	✓	
Waste disposal	✓	✓		✓	✓	
Planning applications	✓		✓	✓	✓	
Strategic planning	✓	✓		✓	✓	✓
Local taxation collection	✓		✓	✓	✓	

Table 4: Responsibilities of the Different Tiers of Local Authorities in the UK (Local Government Group, 2010, p.5)

5.2. Good Governance Practice in Local Authorities

5.2.1. Quick Overview of Governance

The term 'Governance' has recently witnessed a rise in its usage in public administrations especially when perceived, according to theorists in the field of public administration, as an organising concept that guides the shift from a bureaucratic state to a hollow state (United Nations, 2006). A "hollow state" or "state of agents" is used to describe the set of practices in which public authorities use third parties (non- profit organisations/ private companies) to deliver public services (including social services) and act in the name of the public authority (Milward and Provan, 2000). The United Nations Development Programme (UNDP) (1997) defines governance as

> *"The exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences"* (United Nations, 2006, p.3).

Sheffield Hallam University has a simpler definition of governance questioning who has authority, who makes decisions and how the organization is kept accountable (Sheffield Hallam University, n.d.). Governance can be seen as the structure and processes for initiating and determining:

- The effectiveness of public policies and strategies and their effect on public services as these outcomes give a meaning to the role of LAs.
- Accountability for decision making and service delivery.
- The process of interaction between the State, private sector and civil society based on universally accepted principles like transparency, equality, separation of powers, accountability, rule of law, access and participation (United Nations, 2006).

Governance is an important topic for local authorities as they are large essential businesses using public money to operate. These organisations are keenly observed, criticised, and have the obligation to design and implement plans and strategies that will help in attaining high standard services which ensure that public resources are used effectively (The Chartered Institute of Public Finance & Accountancy, 2016). These strategies and plans should bring together governance and management principles in addition to legislative and statutory requirements in order to ensure that public money is well spent and resources are used in accordance with the organisation's strategies and priorities. Local Authorities in the UK are compelled more than ever to instil the culture and practices of good governance in their organisations especially now that they are witnessing funding cuts from Central Government, and the savings they can achieve can help in delivering the services they are bound to provide to the citizens of their communities. This is why good governance should not only be a set of rules and procedures but should be embedded in the spirit, ethos and culture of the organisation (The Chartered Institute of Public Finance & Accountancy, 2016) to make every individual - an officer or a manager - feel that they have the obligation to use public money wisely and that their actions are accountable and will affect the performance of the organisation especially with finances subject to close scrutiny (The Chartered Institute of Public Finance & Accountancy, 2007). Managers do have interests and views that can unintentionally influence their decision making and distance them from public interest; this is why governance arises as a mechanism which minimises conflicts of interest between the managers and the different organisational stakeholders by promoting greater control, visibility and supervision by public management (Castro, 2017). On the other hand, poor governance opens doors for corruption leading to the loss of public trust in their representatives and their public institutions, or undermining of the organisation's efforts, worsening of public resource allocation and discouragement of socio-economic development and communities' growth (International Monetary Fund, 2016; Mauro, 1995).

5.2.2. Good Governance

There is no international standard for defining governance or good governance, but the notion of "good" can be defined by identifying the desired outcome which can vary from one situation to another (United Nations, 2012). Good governance is a more specific notion than governance since the latter refers to the exercise of political power through institutionalised modes of co-ordination through which decisions are collectively designed and implemented (Soyaltin, 2017; Scharpf, 1997). In other words, good governance can be reached by achieving the intended outcomes while acting in the public interest; the governing body of the public authority and its members of staff have to try to achieve the targets and strategies - defined by higher management and approved by cabinet members, in addition to statutory duties while acting in the public interest by delivering services which will result in positive outcomes to the community (The Chartered Institute of Public Finance & Accountancy, 2016). Following the UK's Central Government austerity agenda which was initiated in 2010 and led to funding cuts to public organisations including Local Authorities, and while the latter strive to offer services they used to deliver in the past;

this might not be possible anymore since the available resources are prioritised for the delivery of statutory services (Hastings et al., 2015). This can be viewed as an example of good governance where LAs will have to focus their resources on delivering statutory services like street lighting or adult safeguarding and cut the delivery of additional services. One example is that some LAs are decreasing the number of libraries by regions. It is true that LAs or Library authorities have the obligation to provide a ‘comprehensive and efficient library service’ according to the Public Libraries and Museum Act 1964; however, comprehensive and efficient have not been defined by the act (Woodhouse and Dempsey, 2016) which gives room for LAs to interpret it while taking into consideration resources available and public interest. A strategy could be to leave regional libraries open (by city, town, region, etc.) rather than fail to achieve this statutory requirement:

> *“A comprehensive service cannot mean that every resident lives close to a library. This has never been the case. Comprehensive has therefore been taken to mean delivering a service that is accessible to all residents using reasonable means, including digital technologies. An efficient service must make the best use of the assets available in order to meet its core objectives and vision, recognising the constraints on council resources”* (Department for Digital, Culture, Media & Sport, 2015).

Energy Management can be viewed as a practice which reflects the principles of good governance as it will be explained later in this chapter. However, a quick example from Northamptonshire County Council can give a notification of the importance of this practice. Some libraries in Northamptonshire are facing the possibility of being closed or transferred to community groups which will be funding them. Thanks to energy management and efforts of the energy teams of the LA, some areas for energy improvement have been spotted and many of these libraries have seen their operational costs go in recent years; most of these institutions had their lighting upgraded and some of them have witnessed the installation of roof mounted PV which decreased their electricity bills and provided them with an extra income thanks to the Feed-In

Tariffs. The extra income is directly used to fund some community activities organised by the libraries.

5.2.3. Principles and Dimensions of Good Governance

According to Soyaltin (2017), the literature associates good governance with two main analytical dimensions. The first relates good governance to a regulatory and sound administrative framework which has as fundamental and core principles: accountability, transparency and efficiency. This framework is to be provided and guaranteed by the public authority in order to promote public financial management. The second dimension emphasises the respect of human rights and democracy.

The Chartered Institute of Public Finance & Accountability (CIPFA) and the Society of Local Authority Chief Executives (SOLACE) (2016) define a set of principles and sub-principles to achieve good governance in LAs as:

- Behaving with integrity, demonstrating strong commitment to ethical values, and respecting the rule of law.
- Ensuring openness and engaging comprehensively with institutional stakeholders.
- Defining outcomes in terms of sustainable economic, social, and environmental benefits.
- Determining the interventions necessary to optimise the achievement of the intended outcomes.
- Developing the entity's capacity, including the capability of its leadership and the individuals within it.
- Managing risks and performance through robust internal control and strong public financial management.

These core principles help to shift governance from being an abstract idea into a systematic approach that public organisations, including LAs, can use and develop on policies and procedures which will allow them to manage their daily duties in the best public interest. This is why the EU promotes this principle within its member states, and even made it as one of the essential criteria in its enlargement policy; good governance is now a condition for joining the EU (Mungiu-Pippidi, 2010). Moreover, many countries have reformed their public sector in order to instate accountability and transparency in these organisations and to become more efficient and effective when delivering services in order to meet the public's expectations (Abd Aziz et al., 2015). In the UK, members of the public can have access to different documentation that can help them with overseeing the work of LAs. As an example, every member of the public can use Freedom of Information (FOI) requests which were enacted as part of the Freedom of Information Act 2000 to acquire information that is not deemed confidential or will unfairly reveal information about individuals. Thanks to this policy, some cabinet meetings can be attended by journalists and the public, minutes of cabinet meetings are published and can be accessed online, and LAs more often launch consultations to get the public's view about a decision it will take, etc. Another example is related to procurement, and specifically the purchasing of goods and services by senior managers within LAs. Depending on the value of the purchase order, the necessary procurement procedure will vary in accordance with fixed corporate procurement policy. Senior managers will, in some instances, have authority to make purchases without consultation providing it can demonstrate that the purchases provide best value; however, it is certain that significant purchases may necessitate consultation with the council's cabinet i.e. above £500,000 (Northamptonshire County Council, 2016). These practices encourage employees of the public sector to act in the public interest as they know that there is a chance that they will be questioned about their decisions. These principles and examples of good governance help in improving members of the public's trust in their organisations and political and administrative system (Salminen and kola-Norrbacka, 2010).

5.3. Energy Management in Local Authorities in the UK

"Public sectors worldwide are now under pressure to justify the sources and utilisation of public resources as well as improving the performance in their services delivery" (Abd Aziz et al., 2015, p. 163) and the United Kingdom is no exception. Good governance, through the practices and principles described above, can play an important role in achieving this mission. The focus should not only be on service delivery to the communities but also on operational service delivery. Local authorities have some internal ‘operational’ services that do not have a direct link with members of the public but are fundamental for the public service delivery. Such support services include energy procurement, maintenance of estate, human resources, IT, Finance, etc. Using public money and other resources efficiently and effectively in these services as well is one way to serve in the public’s interest. Therefore, energy management can be seen as one of the practices or approaches that translate good governance into measurable actions.

“Energy is one of the largest controllable overheads in many local authority buildings so there are many opportunities to make savings” (Carbon Trust, n.d.). According to the Local Government Association (LGA) (2016), LA energy costs range between £150,000 annually in a small district Council to around £25 million annually in a large city council. The same association adds that there are some energy efficiency measures with an average payback of two to three years that can be adopted by LAs and which can lead to important energy savings - 10% to 18% of the energy consumption - ranging between £60,000 and £2.4 million per year depending on the size of their portfolio of assets. These measures can include lighting upgrades, heating controls, lighting controls, etc. and are labelled as low hanging fruits. Ferreira et al. (2007) add that this approach usually leads to initial and straightforward savings which even if they look minimal in comparison to LAs budgets, can make a change especially when these organisations are striving to achieve operational savings and to afford a good level of public services to the communities they serve. Moreover, local governments have a relatively old building stock which makes it easier to locate an energy saving potential especially when these organisations have a longer financial horizon for investment in energy efficiency compared to the private sector (Borg et al., 1998). The Carbon Trust (n.d.) identifies three areas in which LAs can reduce their energy consumption; one of them is energy management by appointing an energy manager or monitoring the energy use and developing an action plan and training staff. The two other areas are ventilation and heating; the latter accounts for 60% of the total energy cost of an organisation. However, those two areas, and the measures to implement them to decrease their energy consumption should normally be highlighted in the energy reviews, audits and energy plans as part of the energy management system, meaning that they are indirectly accounted for in the first area of intervention.

5.3.1. Integration of Energy Management in Local Authorities

This section will look at the literature around the integration of energy management in LA's strategies in order to help in identifying how it can be incorporated which will be discussed in detail in Chapters VI, VII and VIII.

LAs in the EU zone can play an important role in meeting the GHG emissions reduction targets for 2020; this is why the EU launched an initiative called the Covenant of Mayors (CoM) with the objective to support the role of LAs and to meet the EU's sustainability goals (Kamenders et al., 2017). The Covenant of Mayors for Climate & Energy can be seen as a European co-operation movement where LAs or regional governments voluntarily commit to cut their Carbon Emissions as part of the EU's Climate and Energy Policy framework. This is detailed in the EU's Climate & Energy Package for 2020 for the organisations which joined prior to 2015 and the EU's 2030 Climate and Energy Framework for the organisations that joined after 2015; these organisations are currently committed to cut their CO_2 emissions by at least 40% by 2030 below 1990 levels (Covenant of Mayors for Climate & Energy, n.d.).

To meet the targets they have voluntarily committed to, regional governments are invited to develop and implement a Sustainable Energy Action Plan (SEAP) for countries which joined the COM prior to 2015 or a Sustainable Energy and Climate Action Plan (SECAP) for those which joined after 2015. By the development of one of these two plans, LAs are invited to analyse their energy use and carbon emissions in order to identify and develop measures to reduce their carbon emissions.

However, municipalities face difficulties when trying to implement these plans and reports suggested that the SEAP and SECAP should be supplemented with additional instruments to enable a deeper integration with present and future planning strategies

(Kamenders et al., 2017). A report prepared by Energy Cities and Climate Alliance (2013) reviewed the implementation of SEAP and derived some hindering factors which can be summarised as follows:

- SEAP is perceived as a technocratic response to the initiative more interested in reporting than making actual change.
- It is inflexible and the example given in the report is of situations where municipalities already have long term CO_2 reduction plans, but they still need to prepare a plan for 2020 or 2030 and get the approval of the Covenant of Mayors.
- Lack of experienced staff and data to develop a Baseline Emission Inventory (BEI). This is "a quantification of the amount of CO2 emitted due to energy consumption in the territory of a Covenant signatory within a given period of time – the recommended base year being 1990. It also identifies the principal sources of CO2 emissions" (Covenant of Mayors, 2013).
- Lack of financial and human resources and support from Central Governments or from the EU for applying these plans and lack of experienced staff or a systematic approach for addressing energy efficiency.
- Changing national political contexts which might have a negative effect on the implementation of strategies.

5.3.2. Role of ISO50001:2011 in the Institutionalisation of Energy Management and Energy Efficiency in Regional Governments

One of the additional instruments which were suggested to help with the implementation of the SEAP and to strengthen the systematic approach to energy efficiency was ISO 50001:2011 (Kamenders et al., 2017). This is an international standard developed by the International Organisation for Standardisation and was launched in 2011. It is specific to energy management and is based on the management system model which relies on continual improvement; the same management model used for the ISO9001 'Quality Management' and ISO14001 'Environmental Management' (International Organisation for Standardisation, n.d.). This standard facilitates the establishment of the necessary systems and processes to enhance the energy performance of organisations by addressing the standard's requirements for establishing, maintaining, and improving an Energy Management System (EnMS) by adopting a systematic approach which enables continual improvement of energy related themes like energy use, energy consumption, etc. (Eccleston et al., 2017). This approach is based on the Plan, Do, Check, Act (PDCA) cycle which is an iterative management approach for process control and continuous improvement. This is summarised in Figure 18:

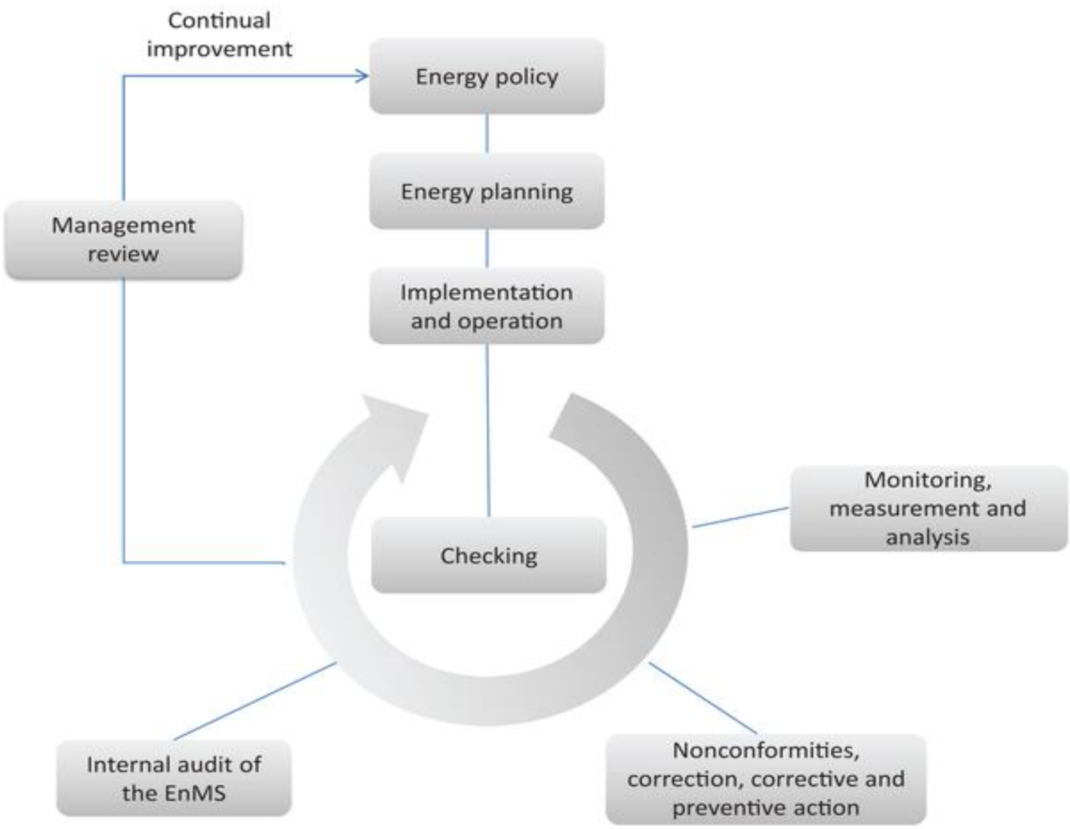


Figure 18: PDCA Approach for ISO50001:2011 (International Organisation for Standardisation, n.d.)

The first step is to produce an energy policy where the top management of an organisation commits to a set of targets defined by the standard. The following steps are described in the main four phases below (International Organisation for Standardisation, 2011):

- Plan: consists of developing an energy plan which is determined after performing an energy review to identify all the energies used by the organization, their quantities, identifying an energy baseline, and defining the energy performance indicators (EnPIs) in addition to the energy objectives.
- Do: this is the phase where the energy plan is put into action. Areas of high consumption have been identified during the energy review, and their respective action plans to improve their energy performance are created and implemented.
- Check: in this phase, the developed plans go through a review phase in the form of internal audits in order to check if they have led to the desired results or not – these need to be compared to the initially established objectives - and to draw some conclusions and lessons learnt for continuous development and improvement. Any issues that might affect the system should be recorded as non-conformities which will need to be addressed accordingly and define their causes in order to avoid their occurrence in the future.
- Act: based on the lessons learnt, the energy manager makes changes to the energy plan and/or the energy policy after consulting with senior management in the periodic management review meeting.

The standard has also a set of requirements related to the law and to the training of key staff members in relation to energy management and the communication of the EnMS to employees, etc. This makes different levels of the organisation take part in designing and managing the EnMS turning it into a system for the whole organisation rather than for a single department. It means that energy management practices are more easily institutionalised since they follow and depend on a systematic approach and a set of rules and guidelines that are communicated to the different stakeholders of the organisation. This is why directive 2012/27/EU of the European Parliament & of the Council (2012) which is about energy efficiency calls for the adoption of energy management systems by public organisations. Kamenders et al. (2017) assume that the adoption of this standard or similar ones will improve energy management practices and will lead to energy consumption reduction thanks to its ability to provide clear and focused energy tasks to management and employees making them feel a higher sense of responsibility and designing data collection systems, clear reporting procedures, and self-auditing mechanisms both to the different units and to the system (i.e. the organisation in this case) as a whole. The same authors believe that the Covenant of Mayors (COM) has a clear methodology for setting up the SEAP in public organisations, but there are limitations when it comes to directions on how to implement and monitor the plan.

5.3.3. Integrated SEAP and EnMS

Thanks to the previously presented measures and mechanisms offered by ISO50001:2011; one of the potential solutions suggested to overcome the challenges facing the implementation of the SEAP was integrating it with ISO50001:2011. The EU commission believes that this energy management standard can help in institutionalising the SEAP and achieve a coherent implementation. A consortium including energy experts led the training and coaching of LAs, participating in this project, in the development, implementation, and monitoring of this integrated approach which will lead to the institutionalisation of the SEAP and certification of the EnMS of the organisation with ISO50001: 2011 (European Commission, n.d.). This integration meant that the boundaries of the EnMS system had to change since the energy policy and the plans will not only include energy related targets but also CO_2 ones (Cf. Figure 19).

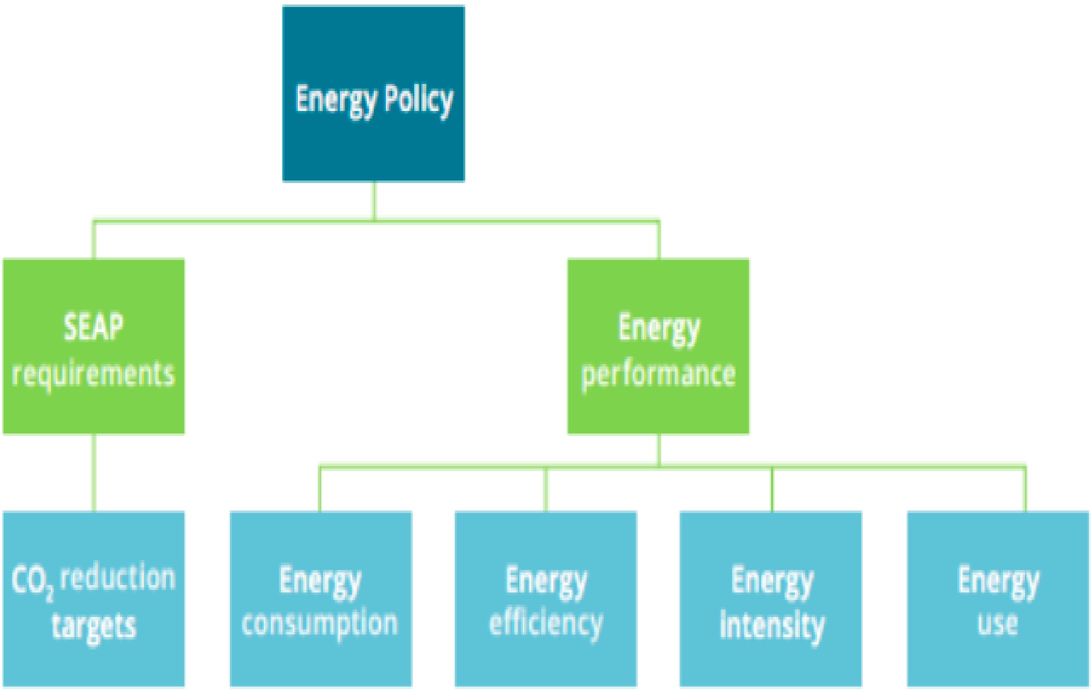


Figure 19: Energy Policy Commitments for the Integrated SEAP-EnMS Approach (50001seaps.eu, 2017, p.10)

Between 2014 and 2016, 41 municipalities from eight European countries (Greece, Poland, Latvia, Romania, Bulgaria, Italy, France and Spain) took part in this project to integrate SEAP and ISO50001:2011 and which found that one of the main barriers to the implementation of the approach was the absence of energy managers in these LAs whose roles are important for ensuring continuous energy performance improvement (Kamenders et al., 2017). One of the most important skills that energy managers should have is cross functionality; they need to be able to link and connect different teams or departments like finance and facilities around one project or one aim which is executing energy programmes since energy management, as it has been mentioned previously, should not be confined to one team but to the whole organisation (Hermes, 2013). Cross-functionality also means knowing about and understanding different resources in order to choose the best solutions when developing energy conservation programmes. Hence, the role of an energy manager is important for the implementation of the integrated approach; each project needs a director or a manager who has the right skills to manage it and energy management is no exception.

The project also found that most of the previous described barriers facing the implementation of the SEAP have been removed after integrating with ISO50001: 2011. For example, LAs have been able to develop plans for attracting investments based on the energy savings. Additionally, the standard helped in removing the technical barrier related to defining significant users or prioritising areas for intervention.

5.3.4. Motives and Benefits of Implementing ISO50001: 2011 by Organisations

Organisations have different motives for implementing an EnMS under ISO50001: 2011. As mentioned previously, the European Commission (EC) and the Covenant of Mayor (COM) chose this standard since it provides a systematic approach and adapts to the organisation's structure and way of work. Additionally, a study by Marimon and Casadesus (2017) found that the main motives for adopting an EnMS highlighted by 57 organisations which implemented ISO 50001:2011 were ecological drivers, competitive advantage and social requirements where the latter refers to incentives by public administration or other professional institutions.

Different case studies found that the ISO50001: 2011 help in achieving energy savings and therefore carbon reductions. As an example, Sheffield Hallam University has saved £100,000 from energy cost even though their estates increased by 2% (British Standards Institute, n.d.). Tata Global Beverages made a saving of £56,000 in the 1st year of implementing the standard and an additional £28,000 in the second year from an annual energy bill of £750,000 (British Standards Institute, n.d.).

In Chapter V, how an LA in the UK implemented the EnMS system will presented, and the rationale behind making such a decision will be explored.

5.3.5. Energy Management Matrix

The Energy management matrix is a diagnostic tool that can be used by an organisation for self-assessment in regard to energy management (Carbon Trust, n.d.; Building

Research Energy Conservation Support Unit, 1995). It allows for a review of the state of energy management practice in order to identify its strengths and weaknesses and identify the key areas that need to be enhanced. The matrix assesses six key energy management areas: energy policy, organising, motivation, information systems, marketing and investment. The assessor locates the organisation at one of four levels of performance (Figure 20):

Level	Energy Policy	Organising	Motivation	Information Systems	Marketing	Investment
4	Active commitment of top management	Fully integrated into general management	All staff accept responsibility for saving energy	Comprehensive system with effective management reporting	Extensive marketing within and outside organisation	Positive discrimination in favour of 'green' schemes
3	Formal policy but no commitment from top	Clear delegation and accountability	Most major users motivated to save energy	Monthly monitoring and targeting for individual premises	Regular publicity campaigns	Same appraisal criteria used as for all other investment
2	Unadopted policy	Delegation but line management and authority unclear	Motivation patchy or sporadic	Monthly monitoring and targeting by fuel type	Some adhoc staff awareness training	Investment with short term payback only
1	Unwritten set of guidelines	Informal part-time responsibility	Some staff awareness of importance of energy saving	Invoice checking	Informal contacts used to promote energy efficiency	Only low cost measures taken
0	No explicit policy	No delegation of energy management	No awareness of the need to save energy	No information system or accounting for consumption	No marketing or promotion	No investment in energy efficiency

Figure 20: Energy Management Matrix (Building Research Energy Conservation Support Unit, 1995)

The Carbon Trust provides an additional tool for Energy Management Assessment (EMA); this allows a more detailed appraisal of the performance across twelve key areas grouped under five clusters (Table 5):

Cluster	Key Area
Management Commitment	Energy Policy
	Energy Strategy
	Organisational Structure
Regulatory Compliance	Regulatory Compliance
Procurement and Investment	Procurement Policy
	Investment Procedures
Energy Information Systems and Identifying opportunities	Monitoring and Analysing Energy Use
	Target Setting
	Opportunities Identification
Culture and Communications	Staff Engagement and Training
	Operational Procedures
	Communications

Table 5: The Key Areas of Energy Management Assessment (Carbon Trust, n.d.)

The EMA provides the assessor with a list of question that allows him/her to score the performance of the organisation against each key area. The results are then summarised by the tool on spider diagram (Figure 21):

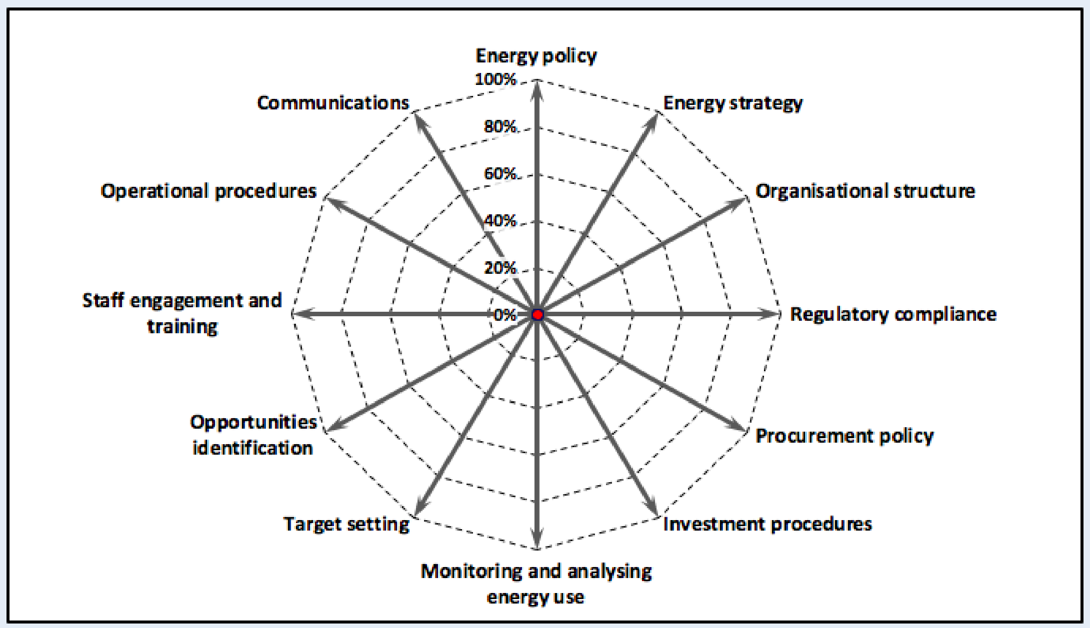


Figure 21: Spider Diagram to summarise the Results from the Energy Assessment Activity (Carbon Trust, n.d.)

The researcher will use these tools in Chapter VII to assess energy management in Northamptonshire County Council as part of the case study.

5.4. Energy Efficiency in Local Authorities

As defined under 4.1, energy efficiency in simple terms means using less energy to provide a service or a product with the same or a better quality. For a building, this is more related to end-use energy efficiency; in other words, it is about the energy saving actions and activities that will lead to decreasing the energy consumption of the building. A decrease in energy consumption is not the only benefit of implementing energy efficiency but its wider benefits "make opportunities even more attractive, such as reduced maintenance, supporting the local economy, improved comfort for building occupants and local energy resilience" (Local Government Association, 2016, p.5). Nonetheless, most organisations do not develop and invest in energy efficiency programmes even when it is the logical thing to do (Mallaburn, 2016).

5.4.1. Policy Role in Introducing Energy Efficiency to Organisations

In the US, for example, the policy represented in the building codes and appliance and vehicle standards is a big driver for energy efficiency adoption in the non-domestic sector (Nadel, 2018). In the UK, there is willingness and motivation from both the Central Government and the European Union to decrease energy consumption of building through energy efficiency measure. The EU Energy Efficiency Directive of 2012 establishes a set of binding measures that EU countries need to follow in order to help the EU meet its 20% energy efficiency target by 2020; some of these measures are (European Commission, n.d., link 2):

- Every year, governments of EU countries must make energy efficient renovations to at least 3% by floor area of buildings owned and occupied by Central governments.
- Any building to be sold or rented should have an energy efficiency certificate or similar.
- Central Government of the EU countries should prepare National Energy Efficiency Action Plans every 3 years.
- Programmes should be in place for rolling out smart meters for 2020 to enable visibility of energy. This has been discussed under 4.3.

In the UK, the regulatory context for energy efficiency has been a constantly evolving landscape. This can be partly due to the measure that commits Central Government to prepare energy efficiency action plans every 3 years for the last 15 years; the Climate Change Act 2008 serves as a long-term driver for energy efficiency with its legally binding targets and where different LAs developed their own plans to help the UK meet the target (Local Government Association, 2016). Different regulations have been put in place in order to address the Climate Change Act 2008 and the EU Energy Efficiency Directive requirements. For example,

- All newly built, sold or rented buildings should have an Energy Performance Certificate (EPC) (Department for Communities and Local Government, 2017).

- Public buildings with a useful floor area greater than 250 m^2 which are used by public authorities or institutions providing public services and are accessed by members of public should have Display Energy Certificates (DEC) and Advisory Reports (AR) (Department for Communities and Local Government, 2015).
- Carbon Reduction Commitment Energy Efficiency Scheme (CRC); this will be abolished by the end of October 2019 (Department for Business, Environment and Industrial Strategy and Environment Agency, 2015).
- Energy Savings Opportunity Scheme (ESOS).
- Building Regulations Part L.
- Energy Performance of Buildings Directive.

5.4.2. Role of Funding for Energy Efficiency Policy Implementation

Mallaburn (2016) confirms that, in the UK, the government has a key role in helping different organisations uncover the potential of energy efficiency and the impact it can have on their energy consumption and to provide support to them in their journey to exploit it. One way to help is through enacting policies that push organisations towards assessing their energy consumption to identify areas for energy savings and to implement schemes to monetise those savings. Another means for the government to help or assist in policy delivery can be by providing a form of funding to support organisations while investing in energy efficiency. In the UK, this was the case since at least 2004 when the British government created Salix Finance Ltd which provides funding for investing in energy efficiency schemes in the public sector.

Salix Finance Ltd. is an organisation funded by the Department for Business, Energy & Industrial Strategy (BEIS), Department for Education (DfE), the Scottish Government and the Welsh Government to provide interest-free public funding to the public sector for saving carbon and decreasing energy consumption. The institutions which can have access to SALIX funding can be LAs, higher and further education institutions, NHS trusts, academies and schools, etc. For example, in England and since 2004, £197 million has been invested in energy efficiency in LAs through Salix with £47 million estimated annual energy savings (SALIX, 2017). The energy efficiency schemes that can be funded through this organisation can be boiler upgrades, lighting upgrades, controllers, pool covers, waste from energy, insulation, voltage management and ventilation among others.

Therefore, providing access to 'invest to save' funding can trigger energy efficiency for example in the public sector. However, even with the existence of these funding opportunities and energy efficiency related policies, governments found that these policies still did not deliver their full potential; Mallaburn (2016) believes that it is due to the fact that they are focusing on overcoming existing technical, economical and organisation barriers to implementing energy efficiency rather than focusing on how this latter fits in the wider investment decision-making processes of an organisation. In addition to this, energy savings triggered by energy efficiency policies are just one of the many benefits that can be achieved once these policies are enacted; other benefits to capitalise on in order to encourage public institutions to adopt energy efficiency into their culture are: lower energy bills, better working conditions thanks to the thermal insulation of buildings, lower CO_2 emissions and its positive effect on the environment and the quality of air and most importantly decreased public spending (European Commission, n.d.). Moreover, setting up targets for energy efficiency acts as an impetus for developing, implementing and reviewing energy efficiency measures (European Commission, n.d.).

5.4.3. Challenges Facing LAs and Measures to Assist Them on Their Journey to Implement Energy Efficiency

There are different mechanisms hindering the adoption of energy efficiency by public institutions and these range from financial barriers, behavioural barriers to information barriers; however, the information/knowledge barrier is described by many authors as one of the most relevant (Annunziata et al., 2014). The danger with this type of constraint is that the lack of information about energy related-problems facing the buildings, the technical expertise to address them and the economic and technical benefits of implementing energy efficiency measures can be the trigger to other issues like the financial one since this lack of knowledge will hinder the decision-making process towards an investment in energy saving projects. Therefore, the knowledge management concept of Davenport (1994) -i.e. the process of capturing, developing, sharing and effectively using organisational knowledge - can be useful through the capturing of energy related information, distributing it to key stakeholders, and effectively using it to develop these projects and support the transition of regional governments into more proactive and effective institutions (Evans et al., 2005) in energy management. The researcher has already presented under 4.2 the different technologies and tools available for organisations to collect and share energy related information.

Annunziata et al. (2014) found that there are four options which can be described as more behavioural than technical for enhancing energy efficiency in LAs and these are:

- Internal competence: Energy efficiency capacity building goes hand in hand knowledge sharing. Members of staff in energy management or property or maintenance teams with the right knowledge and expertise can drive the development and the implementation of energy efficiency measures. This capacity building can be achieved through the training of individual members who by themselves will share their knowledge with their peers and successors.
- Good use of internal resources: in their survey of LAs in Italy, Annunziata et al. (2014) found that one of the failures of implementing energy efficiency policies and measures resides in the non-effective use of internal resources, more specifically the knowledge share. It has been highlighted, under 1.2.1, that departments in municipalities often work in silo structures. This survey confirmed this and argued why it is crucial that different departments from different disciplines work on the same project for ensuring the knowledge share; i.e. departments will be sharing experiences and ideas about the same project.
- Energy audits and decision-making processes: energy audits come after training in their ability to help members of staff become aware of the energy related challenges facing their building stock. However, for a greater impact, energy audits should not only focus on energy accounting but should highlight underlying energy saving opportunities (Shen et al., 2012). The knowledge

created by this tool i.e. energy audits, should inform the decision-making process for investing in energy efficiency schemes.

- Perils of perception: Annunziata et al. (2014) confirm that LAs focus on low hanging fruits when it comes to diffusing energy efficiency measures such as lighting upgrades. Nevertheless, this can be a threat to the adoption of energy efficiency as it doesn't help with improving the expertise of the personnel in relation to more complex solutions that might have a greater impact.

The process and methods, discussed above, which have been used for embedding energy efficiency in organisations can inform the strategy to be developed in this study and which has as goal the incorporation of energy management in LAs. Knowledge capturing and sharing, encouraging professional development, expertise and competence are essential tools for a successful adoption of these two practices, i.e. energy management and energy efficiency. The Standard ISO50001: 2011 can have a significant role in this task as it is designed to help organisations develop and capitalise on these measures and tools.

5.5. Leading by Example: The Role of LAs in Energy Management and Energy Efficiency Dissemination

A study by Tingey et al. (2017) found that the majority of LAs in the UK created sustainable energy plans as part of their ambition to become energy efficient. Additionally, 82% of the 434 researched LAs are actively implementing these plans. Figure 22 presents the distribution of these researched LAs in accordance with their level of engagement in energy systems:

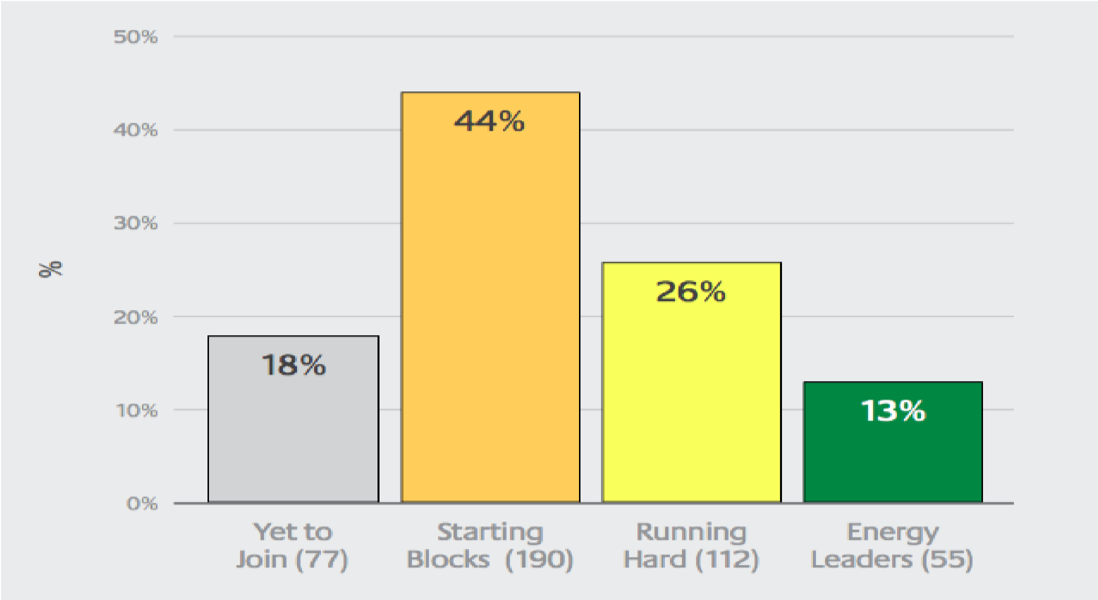


Figure 22: British LAs According to Level of Engagement in Energy Systems (Tingey et al., 2017, p.6)

The four categories of LAs presented in Figure 22, and which are dependent on the availability of energy plans or investments in these organisations are as it follows:

- Yet to join: there is no evidence of the existence of strategic related energy plans or investments in energy schemes
- Starting blocks: a strategic plan has been set or the organization started one or two projects
- Running hard: a strategic plan has been developed and one or two schemes have been launched
- Energy leaders: the organisation has multiple investments in energy projects.

The study did not give any indication on whether these LAs are following a systematic approach when implementing energy management or whether they have an energy management system that is respecting international norms. However, the importance of this information could have helped the researcher in this study in understanding the motives that pushed some LAs to become energy leaders or how they were successful in moving from an organisation with no formal energy management to an energy champion.

In addition, according to the same study, three quarters of the energy projects implemented by these LAs are focused on the infrastructure for decentralised heat and power generation and supply and energy efficiency in buildings for the purpose of demand management. The study also found that LAs can play a big role in climate change mitigation and sustainable energy dissemination at the local level; however, there is a lack of supportive policy. This is why one of the key recommendations (Tingey et al., 2017) is to introduce a statutory duty for LAs to develop and implement local low carbon plans over a defined time frame so that they can benefit from their own or their peers' experience with the SEAP and SECAP development and implementation. There is one standard which makes it possible for LAs to collaborate and benchmark and compete between them. The European Energy Award (EEA) is a standard which is also based on continuous improvement; it promotes the integration of energy management and encourages the use of renewable energies and energy efficiency (The European Energy Award, n.d.). It provides a systematic approach for addressing energy in its broad context, i.e. including water, waste and transport.

This study further confirms the findings presented earlier in this chapter where policy, especially the Climate Change Act 2008, played an important role in driving energy efficiency and low carbon initiatives LAs and that there should be a more updated policy that will push LAs to include these initiatives in their annual strategies as suggested by Mallaburn (2016).

Despite this, LAs can play an important role in disseminating energy efficiency in their local communities. Central and regional governments' in-house energy management and energy efficiency programs can present an important and highly visible showcase to other energy users and build their own credibility as a lead in this field (Department for Business, Environment and Industrial Strategy, 2017; Department of Energy and Climate Change, 2012). Moreover, as the layer of government closest to the citizens, local authorities are at the frontline delivering services and benefit from being trusted by businesses and residents in addition to having

> *"A huge sphere of influence and a duty to promote the social, economic and environmental well-being of their community. As permanent bodies that plan for the long term, they are uniquely placed to play a significant part in achieving the national goal of developing a low-carbon economy"* (Carbon Trust, n.d.)

and to communicate and create opportunities for energy efficiency (Kennett, 2014; Kelly & Pollitt, 2011).

In Chapter V, there will be a discussion and a presentation of the measures, projects and initiatives taken by the energy team of an LA to share knowledge, give the example and encourage the uptake of energy efficiency in its surrounding communities.

5.6. Conclusion about Local Authorities in the UK and Governance Practices

Different LAs have different duties and different geographic areas to rule. This affects the size of the organisation, their assets and the budgets allocated for their operation. However, LAs have a moral duty to well govern their operational services in order to protect public money and to act in the best interest of the citizens they serve. This is why energy managements is one practice that can establish and demonstrate good governance while managing a commodity i.e. energy that is essential for the operation of the LA and which is also one of its biggest costs. Chapters VI and VII will demonstrate what good governance for energy management can look like.

The earlier part of this chapter, in addition to the previous chapters, has set the scene for understanding how LAs function, analysing the results of the interviews presented in the second part of this chapter and helping in interpreting the practices followed by one LA's energy team for energy management and energy monitoring which is presented in the next chapter.

Part II: Energy Management and Use of Energy Data in Different Types of Local Authorities

In Chapter III, the researcher detailed the research methodology used for carrying this study and explained the logic behind choosing it; the 1st part of data collection consists of semi-structured interviews with members of staff with an energy management job role or similar in different types of LA. The purpose of the interviews is to identify if the LA has an energy management team, how energy management is perceived, what it consists of and finally which type of energy data is collected and how it is used. Also, under 5.1, the researcher gave an overview of how LAs operate in the UK, what their different types are and the statutory duties associated with each type.

In this 2nd part of the chapter, the researcher will present the results of these semi-structured interviews. He will also match the responses with the themes highlighted under 4.9; these are the themes that have arisen from the literature review and which explain how smart meters or similar technologies and energy monitoring and targeting can be used in an advantageous way by non-domestic users. Finally, the researcher will identify any new themes that arose from the analysis of the interviews and add them to the framework (i.e. list of themes for a successful adoption of smart metering technologies and energy M&T in LAs) and for identifying what 'Smart' can mean to an LA in the context of energy management.

5.7. Presentation of the Participating LAs and Their Representatives in the Semi-structured Interviews

There are four main types of LA and some of which has sub-types. At least one representative of each type and sub-type was interviewed. In total, the researcher has interviewed thirteen LAs, eleven of which were English LAs. The LAs chosen (see Table 6) for this study were not selected randomly but depending on the ease of reach; most of these LAs were selected because either De Montfort University (DMU) or Northamptonshire County Council (NCC) had a relation with them, and it was easy to get hold of their energy managers. The researcher had access to three non- English authorities and all of them agreed to take part in the research study, but only two did so. These three LAs were reached thanks to a European project that DMU is leading and in which NCC is participating. This project aims at helping public organisations use their short time series energy data to reduce their energy consumption and to save money. Being part of this project does not automatically mean that the participating LA is already practicing energy M&T, but are willing to investigate the benefit of such technologies and activity.

The international LA which did not provide a response is the Regional Catalan Government; however, it is worth mentioning that over the same period, the region of Catalonia was facing major political problems.

The researcher always sought to do face to face interviews unless the interviewee had a different preference. In total, the researcher conducted seven face to face interviews with members of staff from NCC, LCC, KCC, NELC, OCC, CDC and MKC (See Table 6 for full names), two phone interviews with representatives of NeCC and DCC and sent five written questionnaires but got responses for only four from members of staff from BCC, CCC, IC and ST (Cf. 3.2.6 for more information about the rationale behind choosing these data collection methods). An additional reason behind the conduct of face to face or telephone interviews is that the researcher was able to extract more information from the interviews. For example, and by looking at the summary of the interviews on the summary tables under Appendix E, it is clear that there were some cells left empty simply because the interviewee did not answer some of the questions on the questionnaire or did not provide more details.

Name of the LA	Type	Country	Denomination
Northamptonshire County Council	Two Tier Authority – Upper Tier	England, UK	NCC
Leicester City Council	Unitary Authority	England, UK	LCC

Kent County Council	Two Tier Authority – Upper Tier	England, UK	KCC
Milton Keynes Council	Unitary Authority	England, UK	MKC
North East Lincolnshire Council	Unitary Authority	England, UK	NELC
Buckinghamshire County Council	Two Tier Authority – Upper Tier	England, UK	BCC
Newcastle City Council	Unitary Authority	England, UK	NeCC
Cherwell District Council	District Council	England, UK	CDC
Oxford City Council	Two Tier Authority – Lower Tier	England, UK	OCC
Derbyshire County Council	Two Tier Authority – Upper Tier	England, UK	DCC
Cork County Council	Two Tier Authority – Upper Tier	Ireland, UK	CCC
Stadt Nurnberg	Municipality/ City Council	Nurnberg, Germany	SN
Islington Council	Unitary Authority – London Borough	England, UK	IC

Table 6: List of LAs Participating in the Interviews

The researcher has interviewed seventeen members of staff from these LAs whose job role is related to energy. He always aimed to interview the energy manager who sits within the senior management then, but if this job role does not exist, a member of staff with a similar duty like an environment manager was interviewed. In some instances, these senior managers were very busy, and asked team members to attend the interviews on their behalf. However, all the interviewees had a good knowledge of the energy management practices of their organisations. In some instances, more than one representative of the LA attended the interview. The job roles are distributed as below:

- Three Heads of Energy/Environment Department representing NCC, NELC and LCC.
- Seven Energy managers representing NeCC, OCC, LCC, DCC, KCC, MKC and ST.
- One Energy Contracts Manager representing NCC.
- Six Energy/Environment/Sustainability Management Officers representing NCC, CDC, IC, OCC, BCC and CCC.

Due to confidentiality agreement, the interviewees will not be named, and they will be referred to by the name of the LA they are representing in this thesis.

5.8. Energy Management in the Interviewed Local Authorities

The interviews confirmed the literature review finding that energy is an active and growing topic in LAs. It is a significant cost that needs to be well managed. This explains the fact that from the thirteen interviewed LAs, eleven (i.e. NCC, LCC, BCC, DCC, CCC, IC, ST, MKC, OCC, NELC and NeCC) have an energy team or similar with duties which are not only restricted to energy management but can include a climate change or environment function. Two authorities (i.e. KCC and CDC) have no energy teams. The first one, KCC, is characterised by having a large portfolio of buildings. This LA has an energy manager and the reason why it does not have an energy team is that it owns an energy buying group which supports the energy manager with his duties. The second authority, CDC, is characterised by having a small portfolio of buildings which consists of twelve buildings in addition to six leisure centres that are indirectly managed. This LA used to have an energy manager (interviewed by the researcher), but since he moved to another team and became a sustainability officer, the position was vacant at the time of the interview. However, this sustainability officer still performs some energy management tasks from time to time to assist the facilities team; this can be interpreted as knowledge sharing and collaboration between different teams to enable energy management.

These energy teams approached fall under different departments or directorates:

- Eight authorities (i.e. KCC, NCC, LCC, BCC, DCC, CCC & IC) have their energy teams within the Growth, Development, Generation, Transport, Resources, Finance or Economy Directorates/ Departments.
- Two authorities (i.e. MKC and OCC) have the teams under the Public Realm or Community Service Directorates.
- One authority i.e. (NeCC) has its energy team under the Operations Directorate.

Most of the interviewed LAs have their team under a directorate with a focus on using available resources – like financial or energy resources- for achieving growth and development within their respective constituencies. Energy management is not only perceived as a practice for looking after the LAs portfolios of buildings and providing some control over their budgets; it is also viewed as a tool for growth thanks to its ability to help with defining areas for development, i.e. installing renewable energies technologies for long run income generation. One of the interviewees who is the Strategic Commissioning Lead for Energy and Environment for NELC stated that his organisation has adopted an outcome-based approach to its planning by concentrating less on its service delivery and focusing more on the outcomes for their planning projects, and energy has been identified as a commissioning priority. In other words, energy management for internal operational services should be the norm, and this practice should be viewed in the future as an area for promoting the financial well-being of the LA and well-being of the citizens of the constituency. As an example, the same authority has a low carbon plan which promotes the installation of large-scale renewable energies to regenerate the region; the LA is aspiring for the region it is governing to be recognised on the national and the international level as the UK's capital of renewable energy industry and the UK's leading region for low-carbon energy.

5.8.1. Roles and Functions of the Interviewed Energy Teams

All the interviewed representatives of energy teams stated that their teams perform what one interviewee described as “traditional energy management”. This consists of managing the energy contracts, paying the energy bills and working on solving any issues related to them, maintenance of energy related equipment like boilers and ensuring that the LA is conforming with statutory and legal obligations related to energy (e.g. the DEC and the Carbon Reduction Commitment (CRC) Reporting). Though, some interviewees stated that their energy teams provide additional services:

- Some of the heads of the energy teams are members of senior management for the LA where they are seen as holding a strategic role and have the ability to influence, advise and make suggestions in relation to the authority’s strategy affecting their service areas. The researcher came across three authorities i.e. (NCC, NELC and DCC) where the interviewees hold a strategic role which consists of enacting or providing advice on energy policy for the LA, or they are a member of the organisation’s teams developing large energy projects like energy from waste plants, large solar farms, etc. One energy team outside of the UK (i.e. ST) has the ability and the power to develop energy related building standards and enforce them in their region.
- Some of the energy teams are on a journey to lower their operational costs and this is being achieved through charging for their services. Some examples of this approach are as follows:
    - Energy procurement: Councils are the owners of large stocks of buildings, which places them in a better position to get better energy prices. Some of the interviewed LAs use this to offer energy procurement services to other public authorities and, in this case, schools. The choice of schools is not unexpected or sudden but is a natural development as they were historically part of the LA and the buildings occupied by these institutions were classified as non-domestic or commercial ones. The LAs held their energy budgets until few years ago when they were transferred to the schools. As part of the procurement offer, the procurement service includes bills validation,

addition of any supplies and all the paperwork related to it. This means that the schools have only to pay the bills. In exchange for this service, the teams charge a small rebate per kWh and with this rebate, the energy price that the school is paying for is better than if it was going to apply for a deal on its own. This approach is practiced in four interviewed LAs i.e. NCC, KCC, DCC and IC.

- Salix: it was discussed above that Salix Finance Ltd. offers free interest loans to public institutions for developing energy efficiency schemes. Some energy teams in the LAs use this fund to develop projects on behalf of other public organisations and charge a fee which is approved by Salix; this can be up to 15% of the cost of the project. Four energy teams (i.e. KCC, MKC, NCC and OCC) mentioned that they use this approach and all their clients include schools (Cf. 6.3.4 for more details; the rationale behind developing these projects for schools by Northamptonshire County Council will be presented) except in one case, i.e. OCC, because this LA is not a Local Education Authority (Cf. 6.3.4 for more information). NCC has also developed similar projects using the SALIX fund for another LA as part of a joint European funded project. Some schools however do not have the capability to develop energy efficiency projects unlike the LAs' energy teams. The latter have surveyors, access to energy data and trained members of staff who can analyse the energy consumption, visit the buildings to identify areas for energy improvement and prepare the application naming the measures to be implemented, technologies to be used, their efficiencies and the estimated savings for getting a loan from Salix.
- Some of the teams provide energy advice to the landlords' associations and to domestic tenants. This was the case when two of the interviewed LAs, i.e. NeCC and IC, which are unitary authorities and have the duty to provide social housing and review and grant housing development planning approvals. This, for example, is not a duty for upper tier LAs in a two-tier system and is why most of the interviewed energy teams do not offer such a service.

- Three of the interviewed teams, i.e. NCC, NELC and MKC, go a step further to bring income to their LAs by applying for external funding from institutions like the European Union and governmental organisations. All the three teams have been awarded in the past or are currently working on projects funded by the European Union like the European Regional Development Fund (ERDF); this fund has different thematic focus like encouraging the low-carbon economy and providing support for small and medium-sized enterprises (SMEs). For instance, the energy team in NCC developed an ERDF project and applied for funding to assist SMEs with their energy costs; however, this is not something that a traditional energy management team would do as this project means that the team will have to work outside the normal boundaries of its organisation. Though, these projects help with sharing the knowledge and expertise of the energy teams with members of the public using external funding; more details about this approach will be elaborated under 6.3.4.
- Finally, five energy teams, i.e. NELC, NCC, DCC, IC and LCC are either helping their authorities to develop large scale renewable energy projects or are already managing them. Examples of these projects are: large solar parks, district heating and energy from waste. Again, the type of projects to implement depends on the duties of an LA. There are some types of LA which do not have the duty to dispose of waste and hence cannot develop energy from waste schemes.

5.9. Smart Energy Metering in the Interviewed LAs

The researcher has presented under 4.9 a framework for understanding the motives behind rolling out smart meters in buildings and for implementing the energy monitoring and targeting (M&T) practice as described in the literature review. The themes highlighted by the framework will serve as an approach for investigating the reasons behind installing the smart meters and similar technology in different types of LAs for examining the practice of energy M&T and how it is performed.

All the interviewed authorities have a technology capable of supplying short time series energy data. These technologies are either smart meters, Automatic Meter Readers (AMRs), or data loggers. It has been explained under 4.3 that when the suppliers started rolling out energy meters capable of generating short time series as part of the statutory requirements and regulatory obligations, the norm was to install AMRs. In the UK, there is no requirement to install a specific type of meter by the supplier, only that the meter should conform to a set of criteria detailed in the Smart Metering Equipment Technical Specifications (SMETS). The Department of Energy & Climate Change (DECC) – now Department for Business, Energy & Industrial Strategy (BEIS) – developed two sets of guidelines to ensure that any installed meter meets the designated standards: SMETS 1 which included the technical specifications for the period from 2011 to the beginning of August 2017 and SMETS 2 covering the period running from the beginning of February 2017 until the end of the roll out programme (UK Government, n.d.). Both guidelines describe the minimum physical, functional, interface and data requirements for gas and electricity smart metering systems (Department of Energy and Climate Change, 2014).

Twelve of the interviewed authorities use smart meters or AMRs and one international authority i.e. SN uses data loggers. This means that all interviewed LAs collect half hourly energy data. One LA, i.e. LCC, has a duplicate system; it installed AMRs prior to 2010 and has its own reporting system that collects data from these meters. However, once the smart meter roll-out programme started, they were obliged to upgrade their fiscal meters. Moreover, three authorities, i.e. KCC, NCC and MKC, chose to work with their suppliers to install electricity smart meters before they were obliged to do so.

Seven LAs, i.e. NCC, LCC, KCC, NeCC, OCC, CCC and IC have gas smart meters in most of their buildings but only five, i.e. LCC, KCC, NeCC, OCC and CCC, have water smart meters in some buildings. This aligns with the findings from the literature review in Chapter Three which argues that water smart meters are not widely used by organisations because policy does not require it.

5.9.1. Regulatory Requirements

Five of the interviewed authorities, i.e. OCC, NELC, MKC, DCC and IC, stated that their primary motivation for using these technologies was to meet the regulatory requirements. This does not mean that these LAs did not see any other advantages from rolling out smart meters and using short time series energies data, but this subject was the main driver for adopting this technology in most cases, i.e. by four of the five LAs. The other case, NELC, had – at the time of the interview – smart meters only for mandatory half hourly (HH) supplies. However, this LA is aspiring to roll out smart meters in their properties in the near future as part of a project they are developing.

Four of the five LAs, i.e. OCC, DCC, IC and MKC, indicated that this technology is installed and is helping with their Carbon Reduction Commitment (CRC) compliance and carbon accreditation. As explained by one of the interviewees, in the past and under CRC, organisations were paying a certain amount of money and placed on a league table depending on the quantity of carbon they emit. The energy manager of MKC stated that the motivation was

> *"Originally, it was to comply with CRC. Originally, we were in the CRC scheme when it first started and we were trying to push for AMR to reduce our potential payments on CRC and we also needed to get the carbon accreditation then they removed that requirement at the very last stage; so, it was a bit of a waste of time. That took one of the motivations away. We're also now no longer in CRC mainly because we reduced our electricity consumption"*

However, there were different measures to improve the ranking and some of them were having AMRs or the Carbon Trust Standard; - this is a standard launched by the Carbon Trust (CT) in order to recognise organisations that measure and manage their environmental impact and implement schemes to achieve year on year reductions (Carbon Trust, n.d.). The Carbon Trust is an independent and private company which was set up in 2001 by Central Government to assist both the private and public sectors in decreasing their emissions in order to help the Government in meeting its carbon reduction targets (Bourn, 2007). A better ranking means that the organisation gets back a portion of the money it already paid. So, in addition to meeting the requirements, this also constitutes a financial motivation. The level of granularity of the energy data produced by these technologies also helps in a better quantification of energy consumption and therefore a more accurate quantification of carbon emissions. Last, this technology helps in developing energy related strategies and thus establishing a low carbon culture in this interviewed LA i.e. OCC. The energy manager of the latter authority adds that this technology helps in

> *"Developing energy management, carbon management approach within the authority, we recognise obviously you can't manage what you can't measure. So, yeah, there was a driving force with pure energy management best practice approach".*

Another interviewee, from DCC, sees this technology as a way to improve energy management as it provides more opportunities to prevent energy wastage.

5.9.2. Technical Requirements

Seven of the interviewed authorities' representatives, i.e. KCC, BCC, OCC, DCC, CCC, IC and NCC, perceive this technology, i.e. smart meters and AMRs as an enabler for a better visibility of their energy consumption and one of them, KCC, adds that it also helps in tracking the energy generated by roof top micro-generation solar installations. This detail was also one of the primary motivations for adopting it.

Smart meters, according to these interviewees, increase the frequency of receiving energy data which means that more detailed energy consumption and profile consumption of buildings can be easily accessed. Additionally, in three LAs, i.e. CN, DCC and BCC, the profile data generated -i.e. HH data or short time series produced by these technologies- generates an improved ability to develop energy efficiency measures as the level of granularity of energy data provides more insight and details about energy consumption for detecting wastage and preparing feasibility studies. The energy manager and the energy officer of OCC stated that one of the main benefits of having this system is being able to access the detailed consumption figure and see overnight usage without having to visit the site and gave an example of how they detected water wastage in one of their buildings:

> *"In one of our depots, we know that it's running constantly because the urinal controls haven't been fitted. We wouldn't know that without profile data unless you walk around the site daily which we are not".*

In two LAs, SN and LCC, the interviewees suggested that these technologies help them to react quickly to technical failures in buildings. For example, a sudden or unexpected drop or increase in energy consumption can be easily spotted. However, the representative of one LA, OCC, argues that it is correct that early detection of technical failures has been made possible thanks to smart meters. Nonetheless, it does not mean that a quicker reaction or a solution will be found and applied. Sometimes, the layout of the energy infrastructure of the building is very complex, which makes it difficult to locate the source of the problem. In some cases, resources are not available to implement the solution.

5.9.3. Financial Motives

There are different financial motives that can encourage LAs to use smart meters. The one that is most sought by the interviewed LAs representatives is monitoring the performance of their portfolios of buildings. Respondents from six LAs, i.e. BCC, DCC, CCC, IC, LCC and CDC) regularly monitor the energy consumption of their buildings to verify if it meets the predicted budget for the financial year. The second motive is reducing billing errors and estimation; interviewees from four authorities, i.e. MKC, OCC, IC and NCC, are using smart meters for this purpose and one of them, MKC, revealed that it was one of their primary motivations to opt for the roll out of this technology. For instance, smart meters provide accurate meter readings and the bills received by the LAs reflect accurate energy consumption. Additionally, if there is a problem with a bill, the energy manager or officer has access to a history of automatic meter readings which can help with verifying the bill in a short period. The time saved is also money saved especially in the case when some energy teams do the bills validation by themselves rather than relying on an external body to carry out this activity. The energy manager from MKC adds:

> *"When you have an invoice or an account that is repeatedly billed on estimates and then has what we call a catch-up bill, it is either a massive credit or a massive amount, it causes problems with budgeting and verification of those invoices can be very problematical. A single invoice could take well, if you cost it out it could be £300 or £400 in terms of having somebody out for a site visit, to verify the meter and the emails exchanged back and forwards with the utility companies, identifying the problem in the first place even to the extent of having meetings with the budget holder and saying how we going to bill this […] So the consequences of poor billing can be very expensive".*

The interviewed LAs procure energy through buying groups or commercial services owned by public institutions like Crown Commercial Services which is owned by Central Government or LASER Energy which is owned by Kent County Council. One of the reasons behind this decision is that these buying groups have an important buying power, which means that they can buy energy at a cheaper price and resell it to public organisations at a very competitive rate. These organisations also offer different services in parallel to energy procurement and one of them is bills validations; this comes at a cost and not all the interviewed LAs opt for it. However, in the case where an LA does not procure this service, it will have a team within an authority to validate the bills in order to check that they are correct. This is a resource intensive task especially when the LA has a large portfolio of buildings with a significant number of supply points and explains why energy managers are seeking to decrease the amount of time they spend verifying the bills, so they can spend it on other energy management related tasks. This has been made possible due to smart meters; they can nowadays access the system where meter readings are stored and view a full history of a specific supply. The third motive is the monitoring of capacity charges and time of use. Half hourly data enables the pattern of energy consumption to be viewed, to identify when most of the energy is consumed during the day and to check whether it coincides with the times when capacity charges are high. Additionally, it also helps in checking if the organisation uses the full capacity it subscribes to; if it does not and there are no plans to expand sites or install additional electricity consuming infrastructure, then it is worth adjusting the registered capacity as it can help with saving money. An example related to this measure will be presented in the case study under 6.3.4.

The researcher, from his past conversations with the energy supplier of the case study Council and a public energy buying group, has been told that the proportion of the cost of the electricity consumed is less than 50% of the cost charged on an electricity bill (Cf. Figure 23), the other proportion is the different charges, levies, and obligations costs. Figure 23 shows that even if the cost for purchasing energy is forecasted to remain the same, the charges are expected to increase. This is why there is a need to monitor capacity use and time of use in addition to developing energy efficiency programmes.

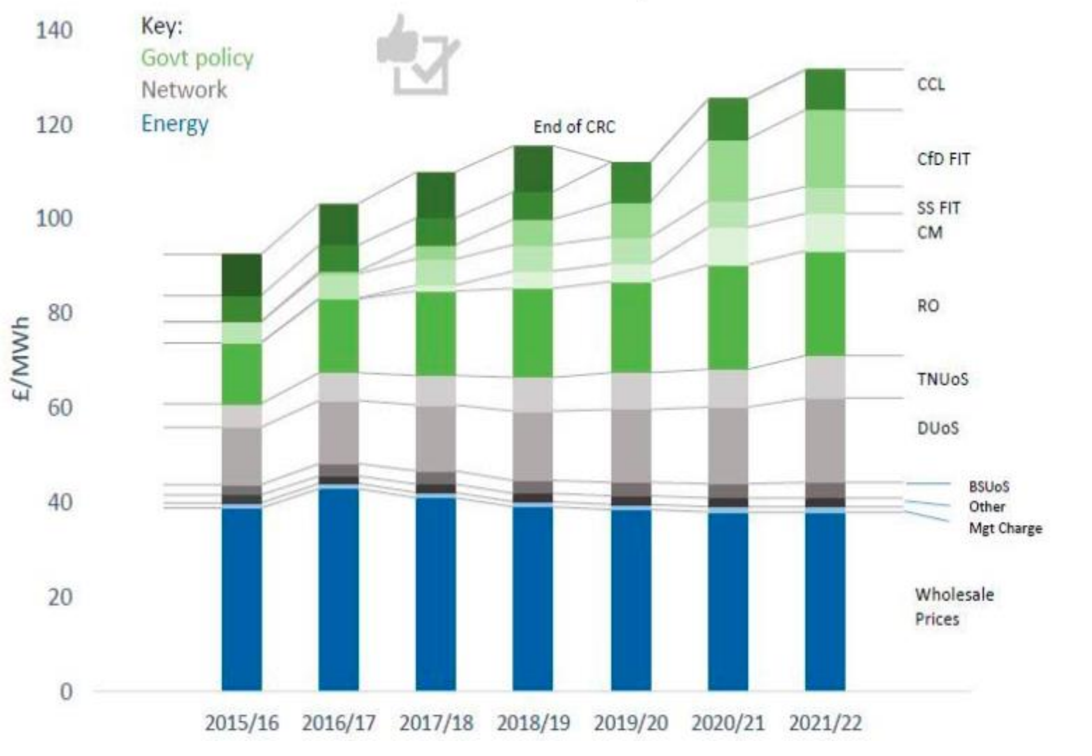


Figure 23: Energy Prices Forecast (High Energy Users of Northamptonshire Meeting)

The charges presented on Figure 23 are:

- CCL: Climate Change Levy
- CfD FiT: Feed-in tariff Contract for Difference
- CM: Capacity Mechanism
- RO: Renewables Obligation
- TNUoS: Transmission Network Use of System
- DUoS: Distribution Use of System
- BSUoS: Balancing Services Use of System
- Mgt Charge: Management Charge

The last motive is saving time when preparing energy audits and this is sought by one LA, IC; energy auditors have access to energy data via a system, and there is no need to go on site to check the meter readings.

5.9.4. Knowledge Share Motive

None of the interviewees indicated that knowledge share, i.e. sharing information about a specific building with its users is one of the motives for rolling out smart meters. However, seven LAs, i.e. KCC, BCC, OCC, DCC, CCC, IC and NCC use them to have a better visibility of their energy usage which might mean that they perceive them as a tool for acquiring knowledge about their energy consumption. Additionally, nine LAs, i.e. KCC, MKC, NELC, BCC, NeCC, CCC, SN, IC and NCC suggest that they use the half hourly data for preparing feasibility or case studies for energy efficiency projects; this means that these technologies are a source of knowledge which is used and transformed by energy teams to be shared with different layers of the organisation for specific purposes and, in this instance, for getting approval from top management for implementing specific energy efficiency measures.

5.9.5. Environmental Motive

None of the interviewees from the represented LAs indicated that the roll out of smart meters was to decrease emissions. However, this can be perceived as a direct result of decreasing energy consumption which is by its turn a direct result of the willingness to save money. Smart meters and their generated meter readings are, however, used by two LAs, IC and MKC, for an accurate reporting for CRC and carbon accreditation.

In Chapters V and VI, and throughout the case study, it will be explained how the energy team in Northamptonshire County Council (NCC) perceive their environmental role and what resources they have made available to meet any corporate environmental targets and objectives.

5.10. Half Hourly Data Availability Arrangements

All the motives discussed above cannot be realised if the energy teams from the interviewed LAs do not have access to the half hourly energy data generated by the rolled-out smart meters or any similar technology like AMRs. Azennoud et al. (2017) specify that LAs can have access to their half hourly energy data for their mandatory half hourly meters since the cost of this is already included in the electricity bill; however, for non-half hourly (nHH) mandatory meters, there is an extra cost that LAs can choose to pay if they want to receive half hourly meter readings.

5.10.1. Mandatory HH Meters

Six of the interviewed LAs, NCC, LCC, KCC, MKC, NeCC and OCC, can access the HH data on a day +1 basis, i.e. data is provided by the supplier one day after it is collected. One LA, IC), on a day+2 basis. One, DCC, on a weekly basis. Last, one LA, CDC, can access it on request.

5.10.2. nHH Mandatory Meters

Three LAs, NCC, LCC and OCC have arrangements for accessing the HH data of their non-half hourly mandatory meters on a day+1 basis. One, NeCC, on a weekly basis. Last, two, MKC and DCC, on a monthly basis. The access to these meter reads comes at a cost and this will be discussed in 7.2.3.

5.10.3. Half Hourly Data Access & Analysis

Ten LAs, i.e. NCC, LCC, KCC, MKC, NELC, BCC, NeCC, OCC, DCC and IC, access their HH data through an energy management software which can produce different types of reports that energy managers need. In the case study under 6.3.2, the researcher will present how valuable such software is for the energy teams in NCC. Two LAs, KCC and LCC, perform active or near real time monitoring of all their HH meters. However, KCC does not have HH meters across all their portfolio of buildings.

Five LAs perform a periodic monitoring; NeCC and OCC do so weekly and one each i.e. NCC, CDC and MKC, monthly, quarterly and annually.

5.11. Barriers Inhibiting the Use of Smart Meters in LAs

The interviews have shed some light on the challenges which impede the use of HH data in LAs for different purposes including active monitoring and targeting. One of the first barriers is related to the technology that generates the HH data; three LAs, KCC, NELC and CCC, found that the roll-out of smart meters is a resource and time demanding activity. However, where these are rolled out and HH data is accessible, two LAs, NeCC and CDC, find that it is difficult to use the data as there is a need to invest in software that enables real time monitoring. Additionally, six LAs, i.e. NeCC, CDC, OCC, DCC, KCC and NCC, highlighted that there is a need for staff members who will supervise the monitoring activity of the HH data from all the smart meters installed in the LAs portfolios of buildings. These staff members will also need to ensure that any energy wastage that arose from the monitoring activity is investigated and any solutions are actioned. The energy manager of KCC adds that:

> "*I think in an ideal world, probably, we would have smart meters in every building and you know we would have good data […] be able to also probably it's to do with cost time and people […] It work for LASER for a while and I used to do a little bit of analysis looking at some of the profile, half hourly profiles, but it's just time to kind go through the data. It's one thing having the data but also interpreting the data. It takes time to do that but like you say, if we did, and we had someone sort of there monitoring it, then we probably pick up a lot of things, save energy. So it is probably cost effective to do it, but it is just a question of budget*".

However, energy teams are nowadays becoming smaller as the LAs are trying to decrease their operational costs, and these teams are covering a wider scope of activities as it has been explained in 5.8.1; hence why the interviewees from these five LAs find it difficult to justify their cause. In other words, these interviewees are not sure that the savings from monitoring and targeting activity using smart meters and HH data covers the expenses for the additional staff members employed for this task.

Moreover, five of the interviewed LAs, i.e. DCC, NELC, MKC, KCC and IC believe that, currently, smart meters and half hourly data are best used for day to day energy management activities and, especially, for energy efficiency. Schemes and projects developed to save energy like lighting upgrade are visible and can have a direct result. As an example, in Northamptonshire County Council, when a lighting upgrade is implemented and if the patterns of using the building are kept unchanged (i.e. the same patterns before and after the upgrade), the energy manager or the project director can notice straight away a decrease in the electricity consumption. The energy manager of DCC stated that:

> *"We get probably more support to do energy efficiency projects than we do on sort of basic energy management side of things because I guess it is more visible and you get a bit more sort of political support to spend the time doing more sort of visible projects which is why in the last couple of years, we have focused on renewables even though really we would be in better spent time on better energy management of our buildings to like get better savings".*

The representative of NELC believes that most Local Authorities are in the same position where they are driven by financial pressures. Money should be spent on the low hanging fruits, i.e. energy efficiency, and invested wisely to get the best return, but there are examples where this LA makes investments with an aim to set an example for other organisations. The energy manager states:

> *"Having said that, it's a balance, so fitting the solar PV on this building or other buildings wasn't the best investment we could've made but we took the conscious decision to do it because we needed to, euh, it was a saving, it was a financial investment and we wanted to set a good example and we wanted to promote their use throughout the community. So it was an important thing to do for all the reasons. So there are examples where we might make decisions other than purely financial or really it is finance that is driving the agenda".*

Another interviewee, i.e. the energy manager of MKC, adds that:

> *"In the hierarchy of things to do with limited resources, AMR [Automatic Meter Reader] is good to have but making best use of AMR is fairly low down*

in the list of priorities. So, we as authorities, we do want AMRs because you do not know when the next problem is gonna occur, and if a problem occurs on a site and it got AMR, you can get into it straight away".

In other words, it is helpful to have HH data generated by AMRs because they make it easier and quicker to understand the source of the problem. The same interviewee adds that his team is making best use of what the Authority has and, according to him, AMR has an immediate impact when used for billing and for the administration of the electricity and gas accounts. Representatives of six LAs (i.e. KCC, MKC, DCC, NCC, CCC, and SN) do, however, believe that active monitoring and targeting is the future for their energy management system.

Another challenge highlighted by four of the interviewees, i.e. NeCC, MKC, OCC and CDC, is that sometimes the HH data is meaningless as it does not help in discovering the sources of energy wastage especially in large buildings with complex systems. This is why the interviewees from the four LAs, NeCC, MKC, OCC and CDC suggest that there should be a need for smart sub-metering in order to have detailed energy consumption data of specific part of the buildings or systems. This goes hand in hand with one of the findings from the literature review where it is stated that sub-metering energy data helps in the development of energy efficiency schemes. Additionally, one of these four LAs (i.e. OCC) is using water sub-meters in some of their buildings; these proved their usefulness in identifying water leakage. For instance, water pipes are buried underground and even if the energy manager notices a larger water consumption which might be due to a water leakage, it will be difficult and expensive to locate the leakage as there will be a need to uncover the pipes. However, when there are sub-meters installed, the energy manager can use the data to compare the water consumption of each part of the buildings and minimise the number of pipes to uncover.

The last barrier presented by the representative of one LA, CDC, is the lack of knowledge transfer between members of staff. The interviewee gave an example where as part of the redevelopment of one of the museums owned by his LA, a

Building Management System and smart meter were installed and a member of staff was trained to use them. However, when they left, the expertise for managing these technologies was lost. In 7.2.4, 7.3.2 and 8.2, the researcher will present more examples and give more details about the effect of changing of members of staff on expertise loss and knowledge share.

5.12. Conclusion

This chapter has started by explaining the different types of LAs and their associated statutory duties. An LA with many statutory duties and a large territory to operate means that it will have a large number of employees to provide the necessary services and a large stock of buildings to ensure that members of staff are provided with the resources to fulfil their duties. After that, the researcher has introduced one of the topics central to the public sector: governance in general and good governance in particular which cover operational services and, more specifically, energy management. The latter has been earlier introduced in Chapters I and IV; however, in this chapter, the researcher has explained energy management in a more focused and context which is Local Authorities.

In the second part of the chapter, the researcher has given real life examples about the concepts discussed earlier in the first part: energy management, energy efficiency, smart metering, half hourly data and energy monitoring and targeting (Cf. Table **7** which presents a summary of the interviews). The examples were collected as part of interviews with energy managers from thirteen local authorities and the framework developed in the Chapter IV (literature review) highlighted the themes which were used to analyse the interviews. These will be explored further in the case study and discussion chapters.

LA	Type of LA	Energy Team	Half Hourly Data Arrangements	Data Access & Analysis
KCC	Two tier - Upper	Yes	Day +1	

LCC	Unitary	Yes	Day +1	
NCC	Two tier - Upper	Yes	Day +1	Monthly
NELC	Unitary	Yes		
OCC	Two tier - Lower	Yes	Day +1	Weekly
CDC	Two tier - District	No	On request	Quarterly
MKC	Unitary	Yes	Day +1	Yearly
CCC	Two tier - upper	Yes		
NeCC	Unitary	Yes	Day +1	Weekly
IC	Unitary	Yes	Day +2	
SN	City Council			
BCC	Two tier - Upper	Yes		
DCC	Two tier - Upper	Yes	Weekly	

Table 7: 1st Phase of Interviews Summary

VI — **The Development of Energy Management in NCC**

Presentation of NCC's EnMS, how it was developed and how it is performing

Case study of the energy management system of NCC

Chapter VI: The Development of Energy Management in Northamptonshire County Council

In Chapter V, energy management was introduced as one aspect of good governance. In this chapter, the researcher will present how this practice is perceived by the different stakeholders of a specific Local Authority (LA). The chapter is devoted to a brief overview of the organisation and its managerial structure, then to an explanation of the process for the incubation of energy management within the culture of the LA, and to the rationale behind the continuous evolution of this discipline.

The information presented in this chapter is collected through interviews and analysis of contracts, reports, case studies and business cases. Some of the documented information presented is generally not available in the public domain but only on the internal domain/servers of the LA as they are confidential documents or contracts or simply for internal use.

6.1. Introduction to Northamptonshire County Council

Northamptonshire is a county located in the East Midlands region of England, UK. It has a land area of 971 square miles and a population of 723,026 and could increase by 12% by 2030 (First for Wellbeing, n.d.). The county operates under a two-tier system with Northamptonshire County Council (NCC) as the upper tier authority and seven district authorities forming the lower tier; these are: Northampton Borough Council, Kettering Borough Council, Corby Borough Council, Borough Council of Wellingborough, East Northamptonshire District Council, Daventry District Council, South Northamptonshire District Council, and Kettering Borough Council. Northamptonshire is predominantly a rural county and has more than 260 parish councils (Northampton County Association of Local Councils, 2014).

6.2. Governance in Northamptonshire County Council

As it has been presented under section 5.1.1, the type of Local Authority under which NCC falls, i.e. the upper tier of a two-tier system, defines the statutory services that the organisation has to provide to the community of Northamptonshire. Therefore, the Council has set and adopted a Code of Corporate Governance which will ensure that the organisation business and operation model is in accordance with the law and relevant standards and public resources are well accounted for and used (Northamptonshire County Council, n.d.). This Code of Corporate Governance is put into practice by all the members and employees of the County Council, especially by councillors and senior officers who are responsible for the stewardship of NCC's resources.

NCC is committed to good governance, and one way to achieve this is through effective leadership that commits itself to openness, integrity and accountability, in addition to six core principles which form the basis for good governance. These are (Northamptonshire County Council, 2010):

- The purpose of the Council which takes to heart the outcomes of its services to residents and service users of Northamptonshire in addition to creating and implementing a vision for the County.
- Members and employees of the Council should have clearly defined roles but should all work collectively to accomplish the common purpose.
- Upholding high standards of conduct and behaviour.
- Decisions are taken with care and openness and risk management and effective scrutiny are taken into account.
- Ensuring that the County Council members and employees are effective and have the necessary skills to deliver their duties.
- Guaranteeing a robust local public accountability through the engagement with the authority's stakeholders.

NCC has set a system of triggers that enables to monitor the establishment and the use of the Local Code of Corporate Governance. Figure 24 summarises this system:

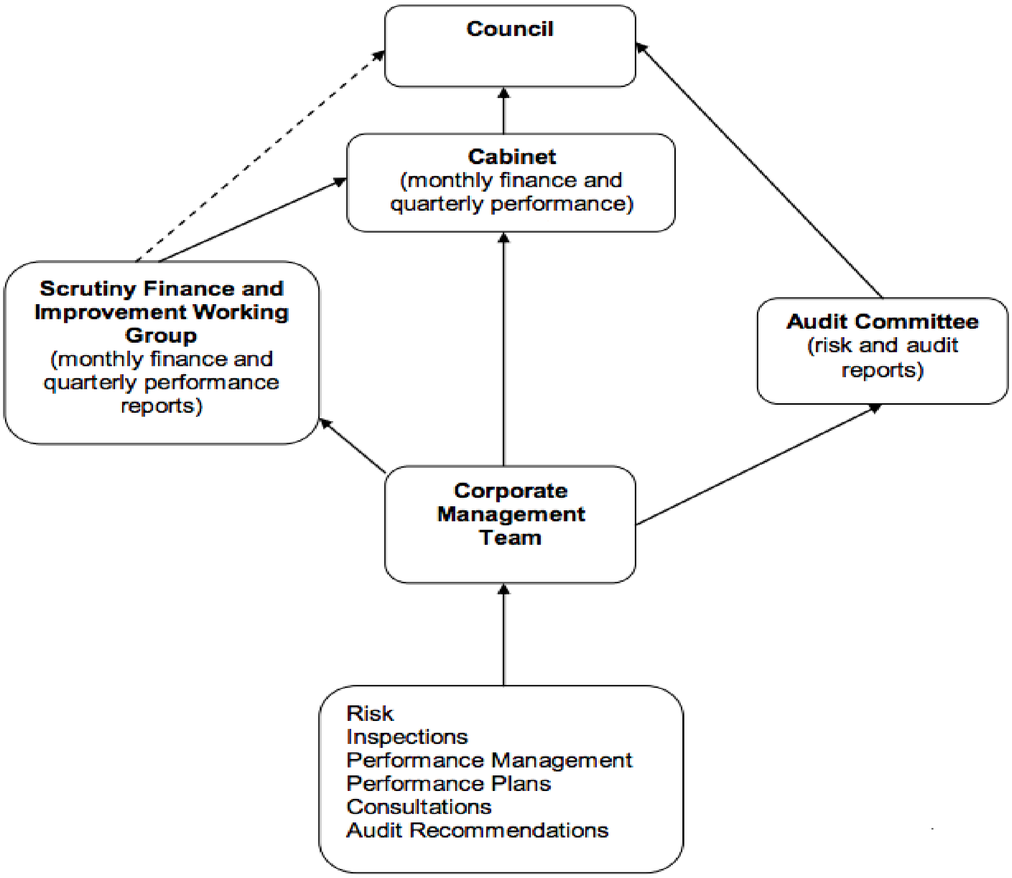


Figure 24: Good Governance System of Triggers (Northamptonshire County Council, 2010, p.12)

Last, NCC produces an Annual Governance Statement which is submitted to the Audit Committee.

Even with all these systems put in place, NCC has been in a difficult place since the beginning of 2018 when it was strongly criticised in an independent report produced after the Secretary of State for Housing for Communities and Local Government ordered a probe into the authority's finances after allegations of financial failings (BBC, 2018). NCC is described in many media sources and by many Members of Parliament as the worst run LA in the country. The report concluded that NCC

> *"Has failed to comply with its duty under the Local Government Act 1999 (as amended) to secure best value in the delivery of its services over a prolonged period" (*Caller, 2018, p.34*).*

The report presents all the reasons advanced by the authority to explain this failure like the Central Government funding cuts, the rapidly growing population which is not adequately accounted for by the funding formula to local government, the freezing of the Council tax for many years and its characterisation of being the lowest of the country. However, the auditor believed that these are not the major causes for reaching this breaking point but that bad management and governance is. The auditor found that the budgets were not respected; some departments were overspending and did not achieve the savings they had to make. However, this report denied any claim that can doubt the hard work of the members of staff; on the contrary, it recognised that they are dedicated, hardworking, and in no way culpable of the current situation (Caller, 2018).

This current situation and this report jeopardise the efforts made by many teams and members of staff who strive to use public money effectively and provide a good service to residents of the county.

6.2.1. Next Generation Model

NCC's administrative leadership was aware of its financial struggles and developed a management plan for this Council. By the end of 2016, NCC was due to adopt a new model of working and delivering its services. This model was known as "Next Generation" (Cf. Figure 25), and its aim was to build upon nationally established good practice principles of "smart working" to reduce the costs of government working, be it central or local, and to improve its effectiveness. The traditional model that NCC was following is characterised by being unsustainable and outdated. Further, it was hoped that the implementation of the model would help to facilitate an efficient working environment where, amongst other aims, employees (Northamptonshire County Council Intranet, n.d.- this is not accessible by members of public).

- work flexibly and cost effectively,
- are empowered by technology, and
- maximise productivity and innovation while reducing the environmental impact of work.

The model also aimed to change the structural framework of the Council whereby its services are provided not only by NCC but also through federated bodies which are created in partnership with other public institutions like the University of Northampton or the NHS, the voluntary and community sector and partnerships with the private sector (Northamptonshire County Council, 2016). This allows the NCC's core to have a small commissioning group working with a mix of delivery vehicles, i.e. the federated bodies which are characterised by being outside the Council and can benefit from this advantage to generate revenue; though, it was not clear how this could be achieved. Figure 25 shows the desired working model:

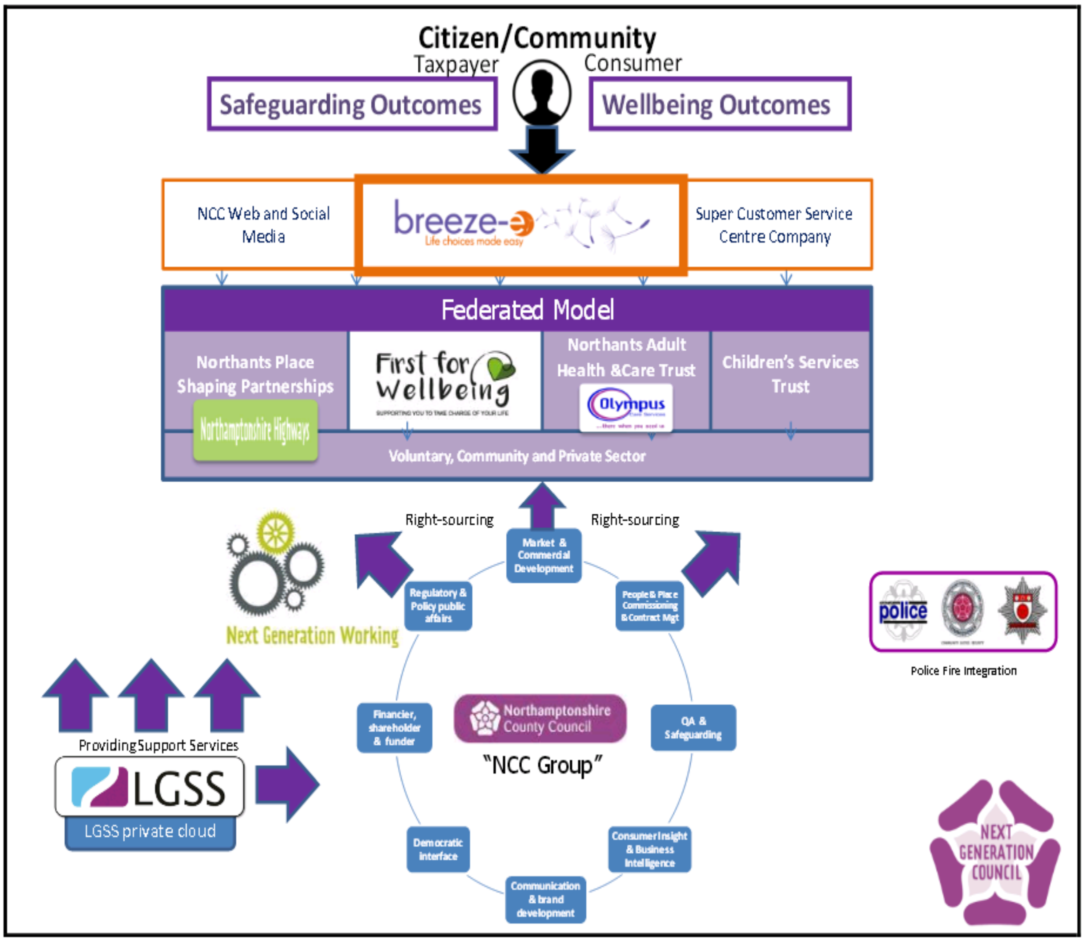


Figure 25: Next Generation Working Model (Northamptonshire County Council, 2016, p.6)

The idea was not new because NCC had been working with federated bodies since early 2010 on a process which formed the early key pillars for this new model. Two institutions were created. The first one was LGSS which stands for Local Government Shared Services and which was established by the merger of corporate services of NCC and Cambridgeshire County Council. It is seen as a shared services organisation. Later in 2016, a third partner joined the group, Milton Keynes Council. LGSS provides a range of corporate services like Finance, HR, Payroll, Procurement, IT, etc. to a range of public institutions like LAs, health and emergency services. Thanks to the wide scope of its customers and the significant economies of scale, LGSS can offer competitive services and can achieve savings to these organisations, and thanks to its legal statute, waves the need for tendering and formal procurement agreement which is supported by the Local Government Acts of 1972 and 2000 and the Localism Act of 2011 (Local Government Shared Services, n.d.).

The second federated body was Olympus Care Services Limited (OCS) which was created in 2012 and looked after elderly homes. The concept of shifting to federated bodies was

> *"Seen as necessary to remaining 'efficient, responsive, flexible and commercial' so as to 'accommodate the requirements of a rapidly changing market place and demographic pressures.' Underpinning this rationale was the expectation that establishing OCS would incrementally reduce the cost to NCC of providing the services transferred to OCS."* (Caller, 2018, p.44).

One of the main motives behind the shift to the Next Generation Model is to lower the operation costs and achieve savings. However, Caller (2018) finds it difficult to trace the savings achieved or the income generated by these two organisations. First, Olympus Care Services had only one customer which was NCC and was relying on its orders. Thus, when NCC was facing budget cuts, OCS was also affected and was pushed to find ways to pay dividends to the LA rather than focusing on delivering its services. Additionally, the top management of OCS was not totally independent from the top management of NCC which meant that the organisation did not have the freedom of decision making which might enable it to flourish away from the LA and generate income from its service delivery to other clients. Second, the Local Government Shared Services (LGSS) was designed in a way its employees were still part of the councils which own the organisations and were working on their respective projects, which means that the workforce wasn't allocated flexibly. The only difference was that these employees shared the same top layer of management. Also, LGSS was only signing and working on small contracts and any achieved savings are only services' budgets cuts that they had to adapt to. In other words, even if these services remained under the respective councils, those savings would still have been achieved as they are budget cuts.

After the adoption of the Next Generation Model, the structure of the top management in NCC has changed; however, after this change of the administrative leadership, it has been decided to bring back those federated bodies under NCC. Figure 26 shows the new organisational structure as of May 2018:

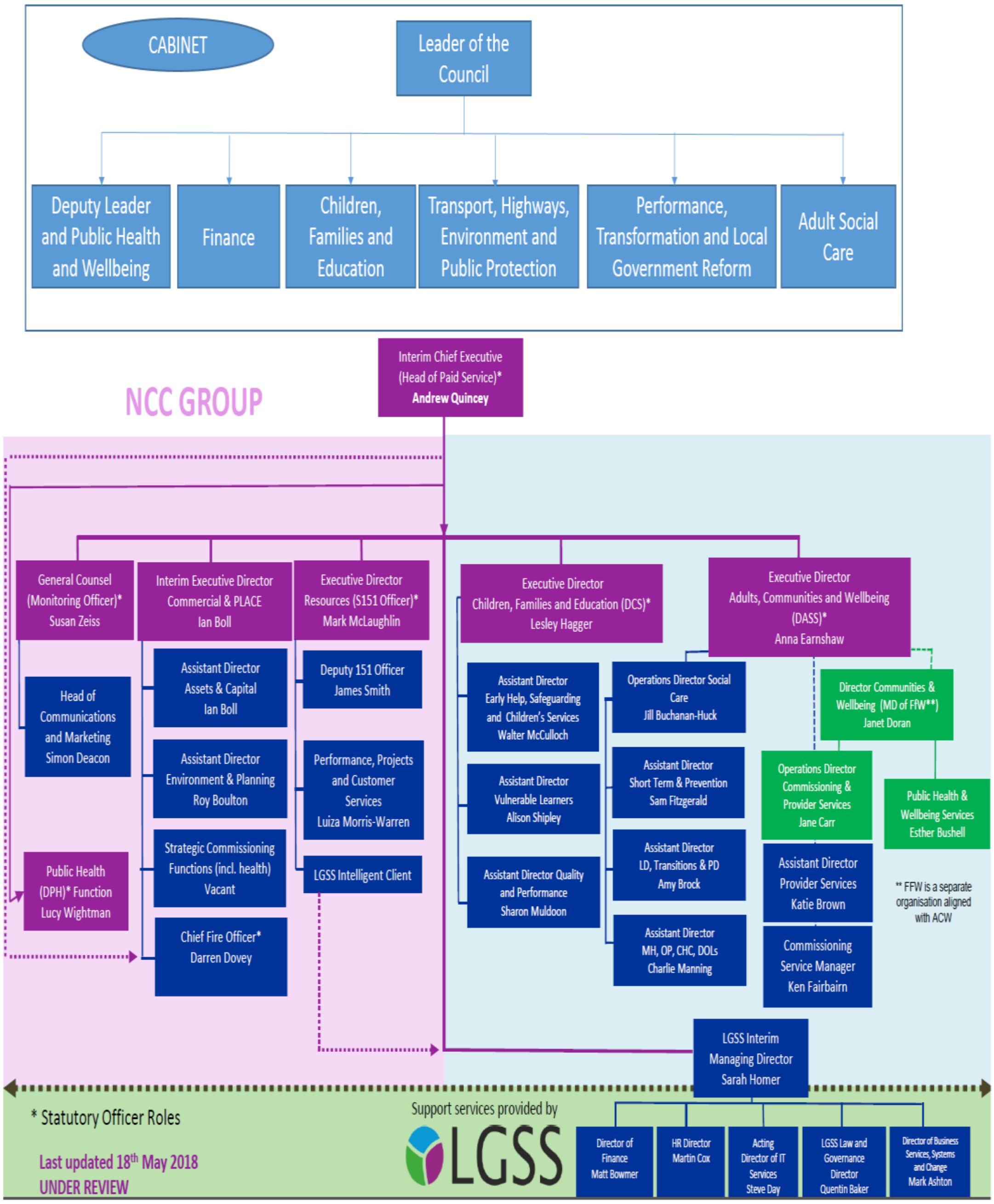


Figure 26: NCC Organisational Structure (Northamptonshire County Council Intranet, 2018)

The whole organisation sits under the Council's cabinet which is constituted of Councillors elected by the citizens of Northamptonshire.

6.2.2. Council, Cabinet and Councillor Duties

The researcher has briefly introduced in 5.1.2 the different operating models a local authority can choose from and the duties of a councillor. NCC has an operation model with a Leader of the Council and a Cabinet Executive. Both the Leader of the Council and the members of Cabinet Executive are elected councillors and are chosen from the majority party which won the County elections. The Cabinet is "the body that takes most of the decisions relating to the running of services provided by Northamptonshire County Council, within the policies (the Council budget for instance) that have been agreed by Full Council" (Northamptonshire County Council, n.d.) and is made of a specific number of Councillors who are portfolio managers. Figure 26 presents the seven portfolios within the Cabinet, whereas the Council is made of all the elected councillors, i.e. 57 for NCC in February 2018. The Council normally meets only six times per year to develop, discuss and vote for the most important decisions affecting NCC like setting and voting for the annual budgets, key policies and plans, yearly council tax levels, etc. Hence, the Cabinet can be seen as the executive body of the Council overlooking the daily management of NCC.

Each Cabinet member has a set of duties as part of his/her role of portfolio manager. These duties can be:

- *"The spokesperson for the policy area or 'portfolio' they are responsible for.*
- *lead on developing council policy and make recommendations to the Cabinet*
- *provide guidance to the Cabinet on running activities*
- *give guidance to the Cabinet on budget priorities*
- *monitor performance and make sure policy is delivered*
- *lead on improving council services*
- *make sure that activities meet the council's overall vision, core values and guiding principles"* (Thurrock Council, n.d.).

The administrative body cannot make major decisions without referring to the Cabinet or the Council and getting their approval. The administrative body of NCC works closely with the Council and especially with its Cabinet. For example, the Cabinet members meet regularly with the managers working under their portfolios to get updates and see how they can collaborate for the successful running of the services.

6.3. Energy Management in Northamptonshire County Council

6.3.1. The Development of Energy Management in the LA

Energy management was instituted in NCC in different phases. Before 2010, it was decentralised, i.e. every department was managing their energy use separately; for instance, the Council's Property Manager was managing energy differently to the Street Lighting Manager. This method of management is described by a senior manager in NCC as a 'Traditional Local Authority Management'; it has been used by most LAs in the past and is still used by some in the present.

Nevertheless, in 2010, NCC's cabinet and the Council identified that the latter did not have a designated 'environment' function and decided to create one. Primarily, the decision was driven by NCC's willingness to support the UK's efforts to meet their GHG emissions reduction targets under the Climate Change Act of 2008, with the UK legally bound to decrease its GHG emissions by 80% in 2050 compared to the levels of 1990 with intermediate targets of a 34% reduction by 2020 and 50% by 2030. Some of the measures and regulatory requirements enacted by the government to help with achieving these targets have already been presented in section 5.4.1. The created role led to the establishment of the Environment, Development and Transport Directorate. Under this directorate, two roles were created: one for energy and carbon management and the other one for environment management.

The Head of Energy and Carbon Management, who is the industrial supervisor for this research and a line manager for the researcher in NCC, believed that it would be better if energy was managed centrally as it would allow the organisation to have a clearer view on energy procurement, spend and budgeting in addition to setting policies that will affect the use of energy. The plan was put into work and different departments held their own energy budgets, i.e. energy was procured centrally but paid for by different departments depending on their energy consumptions. This can be viewed as an example of good governance as departments have specific yearly budgets, and they need to manage them carefully to avoid overspending, which means that if they pay for their energy use, they will put more effort into controlling their energy spend.

Moreover, this same senior manager had the view that energy should be managed in its broad context (i.e. including water, waste, etc. as they also are sources of energy). This perspective aligned with the government efforts at that time to decrease carbon emissions. The period running between 2010 and 2012 had witnessed the publishing of different reports which shed light on the potential energy savings and carbon emissions cuts that can be achieved if LAs are statutory pushed to decrease their energy emissions. LAs and other public bodies are large consumers of energy and should be setting an example when it comes to energy efficiency measures as they are permanent bodies which plan for long term and are uniquely placed to help with achieving the national targets set in Climate Change Act 2008 (Carbon Trust, n.d.) and as previously discussed in section 5.5. For instance, the Committee on Climate Change (2012) - an independent statutory body created under the Climate Change Act of 2008 - reported that LAs in the UK can decrease their emissions by 20% in 2020 compared to the levels of 2010 and by 30% compared to the levels of 1990. This can be achievable, first, if ambitions are set, policies are developed and monitoring is undertaken (Committee on Climate Change, 2012) and, second, due to the nature of operation of LAs and the broad scope of services and interventions which include waste, transport and buildings and knowing that the activities of these three sectors are responsible alone for 40% of the greenhouse gas emissions (GHG) of the UK. The report published by the CCC adds that

> *"Local authorities play an important role in delivering national carbon targets. They can drive and influence emissions reductions in their wider areas through the services they deliver, their role as social landlords, community leaders and major employers, and their regulatory and strategic functions."* (Committee on Climate Change, 2012, p.10)

Last, the Head of Energy and Carbon Management had a principle that energy management should not be costing money for NCC but should be generating or saving it. This same perspective was shared by many organisations, one of them is the Carbon Trust which stated that "Energy is one of the largest controllable overheads in many local authority buildings, so there are many opportunities to make savings" (Carbon Trust, n.d.).

6.3.2. Stages of Energy Management Adoption in NCC

Pre-2010

As mentioned in the previous section, energy management was not centralised within NCC, but every department had the freedom to manage as it best suited their budget. Additionally, energy management was not a priority, but energy budgets were. The department managers were interested in decreasing their expenditure and energy is one way of doing so because it has controllable overheads and should be a natural choice to explore options for decreasing the energy cost. Decreasing this latter does not mean necessarily decreasing energy consumption as there are many ways to achieve the first without affecting the second. For example, the teams managing energy can be restructured in a way that will lead to decreasing their costs, or the energy managers can change suppliers to look for better deals, etc.

One of the options adopted by the Council in the early 1980s was when the property department procured an energy management software called Stark. The goal was to explore the electricity tariffs which best suit every property or group of properties. The system allowed the Council the storage of energy data and prices per buildings and their analysis. At that time, the electricity market was still not deregulated in the UK, meaning that it was essentially a monopoly. This resulted in important financial savings to the Council by switching many buildings from a single to a dual tariff. Many buildings had a significant electricity consumption at night, e.g. schools or libraries with night activities, buildings with storage heaters (an electrical heater which generates and stores thermal energy 'heat' at night and releases it during the day). Switching to a dual tariff meant that the electricity night tariff was cheaper than the day tariff and hence financial savings are achieved even if the electricity consumption was the same. At that time, the portfolio of buildings included schools and their energy and maintenance budgets meaning that the Property Department of the Council had a very large portfolio to manage and therefore large savings could be achieved. However, these energy and maintenance budgets were later transferred to the schools. Today, every school manages its own budget and has independence of financial decision making. Nonetheless, schools are still a big energy customer for the Council; this will be elaborated later under section 6.3.4 when discussing the services offered by the Head of Energy and Carbon Management and his team.

After the decentralisation of budgets, i.e. after schools and many NCC departments became responsible for their own budgets, a new system had to be adopted for energy management. The new system needed to allow for energy monitoring, be compatible with Microsoft products like Excel, allow multiple users to upload their energy data (for example, meter readings), view it and be able to analyse it. The new system chosen by NCC was SystemsLink and is still used by the LA for energy management. It is important to note that energy monitoring in this case meant analysing the energy data for preparing business cases and for better insight about the energy situation of the Council for contract negotiations. Energy monitoring did not include real time monitoring of buildings because this task was resource intensive according to different energy managers from this LA; this will be elaborated under section 8.2.1.

After 2010

The year 2010 witnessed a change in energy management in NCC. This change was started by the creation of different job roles related to energy and environment such as the Head of Environment Management and the Head of Energy & Carbon Management, who in turn, created different roles like carbon management officers, etc. As mentioned earlier, the corporate energy manager (i.e. Head of Energy & Carbon Management) decided to centralise energy management within NCC operational boundaries, i.e. not including schools. His responsibility includes setting the strategy, targets, corporate monitoring of energy management, and energy contracts management; all the departments which have a direct contact with energy should report their energy consumption to him. He also had a goal to structure energy management in the Council and started by creating the Energy & Carbon Management Team (ECMT) to help him in his day to day duties and assist other departments in energy management activities like developing energy efficiency projects, funding, advising and support, etc. The process of institutionalising or embedding energy management in the organisation went through three stages:

The first stage had as a goal the creation of a base for energy management and a framework of delivery of activities. In other words, it was essential to quantify the energy use and the energy emissions in order to create an accurate base (in the form of an energy baseline) to design programmes for energy efficiency, for targeting areas which need attention and for quantifying savings in comparison to the fixed baseline. Therefore, the ECMT decided to opt for Carbon Trust Standard (CTS) certification. The CTS

> *"Recognises organisations that take a best practice approach to measuring and managing their environmental impacts, achieving real reductions in these year on- year, providing a framework for organisations to enhance their operational sustainability, improving efficiency and resource management at the same time as cutting costs"* (Carbon Trust, n.d.).

The CTS certification decision was approved by the Council because it falls within the efforts of NCC for helping the Central Government in achieving the reduction of carbon emissions; the leader of NCC for the period 2005-2016, said when NCC was certified with CTS:

> *"We have become increasingly aware of how our actions can affect climate change and it is imperative that we do what we can to reduce our impact on the environment. Our role as the largest employer in the county and our impact on the community means that we wanted to lead by example. Achieving the Carbon Trust Standard is recognition for what we've done so far and inspiration for staff, stakeholders, partners and local businesses to continue with the vision"* (Northamptonshire County Council Intranet, 2012).

This stage lasted until 2013 and was characterised by having one individual, i.e. the Head of Energy and Carbon Management pulling together all energy management activities. In other words, the energy management system of NCC was directed and managed by one senior manager, and there was no formal set of procedures or a written systematic approach which allows knowledge capture and that explains to any stakeholder how the work is carried out and will guarantee continuity if the senior management changes.

The second stage had an aim to move from a one-person energy management system into a well-structured system to drive energy management. To enable this change, the Energy and Carbon Management Team (ECMT) decided to develop an Energy Management System (EnMS) that complies with the requirements for the international standard ISO 50001:2011 and apply for certification to guarantee that the NCC's EnMS meets the requirements and can achieve the purposes it was developed for. This standard has been discussed in length under section 5.3.2. The choice of this standard was not arbitrary for two reasons: the first one is that the ISO50001:2011 specifies the

> *"Requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption"* (International Organisation for Standardisation, n.d.).

In other words, by applying for certification, NCC could create a systematic approach for energy management and for delivering the energy services. The Council was successful in its goal and was certified in 2014 with ISO50001:2011. Thanks to the standard, the new energy management system of NCC has an energy policy, defined job roles and duties, can capture energy goals and targets, measures, legal compliance, measurable performance, any non-conformities and areas for improvements. For instance, a list of controlled documents has been created that records and keeps track of each requirement such as legal compliance. These documents are stored in the internal web-based document management and storage system and are audited internally by NCC's qualified auditors and externally by independent auditors to evaluate if NCC's EnMS is performing well and continues to conform to the standard's requirements. Moreover, an Energy Management review is held on a yearly basis to report the achievements and struggles facing the EnMS and to plan for the year ahead. This meeting is chaired by a senior manager, and the reports presented during the discussion are shared with the top management of the organisation. The second reason was to give a green positive image and a competitive advantage to NCC; this standard is known internationally and the ECMT works on European projects with different partners and proves that both the team and the organisation have a set of procedures in place which are recognised internationally and which guarantee best practice energy management.

The third stage which started in 2016 is about enlarging energy management to include energy in its broadest context, i.e. including other resources than electricity and gas. One example can be identifying opportunities for a better water management which is often overlooked by organisations (Azennoud et al., 2017) and waste valorisation. For this purpose, the ECMT started working with the European Energy Award (EEA) to create a unique version for the UK. The EEA is broader than ISO50001:2011 since it includes water, waste, policy and other sectors managed by the LAs. NCC has passed the gap analysis but is still waiting to create a British version of the award. Also, the ECMT wants to help, support and share its experience with other LAs through the British version of the award. The ECMT is collaborating with many other LAs to institutionalise energy management within their organisations. One example is when the ECMT helped one LA to secure European funding under the European Regional Development Fund which focuses its investments on key priority areas, and one of them is Low Carbon investments. The amount of funding secured is around £10 million and will help the authority with investments in the energy efficiency of public buildings. However, this project also includes the use of systems for collecting energy data and analysing it to identify areas for energy improvement, monitoring of energy efficiency schemes, auditing, etc. One might question the purposes behind a team going outside of its statutory boundaries to provide help and assistance to another local authority. There are different motives behind such a decision:

- ECMT believes that it should be sharing its experience in energy management especially with public sector institutions. This is a good example of collaboration between different organisations to achieve a national target which is decreasing the carbon emissions of the UK. It also constitutes an example of good practice as the team and the organisation is looking beyond its boundaries to save energy.
- ECMT will be offering its consultancy services and expertise to help another LA save energy and money and at the same time will be paid for its services in the form of a small percentage of the savings. This is beneficial for both organisations as one will decrease its energy expenditure and NCC will have an additional income stream.

6.3.3. Energy Management Practices in NCC

Even though energy is managed centrally by the Energy and Carbon Management Team (ECMT), which is responsible for the energy policy of NCC and is the custodian of NCC's energy management system, other departments also use energy and have to report to and coordinate with the ECMT. Therefore, this team plays the role of the monitor and advisor to all other departments and some other partners and customers of NCC.

Energy efficiency and energy reduction targets are mainly linked to carbon reduction targets in NCC. As part of the Local Area Agreement (LAA), LAs in Northamptonshire set a target to reduce the CO_2 emissions per capita by 8.9% in the Northamptonshire Climate Change Strategy for 2010-2014 (Northamptonshire County Council, n.d.). The LAA is "A Local Area Agreement and is a three-year agreement based on local sustainable community strategies. It sets out the priorities for a local area agreed with Central Government which are represented by the lead LA and other key partners through local strategic partnerships" (The National Archives, n.d.). The LAA included targets related to environment and climate change, public facilities and behavioural change. NCC has on its own established a corporate CO_2 emissions reduction target which is a yearly reduction of 2% compared to the previous year. Both reduction targets have been achieved thanks to the efforts of all LAs and their partners and, as an example, the CO_2 emissions per capita has decreased by 20% between 2005 and 2013 (Northamptonshire County Council, n.d., p.4).

To achieve these targets, the Council was and is still on board for initiatives which have as a goal to decrease energy use/expenditure and thus carbon emissions. However, there is a hierarchy for energy management or energy decision making within NCC. Although energy management centrally sits with the ECMT; energy related decision making has to follow a specific hierarchy. There are some decisions that can be made within the ECMT or the Environment, Development and Transport Directorate (EDT), and there are others that can only be made after consulting or getting the approval of the cabinet members. However, every decision worth £0.5 million or more needs to have Council approval; these are known as key decisions and can also be related to major service activities. Examples of the two types of key decisions are the energy procurement contracts which are worth more than £8 million per year and the smart meters rollout programme which cost about £20k during the period of the project which was just under four years. Also, the Council's approval is sought when there is doubt about a decision to be made as part of delegation of decision making.

To reduce the energy use/expenditure, the Council and the ECMT adopted different strategies. As an example, the Council decided to decrease NCC's estate and fleet as part of the rationalisation of the business. A successful recent project was moving from ten office buildings to a one corporate office. Although this office is big, it is very efficient as current data shows that its energy consumption is less than one of the buildings disposed of. In fact, savings on energy and related maintenance costs, i.e. operational costs were one of the main motives to build this new headquarter. Another example was the smart meter rollout programme to facilitate the monitoring of the energy consumption. ECMT efforts were focused around energy efficiency of buildings; this includes lighting and boiler upgrade, thermal insulation, pipe work lagging, and installation of controls and Building Management Systems (BMS) as these were perceived as low hanging fruit and their positive impact can be noticed easily; these projects have been developed in partnership with the Property department. Another project which had a big impact on energy consumption is the street lighting upgrade; a part of this project has been achieved by the collaboration between the ECMT and the Highways Department, and the other part of the project was led and adopted by the Highways Department alone.

Also, under a partnership between the ECMT and Northampton Borough Council (NBC), the former helped NBC in their energy reduction targets, and one of the leading projects was the lighting upgrade of the majority of car parks in Northampton. This is another example of partnerships with other local authorities.

Thanks to these efforts, the ECMT has helped with decreasing the emissions of both NCC and NBC and was successful in taking these LAs out of the scope of the Carbon Reduction Commitment (CRC) resulting in large financial savings related to different costs; the cost for staffing for reports preparation and auditing is an example. According to the Head of Energy Management, this cost would have been over £600k for NCC.

In addition, even though schools in Northamptonshire are not part of NCC anymore and all of them have financial independence, the majority are still customers of the ECMT. In fact, the ECMT is responsible for purchasing energy (mainly electricity and gas) for all NCC estate, and since it has access to LASER which is a UK public sector buying group, the ECMT has access to competitive energy prices and developed a low risk management approach for the procurement of energy. Therefore, the ECMT offers this energy procurement service to the schools of the County to help them lower their energy costs, and as part of the service, the ECMT offers free energy advice and Display Energy Certificates (DECs) and Advisory Reports (AR) in order for the team to gain knowledge of the sites.

Nowadays, and thanks to the approach adopted by the ECMT, energy management is generating additional income to the County Council. It is generated from procuring energy at a lower price than the average market price, the commissioning of energy efficiency schemes for NCC estates, schools and other customers/partners like local authorities, the generation of DECs and ARs for different public institutions, bidding for European or national grants, etc.

6.3.4. Energy &Carbon Management Team Main Areas of Work

The Energy and Carbon Management Team (ECMT) can be described as a one stop shop for energy management within NCC. It is responsible for procuring energy, ensuring legal compliance for energy related areas of work, maintaining the Energy Management System, and for providing energy advice and consultancy, etc. All of these services come at no cost to the LA but generate an additional annual income of around £300k net. The area of work by ECMT goes beyond the borders of NCC to include providing extensive advice and support on energy management to the public sector in Northamptonshire as a primary focus and to other public bodies outside the borders of the County. The main services provided by the ECMT both to NCC and other public institutions are:

Energy Procurement

The ECMT is currently purchasing energy, mainly electricity and gas through LASER which is a public-sector energy buying group owned by Kent County Council. The ECMT has been purchasing electricity from this organisation on behalf of different public bodies in Northamptonshire for more than 10 years ago and the choice of organisation, i.e. LASER, was made based on the following reasons:

- Very competitive prices compared to the market average. Basically, LASER has a significant purchasing power and uses a risk-managed flexible procurement, i.e. purchasing energy in advance for the coming years when prices are cheap, to buy energy at competitive prices and provide cost certainty for the customers. As an example, prices are set in October for the year ahead and this helps with budgeting as energy managers have an idea about their annual consumption and have a fixed energy rate for 12 months.
- A fully managed service with a cost included in the energy unit rate which is still competitive to market rates. This service includes invoice validation and query resolution and leads to savings. For instance, from July 2016 to June 2017, LASER has saved NCC through its whole energy procurement portfolio,

i.e. including schools, £186k of overcharges and £7,180 admin savings from £923k erroneous invoices stopped (LASER, 2018). An account holder in a school might not have the capability and the necessary knowledge to verify the accuracy of their bills, and this is one of the reasons the ECMT offers a fully managed service through LASER in order to support these account holders who might not have any knowledge in relation to energy management.

The ECMT is charging a rebate on the energy unit rates and the income from energy procurement forms an important part of its annual income.

Energy Assessments

The ECMT offers energy assessments, audits and surveys of buildings at no cost to those that purchase energy through it and at a very competitive cost (at least 10% below the average market cost) to other public bodies. These assessments are usually used to produce Display Energy Certificates (DEC) and Advisory Reports (AR) which are a legal requirement for buildings with a surface area larger than 250 m^2. These assessments can also be used to identify energy efficiency and renewable energy opportunities in the surveyed sites. Last, these assessments are very useful to the ECMT and other departments like Property since it helps with acquiring energy intelligence, i.e. meter readings, state of lighting, boilers, etc. on different buildings on a regular basis.

Additionally, the ECMT can help energy managers with decreasing their energy cost by assessing their capacity use and charges to define whether it is beneficial to decrease the capacity of the site. As an example, when new schools are built and when registering their electricity supply, engineers tend to register the supply with a higher capacity than what the building actually needs because they take into consideration that the school might need to expand in future. In some cases, schools do not expand and end up paying for a capacity they do not use. This is why the ECMT offers to monitor their capacity to quantify the real demand of the site and check if there are any expansion plans before applying on behalf of the site to the Distribution Network Operator (DNO) to decrease their capacity. This is another chargeable service.

The ECMT offers its services at competitive prices because its primary goal is to assist public institutions with energy management. At the same time, the team still needs to cover its cost and generate an income to prove that energy management in specific, and this management culture in general, can be a lucrative way to run a department, lower its operational costs and, if possible, generate additional income especially for an organisation which is in a difficult financial position.

Development and Funding of Energy Efficiency Projects

The ECMT works with different departments within NCC to decrease the energy consumption of the organisation. These departments consist of Highways (mainly street lighting), Property, Waste Management (waste valorisation), Libraries, and Fire & Rescue Services (mainly the fleet management team of NCC which falls under this department). As for the case of the other service offered by the team, ECMT also works with other public bodies – mainly schools - to develop energy efficiency schemes.

However, one of the biggest challenges which face the implementation of these schemes is funding. NCC on one hand is in a difficult financial situation and cannot afford to invest in these schemes even if they can help with saving money in the future. On the other hand, schools and the other bodies also have pressures to fund schemes which were not budgeted for. This is why the ECMT has developed a service where it offers funding through different mechanisms like SALIX, public-private partnerships and applying for national and European funding (Cf. more information in 6.3.4).

Another challenge is to find areas for improvement either within NCC or outside its operational boundaries. Here, the ECMT benefits from access to a database of potential energy efficiency schemes and one of energy data which have been built year on year thanks to the energy assessments service. The ECMT have the necessary information on these databases to build a business case for an energy efficiency scheme and present it to its customers. As an example, the team used to make contact with schools and present them with the business cases with money, energy and carbon saving opportunities. This required a lot of effort and resources with little return as many schools were not on-board with these projects and is why the team is now following a reactive approach; offering the service to schools on demand, i.e. when they need help with decreasing their energy consumption.

a. Funding through SALIX

This is the most used approach for funding energy efficiency schemes as SALIX Finance offers easily accessible funding when there is a solid business case for energy and carbon reduction that meets the funder's criteria. This organisation has been introduced in detail in 5.4.2. The current sub-section will explain how it is used by an LA.

SALIX Finance offers different funding mechanisms; two of them are mostly used by NCC since the others are for the use of academy schools. These are SALIX Energy Efficiency Loan Schemes (SEELS) and a revolving fund known as (RF) which stands for SALIX Recycling Fund. SEELS is a 100% owned by SALIX finance, whereas the RF is 50% owned by an LA and by SALIX Finance. Both funds offer 100% interest free capital finance to support energy efficiency schemes which need to be paid back over a set of years. There are many advantages behind using RF like allowing the LA to have more control over the management of the fund and thus to approve schemes quickly in addition to the funding criteria which are more accessible than the other SALIX Finance funding mechanisms, whereas one advantage is that the funds under RF are limited. For instance, the value of NCC's fund is £600k, i.e. £300k from NCC and £300k match from SALIX Finance (Perry, 2010). However, the value of the annual repayments which keeps replenishing the fund amounts to about £100k per year; this is the actual fund value that is available each year to invest in these projects. NCC was one of the 18 pilot authorities to receive funding from SALIX Finance to operate an 'invest to save' internal energy finance scheme. Since 2004, the capital under this fund has been recycled twice to fund schemes within NCC as it provides more flexibility with the paybacks. SEELS is used to fund schemes developed for non-NCC estate.

The ECMT is the manager of RF and the applying authority for SEELS funding on behalf of NCC and other public institutions. The ECMT, again, charges a management fee which is also funded by SALIX Finance since this fee is paid for energy related expenses; in the case of NCC, to cover the cost of staff members who develop these projects.

b. National and European Funding

Every year there are different funding opportunities from Central Government, UK public bodies and organisation, companies and the European Union that LAs can bid for. The ECMT has in the past prepared, submitted different applications on behalf of NCC or other public bodies and has been awarded with different funds. These applications covered energy efficiency in buildings, upgrading the LA's fleet to hybrid or electrical vehicles, installing electric vehicle chargers for staff use, etc. The latest two awards for NCC and one of its partners fall under the ERDF (Cf. 5.8.1 for more details about both projects) and both are used to institutionalise a low energy economy. The value of the 1st award which will be managed by NCC is £6 million and has as a goal to help Small and Medium Enterprises (SMEs) in the South East Midlands area to improve the energy efficiency of their business. The ECMT will significantly benefit from knowledge share and will improve the operational skills of the team members.

The second project is awarded to another LA but was developed by the ECMT. The value of the grant is around £9.6 million and will be used to help public bodies and SMEs in North East Lincolnshire with improving the energy efficiency of their buildings. Again, ECMT is charging a management fee for the development and the partial running of some energy schemes under this project. This LA got in contact with NCC three years ago to learn how energy management has been institutionalised in NCC and how it can bring income to the organisation. The LA also asked for help in replicating a similar model in their organisation. The ECMT thought that this can be made possible through working on the European Regional Development Fund (ERDF) project. This will enable both organisations to collaborate, communicate more and work using the same operational structure.

c. Public-Private Partnership

NCC has strategic partnerships with different large organisations in the UK and these are: British Gas, Schneider Electric, Travis Perkins and WCIT. The ECMT can have access to these partners to fund or assist in implementing energy efficiency initiatives or ask for support and collaboration under specific circumstances that are case dependent.

Energy Management Service

The ECMT can help organisations with implementing an Energy Management System compliant with the ISO50001: 2011 as it has team members who have been trained to implement these systems and are certified as Lead Auditors for this standard. The ECMT can also help other organisations with getting their CRC or ESSOS certification as was the case for NBC.

Energy Services to Schools

Schools in Northamptonshire are the main customers for the ECMT for three of their four services and these are: energy procurement, energy assessment and the application of energy efficiency schemes. For energy procurement, the schools share of the NCC's energy basket which is valued at £8.5 million yearly (LASER, 2018) and procured through LASER is 58% followed by NCC's street lighting and then LA's buildings portfolio (Perry, 2016). Most of the schools in Northamptonshire are clients of the team; there are schools which use only one service and there are others which use all three of them. The ECMT has more than 300 schools as customers. This strong relation with these public institutions is not surprising as these entities used to be part of the LA. However, successive governments worked on freeing schools from the control of LAs and bringing it back under their control through their arm length organisations (Morris, 2010). This has been done in stages; the first of which was to give financial autonomy to schools, but they will still report to their LA and the Department of Education (DfE). Again, not all LAs have a statutory requirement of providing education but the ones that do are known as Local Education Authorities (LEAs), and NCC is one of them. This decision had a great impact on NCC as the buildings portfolio dropped significantly starting from April 1990 and was mandated in the Education Reform Act 1988. This took the financial control out of the hands of LAs and gave it to the schools head teachers and board of governors (The National Archives, 1988). According to a retired energy manager who was responsible for the maintenance of the properties between 1997 and 2014 but who joined the Property Department in the early 80's, the number of buildings his department used to manage dropped from around 1,000 to around 250 during the late years. Though, these buildings can still be generally regarded as the property of the LA and the schools have the freedom of decision making to operate them.

The decision to take these institutions out of the control of the LA has led to having schools with different status. There are different types of schools, e.g. state, faith schools or private schools. Within the state sector, there are schools which are controlled by the LEA and which are known as maintained schools, and there are schools which are controlled by the Central Government (UK Government, n.d.).

In the 2015 budget, the Chancellor of the Exchequer initiated the academisation of schools which will end the link that had tied schools to LAs since 1902; all schools in England have to convert to an academy by 2020 or commit to convert by 2022 (BBC, 2016). Academies are independent state funded schools but can also be funded by private organisations; they are run by a head teacher or principal but overseen by an academy trust which is a charitable organisation that can oversee one academy or a chain of this type of institutions.

These different types of school mean that not everyone can benefit from all the services of the ECMT like having access to the SEELS fund; this requires an understanding of the status of the school by the team before getting in contact with its management group to propose its services. For example, every school in the County can procure energy through the ECMT or can hire the team for energy assessments. However, not all schools can benefit from SEELS or RF funding since there are other funding mechanisms provided by SALIX for specific types of school like the Condition Improvement Fund (CIF) and Salix Energy Efficiency Fund (SEEF) funding for academies. Though, academies can still hire the services of the ECMT to apply for the CIF and SEEF; the chance of getting an application approved is very small because funds criteria are not focused on energy efficiency but on enhancing the state of the school. This is why the ECMT prefers to work with schools which can benefit from the SERS and the RF as there is a higher chance the team will be paid for its services. Moreover, the academisation decision had a negative effect on the services of the ECMT. Academy trusts prefer to procure energy themselves and, for instance, in the last procurement contract, the ECMT lost about 10% of its schools which were mainly academies. For example, the researcher had interviewed a member of the management team of an academy trust whose main funders are a big food company in the UK and a big land owner in Northamptonshire; this academy trust manages ten schools. The academy trust is purchasing energy through the funding food company as they believe that they are guaranteed very low prices since this company has significant purchasing power and a large energy portfolio.

The ECMT has focused its efforts on schools since it understands the potential of improving their energy efficiency. The choice of energy efficiency is though driven by the funding opportunities. SALIX Finance only provides a 100% funding to school schemes with a payback period of less than eight years. If the payback period is greater than eight years, the school must provide the investment required to cover the additional payback years. Upgrading the lighting is the current popular scheme as it meets this criterion in most cases. However, this potential has been decreasing with time for many reasons: more schools are transforming into academies, many schools have already benefited from the schemes with a payback period of less than 8 years; the ECMT has been working with schools on these projects since 2007. Recently, more and more schools are interested in installing roof mounted solar panels which was not funded by SALIX Finance. This is why the ECMT has been in continuous discussions and worked with SALIX Finance to develop a funding offer for other technologies such as solar panels. This was achieved in 2017 and NCC was the first LA to implement a roof mounted PV in the UK using SALIX Finance funding;

Appendix G includes a case study for this project.

Schools can choose to apply directly to SALIX Finance for funding, saving on the management fee charged by the ECMT. However, most of which applied for funding in Northamptonshire used the services of the ECMT for two main reasons:

- Schools do not know about this funding opportunity and, in most cases, it was the ECMT which introduced them to it.
- Schools, generally and according to the Head of Energy & Carbon management in NCC, do not have the expertise or the necessary knowledge to develop these schemes and hiring a consultant for this purpose would be very expensive.

These services allow customers to benefit from a best value product and allow NCC to benefit from an annual income; although it is very small compared to the value of the annual budget of NCC which amounts to around £810 million, it is still significant. Other LAs have been on an energy management journey where they launched energy related projects that guarantee important income. Examples are Kent County Council with their energy buying group LASER or West Sussex County Council which built a 5 MWp solar farm and started generating electricity in February 2018. So why have similar schemes not been implemented in NCC while the existing schemes are mostly limited to lighting or boiling upgrades? It is true that these schemes save energy and money, but they can be seen as projects which are implemented as part of maintenance programmes, and in some cases, reactive maintenance. An example would be the upgrade of boilers in nine NCC buildings where the project was funded partially by SALIX Finance because it was going to save energy as the new boilers have a better efficiency than the old ones, some of which were used for more than 20 years.

However, this project can be viewed as an energy efficiency scheme, but when one looks at it closely, it is part of a maintenance project as those old boilers reached a stage where they may stop working, and the LA cannot neglect this risk as it will have serious effects on service delivery. Different questions arise from the discussion above and these are: why didn't the organisation implement renewable energy related projects? Why doesn't it install a roof mounted solar PV on each estate building that is not listed? These questions were asked in the interviews with senior management in NCC and their responses will be discussed throughout Chapter VII.

6.3.5. Energy Monitoring and Targeting

With the successful certification of CTS and ISO50001: 2011, a culture of energy monitoring and targeting has been put into practice and has been documented, especially as part of NCC's Energy Management System (EnMS). The targeting is based on a yearly energy review to identify the big energy consumers and to put into place measures to reduce high consumption. Though, monitoring and targeting is not always performed on a yearly basis; departments can have different periodic monitoring and targeting activities which depend on specific activities and serve specific purposes. For instance, there is a monthly monitoring and targeting activity performed by the Property Department to check if the energy consumption of the NCC estate is below forecasted consumption. Table 8 as an example, shows the energy review prepared at the beginning of the financial year 2015/2016:

	Units	Total for 2015-2016	Share	Activities	Source of Energy
NCC Properties	kWh	24,586,289	56%	Rationalization of property, Project Angel, NCC Resource Efficiency Group	Gas/ Electricity
Street lights	kWh	15,605,422	35%	Current ongoing street light replacement programme	Electricity
Diesel	Litres *11.1 to kWh	3,698,653	8%	eCar initiative/Cycle Northants bike network/behaviour change projects (such as car sharing)	Diesel
Petrol	Litres *9.4 to kWh	72,380	1%	eCar initiative/Cycle Northants bike network/behaviour change projects (such as car sharing)	Petrol
Total	kWh	43,962,744	100%		
Third parties and public sector clients (Academies, schools)	kWh	28,537,862		Biomass project/Salix programme/ Schools Action Plan	Gas/ Electricity

Table 8: Energy Review FY 15/16

This serves as a quick overview of energy consumption in NCC which helps in identifying specific areas for intervention and where more efforts should be put in order to have the greatest impact. This is why these reports are often backed with more detailed ones on energy consumption of specific estates, specific portfolios (e.g. electricity consumption of street lighting), fuel consumption of NCC ‘s fleet or Fire & Rescue’s fleet, etc. From Table 8, it can be noticed that, from the presented energy mix, the schools portfolio is the biggest energy consumer followed by NCC’s estate then street lighting; this confirms what has been mentioned before in this chapter in relation to the work done with schools and the focus on these entities. However, street lighting is one entity unlike NCC properties which include libraries, fire stations, administrative buildings, etc. or the schools' portfolio which is made of independent entities, i.e. independent individual or groups of schools. This is why, during the last couple of years, significant efforts have been introduced to help the street lighting department to decrease their energy consumption. In this case, the ECMT has one team for major projects unlike for schools where the team will be working with representatives of each school on relatively small schemes.

For schools, lighting upgrade is the main measure used to decrease energy consumption; however, other measures are also implementing cavity wall insulation, pipes lagging, upgrade of boilers or change from electric to gas heating and sometimes biomass, etc. For street lighting, even though NCC was adopting more streets from developers during the last year, energy consumption has been going down thanks to using more efficient light bulbs. As an example, during one of the upgrade phases which occurred in 2016/2017, more than 300 Low Pressure Sodium bulbs with a nominated power between 58W and 90W have been changed to LED road lanterns with a nominated power of 12W which can be dimmed resulting in even less consumption. Table **9** and Figure 27 shows that the electricity consumption for street lighting in NCC has decreased by 13.5 MWh between the financial years 2010/2011 and 2015/2016:

	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
	Usage (KWh)					
April	2,078,273	2,103,489	1,334,964	1,324,050	1,278,339	1,180,946
May	1,796,555	1,807,619	1,173,441	1,150,717	1,101,161	1,010,655
June	1,536,032	1,413,470	1,018,533	992,849	983,362	865,461
July	1,693,905	1,322,887	1,111,620	1,073,209	1,022,895	949,932
August	2,021,562	1,328,974	1,291,138	1,264,949	1,204,891	1,062,465
September	2,310,273	1,489,547	1,495,946	1,453,841	1,378,600	1,237,252
October	2,803,640	1,718,718	1,790,911	1,748,190	1,654,833	1,564,929
November	3,071,109	1,866,746	1,937,066	1,905,390	1,789,638	1,622,742
December	3,368,804	2,043,559	2,118,145	2,085,750	1,955,249	1,763,774
January	3,272,976	1,983,164	2,059,599	2,014,429	1,895,893	1,689,819
February	2,717,347	1,680,287	1,683,592	1,635,572	1,534,948	1,404,033
March	2,573,927	1,569,080	1,618,073	1,567,512	1,465,739	1,253,413
Total (kWh)	29,244,404	20,327,539	18,633,028	18,216,457	17,265,548	15,605,422

Table 9: Yearly Street Lighting Consumption 2010 - 2016

Great savings can be achieved during winter months where the electricity consumption of street lights is high compared to other months of the year simply because the nights are longer with more operation hours. Figure 27 shows the big savings achieved thanks to the lighting upgrade and the dimming of street lights:

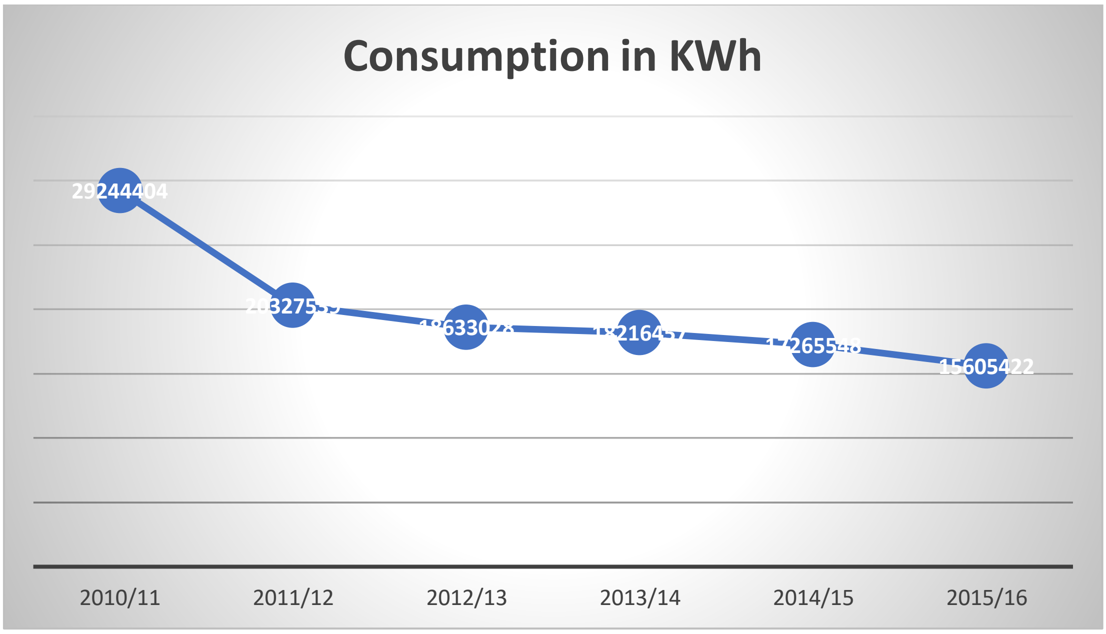


Figure 27: Decrease in Electricity Consumption of Street Lighting 2010 - 2016

Although the monitoring and targeting is achieving good financial and environmental results, the ECMT is aware that their monitoring is reactive and as a way to develop their EnMS, the monitoring should also be proactive, hence the importance of this study; NCC is interested in exploring the most effective approaches of energy monitoring which can assist with better decision making.

6.4. Major Achievements of the ECMT

Since its inception and thanks to its energy management culture, the ECMT has recorded a number of achievements, most of them are for NCC, some for Northampton Borough Council (NBC), some for schools and the remaining for other partners. Some of these achievements are:

- For NCC:
    - More than £ 8.5 million energy savings.
    - More than £ 2 million energy procurement savings.
    - Operational surpluses totalling over than £2.3 million.

    - No carbon tax, the ECMT has managed to take NCC out of the CRC.
    - Carbon emissions have dropped from 95.2 tCO_2 in the financial year 2010/2011 to 46.7 tCO_2 in the financial year 2015/2016.
    - Re-certification of the EnMS under ISO50001: 2011
    - Introduction of electric and hybrid vehicles and their charging infrastructure to the Council
    - Implementation of a European project entitled ZECOS which was about zero emission communities and included three communities from Northamptonshire
    - Securing the funding for a European Regional Development Fund (ERDF) project entitled Smart Energy Businesses which has a start date in Summer 2018 and aims at supporting Small and Medium Enterprises (SMEs) with their energy costs through different solutions including the training of members of staff around energy management and energy efficiency or helping the businesses with implementing energy efficiency schemes.
- For NBC:
    - £ 2.2 million energy savings.
    - No carbon tax, the ECMT has managed to take NBC out of the CRC.
    - Over 14 tCO_2 has been saved.

6.5. Conclusion

Northamptonshire County Council is the upper tier authority administrating the County of Northamptonshire. The organisation is facing challenges that are threatening its existence and is more than ever required to review its operational and governance model to offer a good service to the residents of the County and fulfil its statutory duties.

Good governance examples in LAs are available across the country and within the Council itself. One example is the energy governance through the energy management practice administrated by the Energy and Carbon Management Team (ECMT) and other energy stakeholders within the authority.

The energy management system (EnMS) of NCC has proven its ability in managing energy effectively, saving energy, money and carbon and at the same time creating an income stream to the Council through the different services offered both internally and externally. Yet, there are considerable opportunities to develop the EnMS further. These can be achieved by first identifying the weaknesses of the system itself and by learning from other experiences in other LAs. This will be looked at in detail under 7.1.

Additionally, and going back to the management failures highlighted in the report of Carter (2018) of which was the way federated bodies were set up and how they were operating; the researcher believes that there are many lessons to be learned by looking at how energy management is conducted in NCC and how it can benefit and inspire the other services within the LA. As has been seen earlier, the Energy & Carbon Management Team did not only depend on offering services to NCC and its different departments but also on other clients inside Northamptonshire and outside the borders of the County. In fact, the majority of the income is achieved outside the boundaries of the Council. Besides, the ECMT is bound to generate a yearly fixed income meaning that the results achieved by the team can be quantified. Consequently, this can be seen as a live case where a department or a service can generate income from within the Council and does not need to work outside its boundaries.

VII

Smart Metering and use of Energy Data in NCC

An in-depth study of the identified themes in the previous chapters and in a real-life setting	• Case study of the smart meters rollout in NCC • Discussion around central energy

Chapter VII: Smart Metering and Use of Energy Data in Northamptonshire County Council

This chapter starts by presenting a summary of energy management in Northamptonshire County Council (NCC), then explains how smart meters and similar technology have been adopted in the organisation, its usage and cost, and last, it explores how different staff members use the Half Hourly (HH) energy data and how they interact with the Energy Management Systems (EnMS) in the context of NCC.

7.1. Overview of the Energy Management System

In 6.5, it has been mentioned that there is a need to identify the weaknesses and the strengths of the EnMS to guarantee its continual improvement. To understand the EnMS of the organisation in detail, the researcher decided to use an energy management matrix designed by the Carbon Trust which have the same six key areas discussed in 5.3.5. The choice of this specific tool among others was based on the background of the developer, i.e. the Carbon Trust, and because it provides an additional tool which is the Energy Management Assessment (EMA) also discussed in 5.3.5. Additionally, the Carbon Trust is a reputable organisation in the UK that also has a global presence; it was a public organisation when it was created before it became a not-for-dividend institution. Second, the EMA has a list of questions that cover most, if not all, the areas related to energy management. The areas covered are:

- Management commitment: energy policy, energy strategy and organisational structure.
- Regulatory compliance.
- Procurement and investment: procurement policy and investment procedures.
- Energy information systems and identifying opportunities: monitoring and analysing energy use, target setting and opportunities identification.
- Culture and communications: staff engagement and training, operational procedures and communications

The tool has a list of questions for each section and sub-section with a detailed scoring chart. The interviewer will be filling the matrix based on the answers of the interviewee. The researcher chose the Head of Energy & Carbon Management for an interview to help with populating the matrix and the EMA. This member of staff is a representative of Senior Management and, at the same time, responsible for the delivery of many energy related projects. He has worked for the organisation since 2007; first in the Property Department before being appointed as a Head of Energy & Carbon Management. He is also the Management Representative of the EnMS and thus has been in continuous discussion with different energy stakeholders of the organisation and knows very well the energy culture of the organisation. Last, the interviewee is the industrial supervisor of this research. The interviewer is also placed in a good position and can answer most of the questions included in the tools, he has worked for the authority since 2014 and has been responsible for different projects including energy contracts, the metering contract and the SALIX Recycling Fund. He is also the EnMS Coordinator, which means that he is responsible for the day to day running of the system. However, to ensure impartiality, it was appropriate to have another member of the organisation to answer these questions and give scores as required and as explained previously in 5.3.5 (this section also presents these tools in detail); hence why choosing the Head of Energy & Carbon Management. Appendix H presents the questions asked by the tool with their actual scoring. Table 10, Table 11 and Figure 28 present the results as produced by the Carbon Trust tools:

Level	Energy Policy	Organising	Training	Performance Measurement	Communication	Investment
4	**Energy Policy, Action Plan and regular reviews have active commitment of top management**	Fully integrated into senior management structure with clear accountability for energy consumption	Appropriate and comprehensive staff training tailored to identified needs, with evaluation	Comprehensive performance measurement against targets with effective management reporting	Extensive communication of energy issues within and outside of organisation	**Resources routinely committed to energy efficiency in support of organisational objectives**
3	Formal policy but no active commitment from top management	**Clear line management accountability for consumption and responsibility for improvement**	Energy training targeted at major users following training needs analysis	Weekly performance measurement for each process, unit, or building	Regular staff briefings, performance reporting and energy promotion	Same appraisal criteria used for energy efficiency as for other cost reduction projects
2	Un-adopted policy	Some delegation of responsibility but line management and authority unclear	**Ad-hoc internal training for selected people as required**	**Monthly monitoring by fuel type**	**Some use of organisational communication mechanisms to promote energy efficiency**	Low or medium cost measures considered if short payback period
1	An unwritten set of guidelines	Informal, mostly focused on energy supply	Technical staff occasionally attend specialist courses	Invoice checking only	Ad-hoc informal contacts used to promote energy efficiency	Only low or no cost measures taken
0	No explicit energy policy	No delegation of responsibility for managing energy	No energy related staff training provided	No measurement of energy costs or consumptions	No communication or promotion of energy issues	No investment in improving energy efficiency
Input Score	4	3	2	2	2	4

Table 10 : Energy Management Matrix for NCC

Table 10, i.e. the energy management matrix for NCC, gives an overview of energy management in the organisation. The cells in red only define NCC's level against each of the six energy management key areas but don't present a detailed overview of the strengths and weaknesses of the organisation in regard to this practice. This is why there is a need to also perform an energy management assessment to identify in detail the areas that need improvement.

Characteristic	Score Actual	Score Max	% score
Management Commitment	**28**	**32**	**88%**
Energy policy	*9*	*10*	*90%*
Energy strategy	*8*	*10*	*80%*
Organisational structure	*11*	*12*	*92%*
Regulatory Compliance	**10**	**10**	**100%**
Regulatory compliance	*10*	*10*	*100%*
Procurement and Investment	**18**	**22**	**82%**
Procurement policy	*8*	*10*	*80%*
Investment procedures	*10*	*12*	*83%*
Energy Information Systems & Identifying Opportunities	**27**	**34**	**79%**
Monitoring and analysing energy use	*13*	*14*	*93%*
Target setting	*6*	*10*	*60%*
Opportunities identification	*8*	*10*	*80%*
Culture & Communications	**17**	**30**	**57%**
Staff engagement and training	*8*	*10*	*80%*
Operational procedures	*5*	*10*	*50%*
Communications	*4*	*10*	*40%*
GRAND TOTAL	**100**	**128**	**78%**

Table 11: Scoring of the Different Areas of Energy Management for NCC

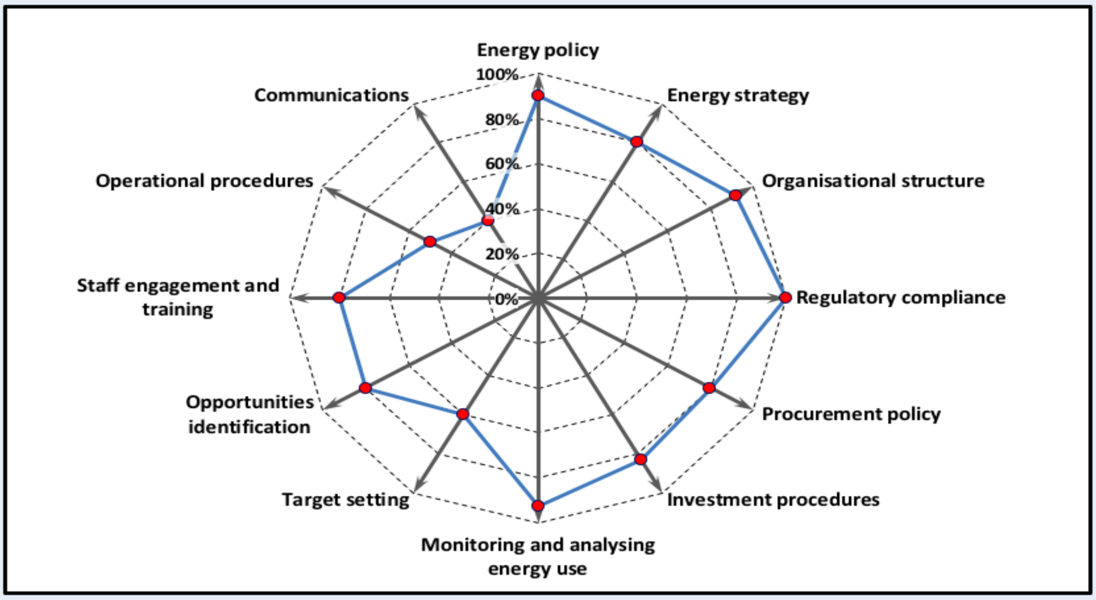


Figure 28: Energy Management Assessment of NCC

Both Table 11 and Figure 28 help in locating, with more precision and depth, the strengths and the weaknesses of NCC's EnMs. As an example, the energy management matrix identified that NCC is weak when it comes to measuring the performance of the system. The energy management assessment specified the source of this limitation; NCC is weak when it comes to communicating energy targets, strategies or achievements to all its employees except to the energy stakeholder; this will be explained under 7.3.1. The researcher will use these results to shape some of his interviews with the members of staff and try to find answers or solutions from his previous interviews with energy managers from other LAs. This will be discussed more throughout this chapter and the next chapter.

Last, Figure 29 presents the organisation structure of energy management (documented by the researcher) in NCC as of July 2018:

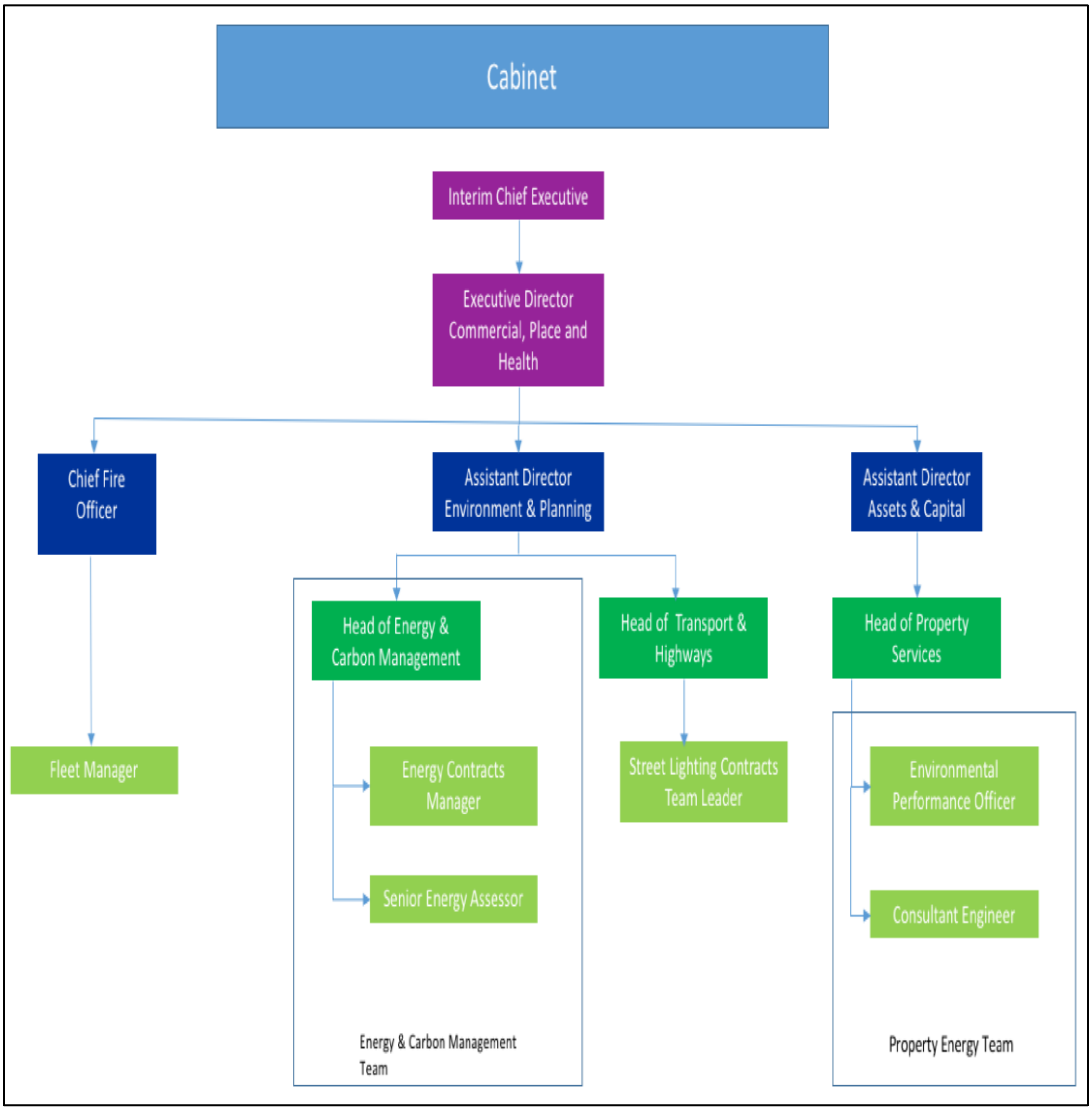


Figure 29: Energy Management Organisational Structure for NCC

7.2. Overview of Smart Meters and Similar Technology Adoption in NCC and their Uses

It has been stated in 6.3.2 that one of the reasons to purchase energy management software was to store energy data - mainly monthly meter reads – of buildings in order to understand the consumption patterns of groups of buildings which are operated in the same way as libraries and schools to see if it is beneficial to switch to a dual tariff and thus save money. However, NCC and its energy teams did not find a great use of that specific type of data as it had a very low resolution since it only included monthly readings and cannot be used for different purposes except for energy budget monitoring.

4.2 presented the sources of energy data and most of those techniques were used by NCC. When the organisation did not have any smart meters, the Property team relied on its members of staff, site managers or clerks, to read the meters monthly and submit them on cards or through energy invoices. The meter reads were then entered manually by a member of staff to the energy management software. This process was exposed to human error when writing the meter reads on the cards and when copying them to the system. Additionally, this process was most of the time relying on human intervention. Finally, the frequency of data was very sparse especially for buildings where there are no site managers or clerks to take meter readings and commodities invoices need to be used. The problem was that the invoices were mostly estimated since no meter reading was submitted from the organisation, and some of them were quarterly. This resolution of data will make it hard to detect any early abnormal energy consumption, and even when it is detected, it will be difficult to identify its source or when the problem started as this type of data does not reveal the profile consumption of a building.

The solution to this problem was to use half hourly meter reads with the accompanying need to install the technology that will allow generating and capturing high-resolution energy data.

7.2.1. Technology Rollout for the Electricity Supply

A first trial of this technology took place in May 2007 when electricity Automatic Meter Readers (AMR) were installed in the five heaviest electricity consuming buildings. This trial was successful in terms of achieving the tasks it was designed for, i.e. an automatic service for producing and displaying the half hourly (HH) meter reads. This is why when the LA was approached in 2011 by its electricity supplier to install electricity AMRs, as part of the Smart Metering Roll-Out Programme launched by the Central Government, in all its estate and the schools covered by its energy procurement basket; NCC accepted the offer. The programme included 529 sites.

However, before May 2015, 54 sites were withdrawn from the programme because they were either located in an area with a poor mobile network or because the sites no longer existed under the NCC's portfolio, i.e. they were sold or demolished.

7.2.2. Technology Rollout for the Gas Supply

In 2013, after about 6 years of using AMRs for the automatic collection of HH electricity meter reads for most of NCC's estates and the schools which were under its energy contract with LASER; the organisation built a more positive experience from the historic usage of this technology and decided to rollout gas smart meters in the highest gas consuming buildings for two main reasons. The first was to avoid sending staff members to collect meter reads and saving on their cost and time. The second was to build and improve the data quality database that contains the gas meter reads to ensure the consistency of historic data for energy management and invoice checking. 27 smart meters were installed and later in 2017, the ECMT was made an offer by its gas supplier to install smart meters in all properties under their energy contracts. The offer was accepted but this time the team decided to rollout the smart meters for all its estate where possible and also asked schools for their permission. The reason for this was that the installation of a gas smart meter can cause disturbance to schools especially during winter when the supply of gas may be interrupted for a specific period affecting the heating of the site, and the ECMT had to be sure that the schools were fully aware of this and gave their consent. The team got in contact with all the schools on the energy contract and explained the process and the benefits of having such a technology – most of these schools already have an electricity smart meter or AMR – less than 50% of schools accepted the offer; the remaining ones did not reply for unknown reasons. The programme started in the spring of 2017 and is due to end in the summer of 2018.

7.2.3. Cost of Using Smart Meters and Similar Technology and for Having Access to HH Data

Having a smart meter that automatically sends HH data does not mean that the organisation can have access to the data. In most cases, organisations have to pay to receive this data from their energy supplier. Below is a description of costs incurred by NCC in relation to the smart meter rollout and the use of HH data for commodities, i.e. electricity and gas. The following prices described are collected from metering contracts which are managed by the researcher and from private conversations with LASER and the suppliers.

Electricity

The rollout of smart meters in the UK is part of a national programme as explained in 4.3. The suppliers of electricity and gas have the obligation to upgrade meters into smart ones free of charge. These suppliers, from an economic point of view, still need to recover the cost of this programme and this is done as part of the charges on utility bills under the standing charges. These charges vary depending on the electricity profile of the meter; they can be relatively high for mandatory half hourly profiles, and minimal – in most cases zero – for non-half hourly profiles. This said, NCC has still incurred costs for the installation of smart meters for the two types of profiles: mandatory and non-mandatory half hourly.

When a site falls under a mandatory HH profile, it automatically gets a smart meter. In 2011, when NCC was approached by its energy supplier to rollout this technology in the buildings covered by their energy contracts, the organisation could have declined the offer, but while 2020 gets closer those meters will have to be upgraded. All the supplies covered by the offer were non-half hourly and from the financial point of view of the organisation if this rollout programme is going to cost anything, it might refuse it as it is not their statutory duty to upgrade the meters. This is why the offer from the electricity supplier was free of charge in order to encourage organisations to accept it. Nevertheless, during the whole period of the rollout, NCC ended up paying at least £20,000 excluding the cost of a member of staff who was employed full time to manage the programme. This cost covered technical upgrades that had to be made to the electrical supply before the supplier could install the meter. As an example, some sites had very old cables that were too large to fit in the new meters. Other sites had an electricity supply at 400 amps, and additional protection had to be added to the main electrical circuit. Some of these costs should have been paid by the schools, but since there was no previous agreement with them with regard to this programme, and since they did not value these meters and thought that the costs were too high, they refused to pay them and NCC had to incur the cost. This is why, when the ECMT was negotiating the terms of the rollout of the current gas smart meters programme, it made sure that any costs related to the meters upgrade were paid by the supplier. Also, and as part of acquiring the consent of the schools to take part in this programme, the team notified them of the terms and conditions which included that they will incur a cancellation fee if they decide to take part in the programme and then pull out without notifying the supplier once an installation date for the meter has been agreed upon. This means that NCC will have to pay for any cost incurred in relation to their estate only.

Today, all NCC's estate is equipped with smart meters or AMRs unless it is technically impossible to have them, and all of these meters supply half hourly meter readings. However, NCC has to pay a monthly charge to have access to the meter readings.

For mandatory half hourly profiles, there are two costs paid annually by the organisation. The first one is for the settlement contract and is on average around £200/meter/annum; in NCC the lowest charge with regard to this contract is £143/meter/annum, and the highest charge is £300/meter/annum. The second one is the cost for accessing the HH data and is priced at £280/meter/annum. In the beginning of 2017, NCC used to have five supplies under the mandatory HH profiles, but with the introduction of P272, i.e. adding electricity Profile Classes (PCs) 5, 6, 7 & 8 into half hourly settlement, the number of supplies increased to fourteen.

In the same period, i.e. beginning of 2017, NCC had 134 sites which fall under non-half hourly (nHH) profiles. The ECMT and the Property Energy Team both decided that it is beneficial to have HH data for this group of sites and voluntarily decided to purchase this data from the supplier as it makes the energy database consistent since most of NCC's estate will have similar types of data. The cost for having access to HH meter reads was £90/meter/annum prior to October 2016; however, when the contract was due for renewal, the ECMT negotiated new rates and was successful in lowering the cost per meter per annum by half. Additionally, the ECMT pays for this type of data on behalf of the schools which are under the nHH profiles and which are on NCC's energy contract. This is part of the package offered to the schools to encourage them to, first, purchase energy through NCC and, second, to monitor their energy consumption and control their energy cost. It also gives valuable information to the ECMT on the energy consumption of schools that can be used for issuing Display Energy Certificates (DECs) or preparing feasibility studies for energy efficiency schemes without having to request this data from them.

Gas

The contract signed in 2013 for the 27 highest gas consuming buildings defines that the cost for having access to HH data is £95/meter/annum. When NCC's gas smart meters rollout programme ends this summer, NCC will buy HH data for additional supplies, and the annual rate is expected to decrease.

All in all, the cost for having access to HH data for the financial year 2016/17 was around £21k excluding the cost of staffing and the energy management software. The software is partly used for energy monitoring and targeting, and the staff members use the data on a regular basis for achieving this activity, but it is difficult to estimate its cost as the main job of staff members is not to continually monitor energy consumption.

7.2.4. Usage of Smart Meters

Regulatory Requirements

NCC is expected to follow the regulatory and statutory requirements that relate to it. As an example, when P272 was due to be applied (Cf. 4.3.2 for more details), NCC worked closely with its electricity supplier to check if all the buildings which fall under these PCs have meters which are capable of supplying HH data and to rollout smart meters for buildings which do not have them.

Technical Requirements

It has been mentioned in the previous section that one of the main motives to rollout smart meters is to build a database with high-resolution energy data. This data is used to:

- Verify if energy bills are accurate. In case an energy bill is higher than what it was predicted, the Property Energy Team (PET) has meter reads available on the system to check if there was a mistake on the invoice without having to visit the site.
- Monthly monitor and target: the Property Energy Team every year prepares energy budgets for each site. These budgets take into account the historic monthly consumption of the site. Therefore, on a monthly basis, the energy team compares the predictions to the real consumption to see if the latter is higher; if there is a significant difference, the team starts an investigation.
- Spot high energy consumption: the energy teams of the organisation i.e. the ECMT and the Property Energy Team have detailed energy data which can help them with tracking the history of the problem and try to solve it. According to one of the PET members, having this data on the system helps in spotting any abnormal consumption over a maximum period of 30 days. These can be a long period before spotting such an abnormal consumption, but it is still better than relying on energy bills since some of these are estimated and do not reflect the accurate consumption. The energy teams are aware that there is much potential from monitoring and targeting energy consumption more frequently, i.e. weekly. However, this activity is resource intensive and as Figure 29 (Cf. 7.1) shows, both energy teams are small and are already using their human resources extensively; it will be difficult to add this activity to their duties on a weekly basis.
- The detailed energy data is used for preparing business cases for renewable energies and energy efficiency schemes. As an example, NCC started recently developing business cases for installing roof mounted solar PV on its estate and in schools; having profile data, i.e. half hourly data makes it very easy to quantify the base load consumption of the site in order to size the PV system adequately.
- The energy data is used to create Display Energy Certificates (DECs) quickly and easily since the energy assessor can have access to the data just with one click on the energy management software rather than relying on site managers

or energy suppliers to send it to him. This saves time and potentially increases productivity.

- The energy data is also used in different activities such as changing the ownership of sites. Recently, NCC took over the management of some children services sites, and their ownership was transferred back to the organisation. Therefore, the PET had to add their meters into NCC's energy contracts and to be able to do that, a meter reading is needed as part of the application. This process was longer than expected because the energy manager of the PET did not find the time to visit the site whereas if the latter had a smart meter, he could have acquired the metering reading in a very short period.
- Capacity checking: the data is used to check if the sites are over-using or under-using the capacity they have been assigned. If it is the case, energy managers use historic data to identify the real capacity usage and apply to the DNO to change it adequately.

Financial Motive

The financial motive is related to the technical criteria introduced above; an early detection of energy wastage helps in saving money. Also, having data on a system helps save time and money, i.e. example of preparing DECs. This energy data helps in saving time when it comes to preparing feasibility studies for energy efficiency schemes. However, it is difficult to quantify these savings.

Knowledge Share

The energy data is available via an energy management software that can be accessed by any member of staff who has a login. According to the energy manager of the PET, energy stakeholders including building managers or service managers, i.e. budget holders, should all have access to the system because it helps them in viewing their historic and actual energy consumption for energy management purposes. However, do these individuals use the system for this purpose? Do they even know about its existence? Is energy management a practice that energy stakeholders think about? To answer all these questions, the researcher interviewed different members of staff in different job roles and in different positions in the management hierarchy, and the results of these interviews will be presented in the next section. However, the researcher understood, after conducting these interviews, that energy becomes visible and of concern only to the members of staff who hold energy budgets. This impression was also shared by the energy manager of the Property energy team. According to him, even though different energy stakeholders can have access to the energy data of their sites, only a few of them use this access and the reason is that energy is managed centrally by the property team.

Environmental Motive

In the first part of this chapter, it has been stated that the main argument for institutionalising energy management was to decrease the carbon emissions of the organisation. Therefore, it should be safe to assume that all the energy management related activities are performed to decrease the carbon emissions. Though, this is partially true; the main motive is to save energy in order to save money; decreasing the carbon emissions is an indirect consequence. The organisation has an organisational target of decreasing its carbon emissions by 2% year on year (NCC intranet); this has always been achieved and should make the case for proving that the environmental motive is still valid. In fact, it has been stated in meeting minutes of the annual Energy Management Review that the organisation has always exceeded the 2% yearly reductions. This meeting is part of the requirements of ISO50001: 2011 where the EnMS manager needs to report the performance of the EnMS to senior management. The latter achievement is mainly due to the financial motive:

- The Energy and Carbon Management Team (ECMT) generates income by charging a management fee on energy efficiency and renewable energy projects. Therefore, the more projects it implements, the higher the income.
- The Property Energy Team (PET) decreases its energy expenditure through these projects.

7.3. Perception of Energy Management by Different Energy Stakeholders in NCC

7.3.1. Introduction

It has been stated under 6.3.2 that energy is currently managed mainly centrally in NCC by two teams. The ECMT is responsible for setting the policy, procuring energy, financing energy related schemes and running the EnMS, whereas the PET is responsible for energy related facilities management like maintenance and setting hours of use of different energy consuming electronics, i.e. boilers, paying energy bills, etc. This explains why the score related to communication on the NCC's energy matrix is low since the energy management practice is implemented only by a few members of the organisations; mainly the ones highlighted on Figure 29 (Cf. 7.1).

The researcher has interviewed energy managers from both teams to describe, in their own words, how energy management is practiced in the LA and to understand if they perceive any advantages from this central model of energy management. However, there is a need to identify if other energy stakeholders in NCC share the same views. Additional members of staff from within the organisation and from schools have been interviewed since these constitute a major client of the organisation and had recently been part of NCC. These members of staff have also been interviewed to set the scene for energy data usage. The information collected from these interviews has been and will be used in conjunction with that collected from other interviews with NCC staff members (i.e. the Head of Energy & Carbon Management, energy manager of the PET and the ex-energy contracts manager) and which was presented throughout the 2nd section of Chapter IV. Nine members of staff were interviewed with follow up interviews and informal chats with staff from both energy teams. The interviewed members of the organisation are as follows:

- Councillor and Cabinet member, NCC
- Site Manager of a care home, Olympus Care
- Senior Energy Assessor, NCC
- Operations Manager, academy trust in Northamptonshire
- Manager of an adult residential college and conference centre, NCC
- Energy Consultant, NCC
- Business Manager, school in Northamptonshire

The researcher also tried to interview the manager of one of the major libraries in the County and the facilities manager of the Fire Services; however, both declined. The manager of the library stated she was very busy with extreme short staffing in libraries and added:

> *"I'm not sure how much I would be able to help you with your research as I don't know much about the energy usage at [name of the library] Library other than where the meters are when we are asked to provide usage data"*

The Fire Services facilities manager declined the invitation to take part in this study because he also stated that he was busy looking after some Police buildings as there is a high chance Fire services will leave NCC and join the Police to become one organisation.

Finally, the researcher focused on this type of energy stakeholders and not on building users for two main reasons. First, and as it has been presented in the previous chapters, the focus of this thesis is energy management; this is why the researcher focused on interviewing key energy stakeholders. Second, the individual impact of buildings users on the energy usage is small unlike that of energy managers. The researcher acknowledges that the aggregate impact of all staff members can have a great impact and this can be controlled by many measures like behavioural change campaigns. These can influence the behaviour of the building users in regard to energy in order to achieve energy savings but these are not the focus of this research.

> *"Many people in your organisation can have an impact on energy consumption. Some of the key people will be technical staff - maintenance staff in control of boiler plant, process engineers or building managers. Others will be general managers such as departmental heads responsible for managing and motivating staff or for controlling budgets that include energy. Although most staff only have direct control over a small amount of energy use, together a change in their general behaviour can have a large aggregate impact on consumption."* (Building Research Energy Conservation Support Unit, 1995, p.7)

7.3.2. Discussion about Central Energy Management

According to the energy manager from the Property energy team, only a few members of the Council have a relationship with energy management. This is mainly due to the fact that only a few members of staff hold energy budgets. Energy is procured centrally by the ECMT and mostly paid for centrally by the Property energy team except for schools and some minor sites. This energy manager pays most of the bills, then recharges the respective departments like Fire Services, Adult Services & Olympus Care, Libraries, etc. Most of the time, these departments do not ask for details related to the charges. However, there are a few departments which ask for their energy data to keep track with their expenditure and one of them is Fire Services. Unfortunately, the researcher could not get enough detail about how the shared energy data is used by the facilities team under Fire Services, but a phone call with one of their team members confirmed that the data is used purely for knowing the energy consumption of the buildings occupied by this service.

The energy manager from the Property Energy Team (PET) adds that a few years ago, most large buildings of NCC had site managers or care takers and some of their duties were to take meter reads, report any energy related problems, set the timing for the heating systems, etc. These members of staff have now been replaced by a contract with a company which takes care of the hard FM, i.e. facilities management of the organisation (heating, lighting, ventilation, etc.). This means that while the organisation acquired good expertise to maintain its buildings, it has lost its direct contact with the buildings and now relies on members of staff to report any energy related problem to the Help Desk who will then open a query, investigate it and call the contracted company if an on-site intervention is needed. The same energy manager believes that having a company that employs skilled technicians is very useful especially that currently NCC does not have personnel that are capable of performing these tasks and certainly the site managers or clerks used to lack these skills; meaning that the contracted company is providing services that could not otherwise be delivered. This company is responsible for planned and reactive maintenance. The energy consultant believes that hiring contractors will lead to the disappearance of knowledge related to energy systems. For instance, this engineer has worked for the organisation for almost 30 years and was an energy manager for the PET before his retirement, but he is currently brought back from retirement as a part-time worker since he has extensive knowledge about the energy systems as he was part of the team who developed them. He describes himself as cost effective since he is cheaper than a contractor and can find problems with the systems easily since he knows them very well and knows their history. Though, he also believes that the organisation does not value knowledge share. In other words, members of staff should have been employed before his retirement so that he could share with them his knowledge and they can replace him once he leaves the organisation.

The consultant engineer believes that it is good to have a contracted company with skilled members of staff, but to make their work effective, an energy saving clause needs to be added to their contract. NCC used to have such an agreement with a company which was managing energy and maintenance of the maintained schools in Northamptonshire. The company was penalised every year if it did not meet its energy efficiency targets. Unfortunately, the penalties were not high, and it was easier for the company to pay the penalties than implementing adequate schemes. The consultant engineer adds that these companies need to be supervised closely, but it is difficult when the organisation has a PET with only one full-time and one part-time member. For example, if a building is becoming cold, the contractor might just extend the heating hours or increase the temperature rather than investigate the problem. Another example, in the past, this member of staff used to go to the maintained schools at night and check if lights were left on; if it was the case, he would then report it to the company that manages this type of schools.

Another example of central energy management is when NCC replaced ten office buildings by a main headquarter where heating, ventilation, lighting and windows opening is centrally automated and members of staff cannot interact with it. One of the reasons for building this headquarter is saving energy and current consumption figures show that it is currently successful in achieving this goal as it is consuming less than the consumption of one of the ten buildings. The consultant engineer believes that this is a good example of energy management since it is difficult to please every member of staff. As an example, in one of the buildings that is now sold, when a member of staff feels cold, they would contact the help desk who will then instruct the site manager to turn the heating on. Other members of staff may feel warm and by walking around the buildings, one can notice windows open while the heating is on which is a waste of energy.

7.3.3. Role of Site Managers

One of the interviewees, who is the operations manager of an academy trust in Northamptonshire, believes that it is difficult to get hold of site managers or clerks for helping with energy management since they are very busy doing other work and energy is not a high priority for them. The energy consultant of NCC who used to be an energy manager for the organisation adds that energy management is a low priority for caretakers who lack the required knowledge in relation to energy management and even if given the adequate training, these members of staff have low paid jobs which they often leave when they are offered another job with a higher hourly rate, which means that the organisation will put resources into training a new site manager. Though, the consultant gave an example where a problem was spotted in one building after he consulted its energy data and needed to check if his assumption was right and he had to visit the site. If there had been a site manager on site, it would have been easier to get hold of them and task with making the necessary checks. The site manager of an adults' care home also confirmed that his main role is DIY; he understands what energy management means but has no interaction with it. He does not do any monitoring or targeting of energy consumption and has never heard of the energy management software that he can access in order to check the energy data of the site. For example, when changing burnt light bulbs, he always tries to replace them with LED bulbs because he knows that it helps with saving energy. This site manager has already finished his building trade training, and owns his own company – in parallel to this current job with NCC- and believes that it is beneficial to have a site manager like him on site because they can fix problems quickly and can save costs compared to calling contractors for doing these works. As an example, if a tap is leaking, it is easier and quicker to fix the leak himself compared to buildings where there is no site manager and the leak might or might not get noticed by a member of staff who might or might not report it to the Help Desk who will then need to send for the contracted company to fix it. This site manager contacts the helpdesk only when he does not have the necessary skills to fix a problem.

7.3.4. Energy Management Case: Manager of a Service Holding an Energy Budget

Over 15 years ago, few service managers chose to be responsible for the management of the operational aspects related to their services including the energy budget. However, they still have to procure energy for their sites through NCC to ensure that they are benefiting from low tariffs. The researcher interviewed one of these managers who is responsible for an adult residential college and conference centre which falls under one of the federated bodies of NCC. The centre provides meeting catering and sleeping rooms. This is a listed building owned by the LA but the federated body has a yearly contract to use it for income generation. This site is relatively old and has been facing many energy related problems over the last years, mainly related to its boilers.

The manager of this site has an income target and one way to achieve this is by decreasing expenditure. With the help of the site supervisor, the energy use is monitored closely to see if it meets the budgets and for this purpose they use the meter reads they take regularly from the fiscal meters on site. It is not always easy to take meter readings as they are outside and the water meter is on another property. Additionally, human error can occur when taking thee readings. As an example, the site manager took a meter reading for the water meter and when the interviewee (i.e. the manager of the adult residential college and conference centre) used it to check if the consumption is close to what was budgeted, he was surprised to find that the consumption was way over suggesting a major leak. He decided to send two members of staff to read the meter again to double check the meter reading; they found that it was just a meter reading error and that there was no water leak. Additionally, every day, the manager and his site manager go around the building to check if any heaters or lights are left on. Some of the buildings only have electric storage heaters which cannot be controlled centrally. This is a resource demanding task since the duty managers always need to check the schedules of usage for each room in order to see if they need to keep the heaters on overnight or not or when to turn them on/off. All this shows that the energy consumption is monitored in a "juvenile, soft and non-scientific" way as the interviewee described.

Getting hold of and managing the energy budget means that the manager is responsible for the maintenance of the energy infrastructure on site and any related costs. The manager can still have access to NCC for help and advice, but he is responsible for paying the maintenance cost when a problem occurs. At the time of the interview, the site was having a problem with one of its boilers and the manager will have to pay for a replacement putting his budget under stress. The manager is also free to use the contractors he wants while he still follows the procurement rules imposed by NCC. Though, the interviewee prefers to contact Property members of staff with whom he held good relationships rather than going through the help desk since he believes he can get good advice quickly and easily. The interviewee, for instance, has in many occasions contacted the ECMT or the consultant engineer working for the energy team under the Property Team - who is also interviewed as part of this case study – because he holds important knowledge about the site.

Last, and in relation to centralised energy management, the manager thinks that there are days when he is happy he made the decision to take control of the energy budget because any savings he makes helps directly with his income target. Whereas, if the Property department was holding the budget, any savings he makes go directly to Property. However, there are days when he regrets the decision especially when a major energy infrastructure breaks and he has to find the resources to fix it. The manager thinks that it will be helpful if he can keep his energy budget but at the same time have access to NCC's contractors to hire because their rates will be very competitive. After all, he is managing a site that is owned by the authority.

7.3.5. Energy Data Access and Usage across the Organisation

Any employee working for or on behalf of NCC and who has an interaction with energy management can have access to the energy management software to both input the meter reads of their site and use the system for energy monitoring and targeting. Schools can also have access to the online platform of the system to upload or download their energy consumption. However, it appears from the discussions and interviews that the researcher had with different members of staff that not all of them are using this tool for monitoring energy consumption. The example of the manager of the adult residential college and conference centre is one example. He mentioned that the way he monitors the energy consumption of his site is *"juvenile"* - as he describes it - but he can have access to the software and view the hourly consumption of the site and use different tools to generate different reports, etc. Another example is the manager of the library who said that the only interaction she has with energy management is supplying the meter reads. A third example is when the energy manager of the Property energy team sends a monthly report to Fire Services which details the energy consumption of their sites. The facilities management of the service can have access to the system and prepare this report. In NCC, there are only five or six individuals who continuously use the software and among them are: the energy manager of the Property energy team, the consultant engineer, the energy assessor and the energy contracts manager, i.e. the researcher.

The researcher, thanks to his job position, is aware that many schools use the system for uploading the energy meter reads and also for viewing their energy consumption. As a matter of fact, when the energy assessor visits the schools for issuing DECs, he introduces them to the software, and if they are willing to use it, he then creates an account for them on the online platform of the software. The school business manager interviewed through a questionnaire as part of this case study stated that she uses the software to view the energy consumption of the site which is reported to the governors and benchmarked with other schools. This is an example of a school that tries to be as energy efficient as possible:

"*Staff are diligent in switching off lights and heaters when rooms are not in use, the building is not heated during holiday times, set to frost protection only*" (school bursar).

7.3.6. Cabinet Role in Supporting Energy Management

The reason for this interview was to understand the role of Cabinet (Cf. 6.2.2 for more information about Cabinet duties) in energy management and in decision making around different projects related to this practice. The Councillor explained that the role of the Cabinet is to direct and assist managers in their roles. As an example, when it comes to energy management, the Cabinet Member, i.e. the interviewed Councillor, is not the expert in relation to this practice but the Head of Energy & Carbon Management who is hired to fulfil this role; this is why this latter has the support of the Councillor responsible for his portfolio which also includes facilities management. According to the Councillor, the ECMT is cost neutral and brings additional income to an organisation that is striving for it. Therefore, the ECMT under its current model saved the Cabinet from the hard decision of whether it should fund an energy team or not. Both individuals meet regularly so that the cabinet keeps informed and updated about projects, achievements and struggles. When it comes to voting on projects and decisions, the Councillor always meets with the Head of Energy and Carbon Management; this latter will present the business case that will be used by the Councillor to present the project to the Cabinet.

The Councillor confirmed that energy management is an example of good practice that the organisation uses since it represents public services and is the biggest employer in the County and therefore has the moral obligation of leading by example when it comes to energy efficiency and decreasing carbon emissions. The Councillor is also supportive of centralising energy management and taking control away from users because it helps in saving money. He gave an example of lights being automatically turned off when there is no movement in the building because it is inexcusable to have lights on during the night when the building is empty and adds that this might have been the case in many buildings in the past.

The researcher took this opportunity to ask why the organisation is not implementing large renewable energies projects and the Councillor stated that NCC is looking at building a large energy from waste facility. The Cabinet is open to any ‘invest to save’ scheme but there might be cases where resources need to be allocated by order of priority; he added that he would love to see solar farms and roof mounted solar PV.

7.4. Conclusion

This chapter dealt in detail with the Energy Management System (EnMS) of NCC to identify its weaknesses and strengths. It has also looked at the motivation behind enrolling the smart meters and similar technologies, using them for generating half hourly data and how this is used for energy management.

The chapter has presented not only the perception of the major stakeholders of the NCC’s EnMS but also the view of the other stakeholders. It has also looked at how energy data is used by different employees who have an interaction with energy management.

Key findings have been that energy is mainly visible to the managers who pay the bills and energy management can save money and generate income. Additionally, NCC has prioritised capital investments in equipment and fabric over behavioural change campaigns.

Additionally, even if the overall management of the Council has been strongly criticised in the first months of 2018; the energy management model in NCC can be an example of good management and good governance clearly demonstrated by the continuous energy consumption reductions and holding the ISO50001: 2011 standard.

The next chapter will be devoted to discussing the case related findings from Chapters IV, V, VI & VII.

VIII	Energy Data Management for shifting towards a Smart LA	
	To discuss the findings and create a Smart Energy Management framework for LAs	- In-depth review and analysis of the findings - Researcher reflections

Chapter VIII: Energy Data Management for Shifting towards a Smart Local Authority

8.1. Introduction

In the first chapter, the researcher asked the question if ‘Smart’ means relying heavily on systems to collect, analyse and process data and automatically make the necessary interventions, or whether it can have another meaning that includes human interaction. To answer this question, the researcher explored how half hourly energy data is used in general through a literature review and in a specific setting which is a Local Authority (LA) through interviews, questionnaires and a case study with energy managers and organisational energy stakeholders in order to address - at the same time and in parallel - one of the objectives of this thesis. A Smart City relies on different types of data which are fed by different systems in a manual (by humans) or automatic (by sensors) way to get insight on different aspects which has an effect on urban life (Cf. 1.4). This study has focused on local authority which is a smaller setting, compared to the size and complexity of the city, and on a specific aspect of the LA which is energy management in non-domestic buildings. This overlaps with the current job position and expertise of the researcher and closely links with smart meters and Automatic Meter Readers which can be viewed as one of the sensors that the Smart City relies on and which are used to collect specific energy data like instantaneous energy consumption. The study has presented how this energy data is collected and how it is used. In this chapter, the researcher looks at what makes it ‘Smart’; is it the type of data, its collection frequency, how it is used and, or, for which purposes? The researcher is aware that it is necessarily to look at energy data within energy management and the legislative context of the UK, in order to make sense of it. This explains why the data collection tools used on this research also focused on asking questions in relation to this practice. Having access to half hourly energy data does not necessary mean that the energy management culture of the organisation is strong but may only be a direct result of statutory requirement, i.e. data collected under mandatory half hourly settlement.

This chapter analyses the information presented in Chapter IV (i.e. literature review), Chapter V (interviews with main energy stakeholders from different types of local authorities) and Chapters VI and VII (case study of Northamptonshire County Council) in order to derive the main findings of this study.

8.2. Smart Meter Roll-out in Local Authorities

8.2.1. Motivations

Numerous financial, technical, environmental, legal or knowledge sharing motivations have been summarised under 4.9, for LAs to opt for rolling out smart meters and similar technologies in their buildings' stocks. However, this study has found that the interviewed representatives of the LAs had three main motivations for smart meter roll-out with the dominant one being legislation and statutory requirements. The two others are technical and financial motivations (Figure 30):

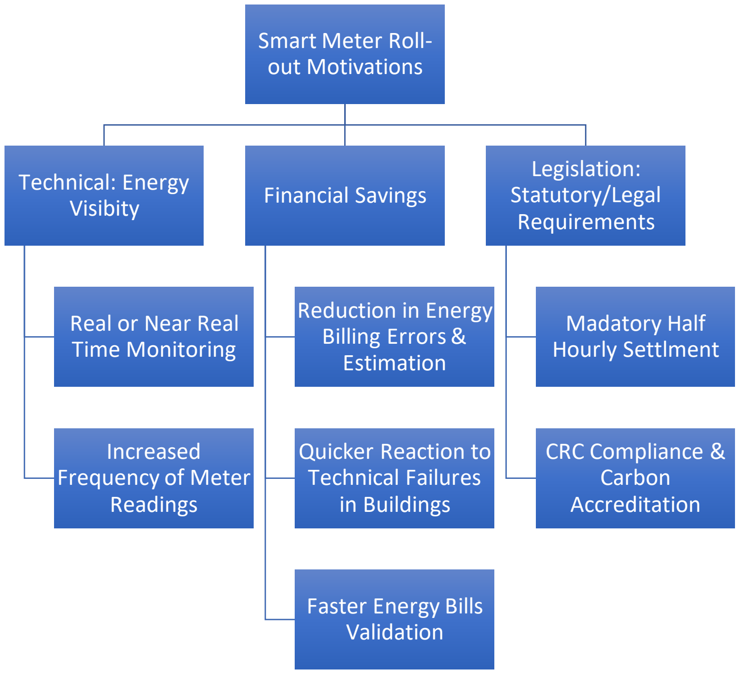


Figure 30: Primary Motivation for Smart Meters Rollout by Interviewed Local Authorities

The environmental motivation is missing in Figure 30 from those highlighted in Chapter IV. This can be explained by the fact that energy managers are primarily interested in saving money or at least delivering to their budgets, and this can be achieved through saving energy which automatically leads to cutting carbon emissions; it is easier to build projects and business cases around financial figures than energy or emission ones as they make more sense to different LA stakeholders who are in a managerial position, i.e. senior management, the Cabinet and the Council, who do not necessarily have a background in energy management.

The other motivation missing from Chapter IV is knowledge share. This has been highlighted in one of the interviews, with the representative of Cherwell District Council, but was not a main motivation. Having a system that records half hourly energy data of a specific site and having access to it by different staff members helps knowledge sharing. Other interviewees focused on gaining knowledge of the consumption profiles of sites to inform their decision making about capacity charges, schemes to develop and implement and time of use. In this instance, knowledge share is just a synonym for energy visibility and was highlighted throughout Chapters IV, V, VI & VII as one of the main motivations for LAs to rollout smart meters.

Legislation Related Aspect of the Rollout

The Statutory requirements meant that:

- LAs had no choice but to accept the roll-out of smart meters and AMRs in their stock of buildings which fall under mandatory half hourly profiles.
- Energy managers from these LAs had the opportunity to get acquainted with this new technology and see for themselves if it can bring any additions to the way they work.

Legislation and statutory requirements can be viewed as an enabler for a comprehensive roll-out of this technology in all LA properties regardless of which electricity settlement profile they fall under. However, this was not the case. As an example, one of the interviewed LAs, (NELC), had this technology rolled out only for their mandatory half hourly sites, and they chose not to have it for the remaining sites because they thought it would cost them money. It was only when the researcher advised one of the energy managers that the legislation made it clear that it is the obligation of the supplier to install smart meters to customers at zero cost that the authority thought about having them for their non-mandatory half hourly sites. In other cases, local authorities rolled out this technology because they had a chance to try it and explore the benefits by themselves. Other examples showed that it was one of the tools used for Carbon Reduction Commitment (CRC) compliance. So why have the legal requirements potentially failed to push for a voluntary mass roll-out of smart meters for non-mandatory half hourly sites? This study, and a paper by Azennoud et al. (2017), analysed the process for rolling out smart meters and AMRs in two LAs and looked at the impact assessments of the UK's smart meter rollout programme which were published by Department of Energy & Climate Change (DECC) (2014), now the Department of Business, Energy & Industrial Strategy (BEIS), and came up with the following findings:

- Northamptonshire County Council, incurred costs while installing electricity smart meters in its portfolio of non-mandatory half hourly sites. This is why when it came to roll out gas smart meters it chose only to do it for major gas consuming sites. Additionally, when the gas supplier made an offer for rolling out the gas smart meters for the rest of the portfolio, one of the contractual conditions was to ensure that the authority will not incur any costs in relation to the installation of this technology.
- Smart meters are installed for mandatory half hourly sites and managers of those can have access to them, however often no training is provided to these members of staff on how to use this data. As an example, the only time members of the energy teams of NCC were offered training by their electricity supplier in relation to accessing the half hourly meter reads, and how to use them, was when they were negotiating a contract for their non-mandatory half hourly sites almost four years after the start of the organisation's electricity smart meter roll-out programme.
- One of the main goals of the UK's smart meter rollout programme is to enhance Demand Side Response (DSR). Energy producers and suppliers and Grid managers nowadays have more information on their customers' consumption. Additionally, for non-mandatory half hourly sites, if the customer chooses not to pay for receiving the half hourly meter reads, the supplier still installs the smart meter but does not share any data with the customer. This suggests that the focus of the programme is not the customer but the upper part of the supply chain which includes producers and suppliers who will use this data to optimise their production of energy. The benefit for customers is accurate billing of their energy consumption.

The UK's programme could have put more effort into designing a parallel programme for training customers to use the collected energy data by smart meters. Customers pay yearly for the data for half hourly sites and it can be viewed as a loss if they are not benefiting from it.

Financial Aspect of the Rollout

The financial aspect is seen, at the same time, as a motivation or enabler and as a hindrance for rolling out smart meters in LAs buildings portfolios. Despite this, when it comes to their advantages, most of the interviewed energy managers perceived it as a tool that can be used in parallel with others to either monitor consumption or to develop feasibility studies and energy related schemes. However, only one authority, Leicester City Council (LCC) developed an 'invest to save' programme that is focused on the use of smart meters. This explains why the organisation has two sets of smart meters in most of its buildings: the fiscal meters which were upgraded into smart ones by the supplier and separate smart meters that were installed as part of the 'invest to save' programme more than 10 years ago. This is an example where the legislation and the UK's smart meter programme did not take into account the existing infrastructure at customers' premises. In this case, and for mandatory half hourly sites, LCC is paying for two systems which are more or less providing the same data.

As a result, for the majority of the local authorities contacted, energy managers do not have a clear perception about how to use smart meters to save energy. In other words, the managers either do not understand how to develop a feasibility study that involves building a case for rolling out this technology to monitor energy and achieve savings, or they believe that the savings are not guaranteed and it is better to invest in another technology which will have straightforward energy saving mechanisms, i.e. upgrading lighting to LED. In fact, smart meters just became an ordinary tool that is fundamental to energy management and which enables high resolution visibility of energy consumption. In addition, for mandatory half hourly profiles, the cost of smart meters and half hourly data collection is included in the electricity bill which means that it might not even be considered by the energy managers since it is seen as a cost to purchase electricity. As an example, in NCC, when energy managers from both energy teams of the authority talk about the cost of half hourly data, they indirectly infer the cost of data for non-mandatory half hourly sites because they receive a yearly invoice for this service. This means that LAs which do not have this arrangement for their portfolio of non-mandatory half hourly sites might not even be aware of the cost of smart metering.

The following sections explain in detail the highlighted financial benefits and constraints.

a. Benefits

This research has explored many financial advantages that can enable or encourage energy managers in LAs to rollout smart meters for their portfolios of buildings especially for non-mandatory half hourly buildings; these are:

- Ability to check accuracy of energy invoices: energy managers have instant access to their meter reads and can check if the quoted consumption is correct or not.
- Reduction of billing errors: since the rollout of smart meters, the number of credited invoices decreased because suppliers rely on meter readings automatically sent by the smart meters. This means that there is less confusion and less time spent on bills verification. As an example, the researcher came across a school that did not have a smart meter, and their invoices were estimated. To receive an invoice based on actual consumption, the school manager had to provide the supplier with a meter reading before the 25th of the month. If this deadline is missed, the supplier still sends an invoice that is estimated which will be later credited when the school manager sends meter readings at a later date. This created a lot of confusion for the school, and much effort was required to solve the financial queries related to their account. Additionally, energy managers claim that they spend less time on queries related to the energy bills of commodities equipped with a smart meter since they have access to a history of half hourly meter reads they can consult to get a better insight into the consumption of the site.
- Decrease in labour cost: energy managers do not need to employ members of staff who should go around sites and take meter readings each month. It is

difficult to check if the savings are associated with this aspect or not as these members of staff have many other tasks associated with their job and taking meter readings is only one of them. This point is valid in the case of NCC where it had a member of staff who was only responsible for logging the meter readings received from clerks and site managers to the energy management software. Additionally, in order to have a fair comparison, when an energy manager pays £50/meter/year to receive half hourly meter reads, it is a great saving since having staff members working 24 hours a day all year round to take half hourly meter reads will cost much more.

- Early detection of energy losses: having access to meter reads on a frequent basis means that energy losses can be detected early. There are energy teams in the LAs which participated in this study which perform monitoring activities on a daily, weekly, by-weekly and monthly basis by comparing actual consumption to budgeted consumption (Cf. Table **7**). In some cases, there are teams who have energy management software which can help them with setting alerts and which will automatically monitor consumption and alert the energy manager when it is unexpectedly high. One can say that detecting energy loss by monthly monitoring cannot be described as early detection especially if the fault occurred at the beginning of the month and was spotted at its end. However, in many cases, there are sites which in the past, and before the rollout of smart meters, did not have their meters read on a frequent basis meaning that it was impossible to undertake even monthly monitoring of their energy consumption.
- Ease of performance of energy monitoring against energy budgets: this relates to the previous point; thanks to smart meters, it is possible to have frequent monitoring of energy consumption with accurate data.

These financial benefits also have indirect financial savings which are linked to time saving, staff efficiency, less queries to investigate and more automated processes.

b. Constraints

Two types of constraint have been highlighted by the study: one is in relation to the technology itself and the other one to the aftermath of rolling it out.

The first constraint entails the following series of costs:

- Cost of rolling out smart meters: in the past there was a significant cost associated with this activity. Some local authorities had to use capital investments to rollout their own smart meters or to cover the cost of the programme led by the supplier. Nowadays, if LAs have a centralised energy contract; i.e. if they have a large portfolio of buildings as a client to a supplier, the latter can rollout this technology at their own expense. However, there are still some costs associated with it as energy managers have to put time and efforts into preparing the list of buildings, coordinating the installation with site managers and making sure that the installation works won't cause major disturbances especially when rolling out gas smart meters, etc.
- Cost of Settlement, Data Aggregation (DA) and Data Collection (DC) contracts: it has been mentioned in 7.2.3 that there are two annual costs associated with mandatory half hourly profiles in addition to the cost of the energy consumed and its related charges. The first one is the cost of the settlement contract and the second is for accessing the meters which is also known as a DA/DC contract; on average, in NCC, the cost is around £480/meter/annum. This is a cost that cannot be avoided since it is related to mandatory half hourly profiles, which means that it is part of the electricity settlement code.
- Cost of data availability for non-mandatory half hourly supplies: in the case where a site under these profiles is equipped with a smart meter, the energy manager can choose to pay for receiving the half hourly meter reads on a specified periodic basis; this means that they will need to pay for this arrangement. If they choose not to, then they will still have the smart meter but the data will only be accessed by the supplier and the only benefit to the customer is that their bills will be based on accurate meter readings.
- Cost of an Energy Management System: energy managers argue the need for software that can automatically store the meter readings and which can provide different tools to analyse and manipulate the data for specific purposes.

- Cost of labour: managing the rollout programme, the analysis of energy data either manually or using software requires human resources which come at a cost to energy teams.

The second constraint concerns the actioning of findings relating to energy monitoring and data analysis activities. These findings can be actual energy losses or peaks in consumption due to a more frequent usage of a building and require staff members to investigate, and in the case of energy loss, put more efforts into identifying the source and solving the problem.

Figure 31 summarises the financial advantages and constraints facing the rollout of smart meters highlighted by the LAs interviewees:

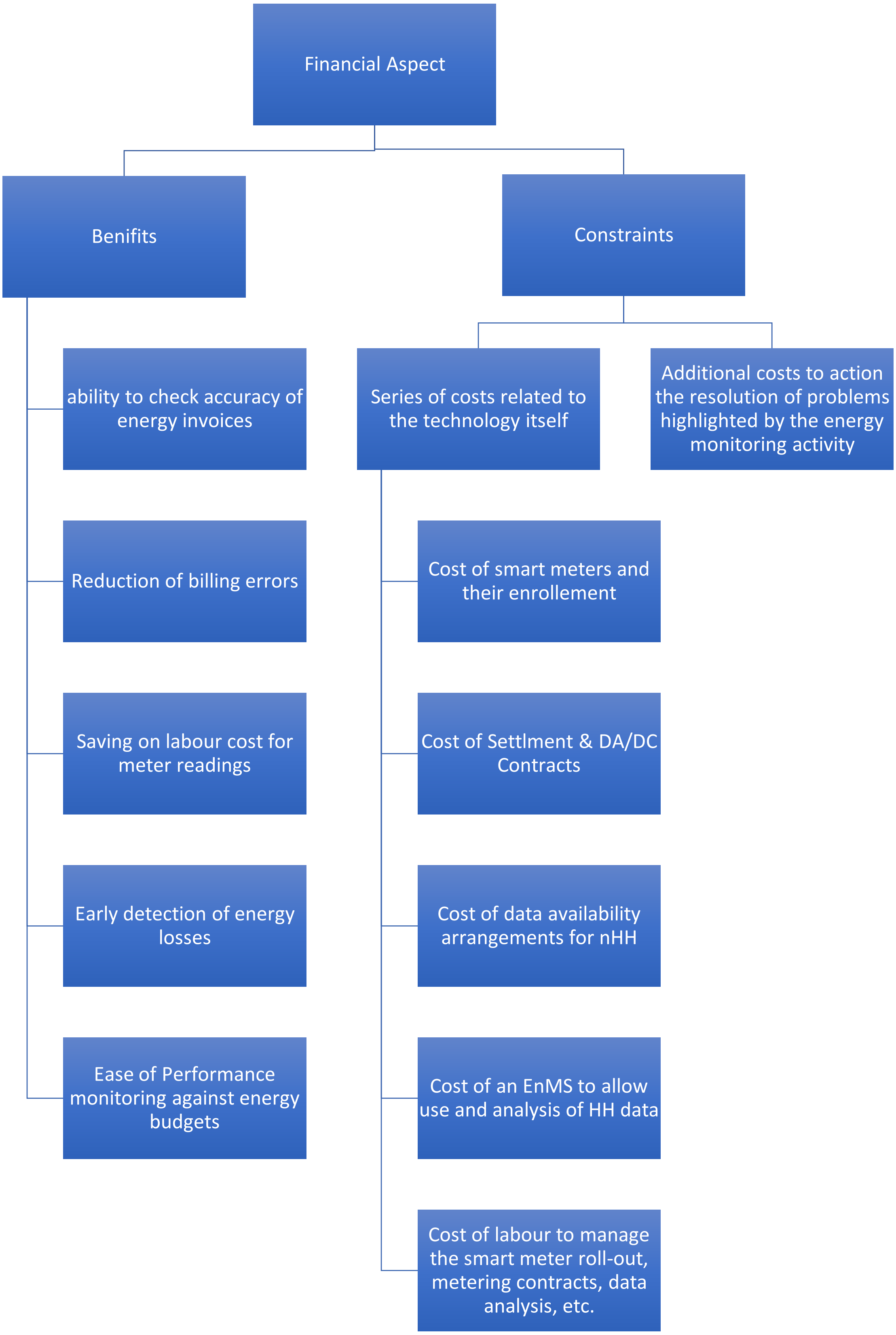


Figure 31: Financial Aspects of the Smart Meter Rollout

Technical Aspect of the Rollout

The technical aspect of technology was also a major inhibitor in some cases for motivating the energy managers in the interviewed LAs to rollout smart meters in their estate.

a. **Benefits**

The research identified more advantages than constraints:

- Quicker reactions to technical failures: this means that the smart meters, through their generated data, will help energy teams detect failures at an early stage if they are looking at the data on a regular basis or have a system of alerts set on their energy management software. One example can be a solar PV panel that is not generating energy and which should be investigated. This was also highlighted as a financial aspect since the result of investigating a technical failure and fixing it can reduce considerably financial losses.
- Ease of preparation of energy efficiency and energy generation of feasibility studies: the half hourly data provides a view of the profile consumption of a building and can be used to prepare more accurate feasibility studies for energy related schemes. As an example, in NCC, the data helps in knowing approximately when a site opens and closes by looking at half hourly electricity consumption; this enables the defining of operation hours with greater precision and can be used to calculate the energy savings from upgrading the lighting and the payback period to verify if it is financially a good decision to invest in the scheme. Another example from the same LA is when the half hourly data is used to define the base electricity consumption in order to size a solar PV system to maximise the use of the energy generated on site and minimise the energy export.
- Ease of running energy audits and collection of energy data: the data is automatically collected and can be used by different stakeholders and for different purposes unlike when, for example, a site is equipped with a data logger. The data generated cannot be used by the energy supplier for half hourly settlement as there are specific requirements for this purpose.

- Ability to monitor capacity charges and time of use: profile data gives a high-resolution view of the energy consumption. Energy managers can know in detail how much energy a site is consuming and when it is consumed and can try to develop solutions to shift the energy consumption to periods of the day when the capacity charges are low; consuming electricity at a peak time is more expensive than any other time of the day.

b. Constraints

Two technical challenges have been identified, these are:

- No in-depth energy data: although smart meters provide high-resolution data, this can be useless in some instances especially when the site is big with different electricity consuming systems and the energy data is showing an electricity loss that is hard to detect. The solution will be to install data loggers for every system or a smart sub-meter to get a higher resolution of the energy data.
- Need for software to analyse the profile data: smart meters generate a lot of data, and it is difficult for an energy manager to analyse it with the use of software especially when they are managing a large portfolio of buildings. There is a range of energy management software in the market but only a few of them actually enable active monitoring which costs more. This is a cost that can be difficult to justify especially if the energy savings from the monitoring activity are not guaranteed.

Figure 32 summarises the technical benefits and constraints:

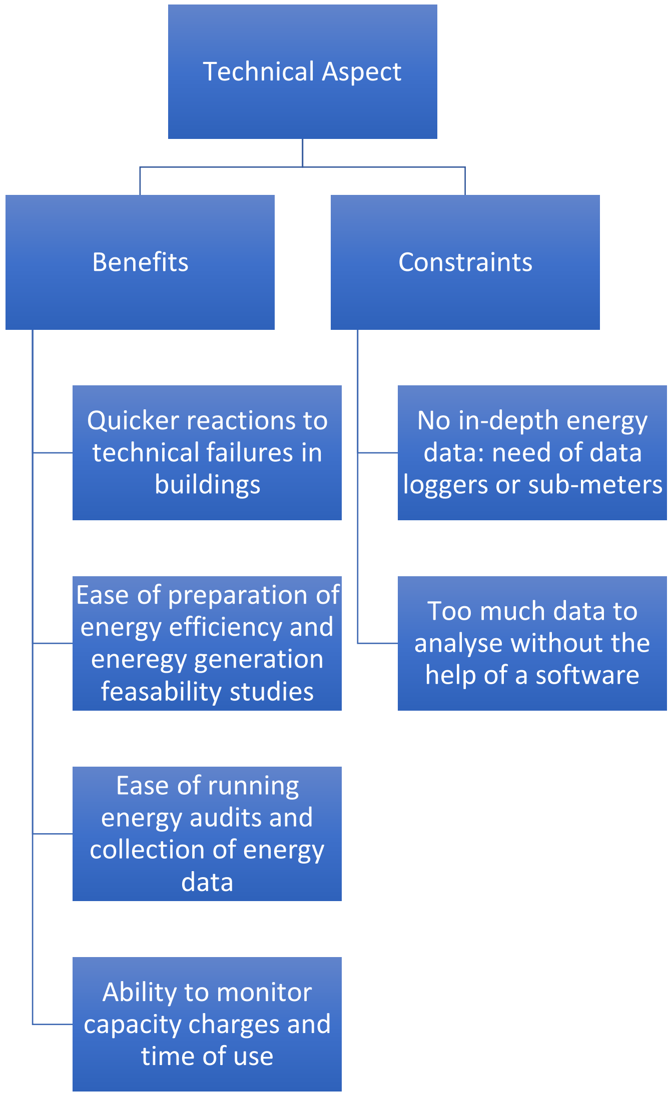


Figure 32: Technical Aspects of the Smart Meter Rollout

Energy Visibility

Interviewees found the technology useful for making energy more visible in buildings. The sections below summarise how visualising energy data, especially half hourly data, is used by the interviewed energy managers for both energy generation and consumption:

a. Energy Generation

The following aspects have been highlighted as advantages associated with energy visibility for energy generation technologies:

- Efficiency monitoring of installed technologies: smart meters are used to collect high-resolution data for the energy generated, which helps in monitoring the efficiency of the schemes and verifying if they are delivering the intended results.
- Feed in Tariffs (FiT) claims: the collected energy data is used for claiming FiTs, though this can also be achieved by using monthly readings. The only advantage is that there is no need to visit the sites with renewable energy generation schemes to take the readings since they are sent automatically sent by the meters.
- Apparel monitoring: half hourly data can be used to check if the installed technologies like PV, for example, are working or not. This can be done by comparing the generation to the installed capacity and taking into consideration the weather situation which can be used as a rule of thumb for more accurate results with the half hourly data analysed and benchmarked to historic energy generation data of the same installation.

b. Energy Consumption

The identified advantages associated with energy visibility for energy consumption are early detection of abnormalities in consumption, monitoring of daily consumption and capacity usage and increase of frequency of receiving meter reads. All of these advantages have been discussed earlier in this chapter.

Figure 33 summarises how visualising energy data is used for both energy generation and consumption.

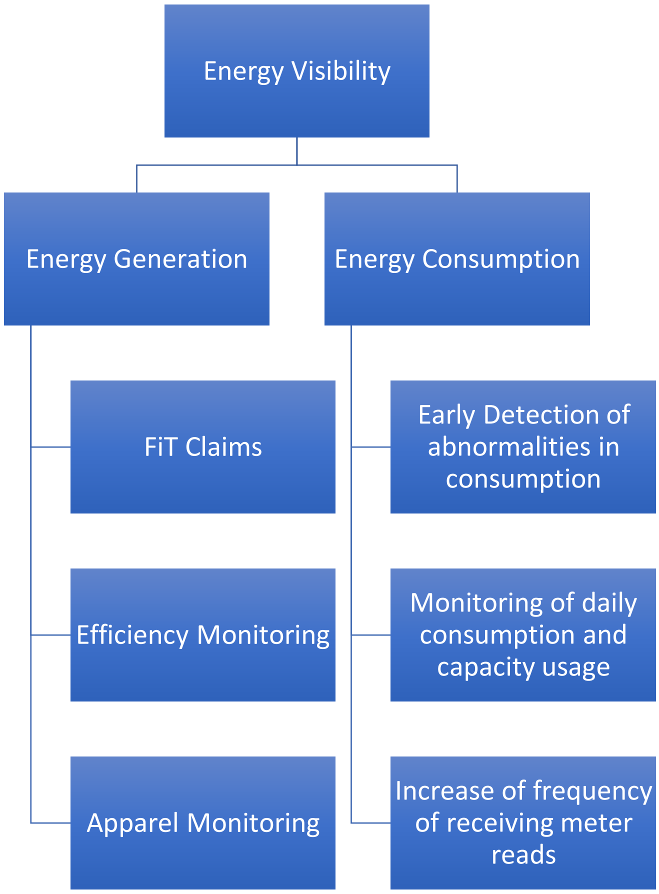


Figure 33: Associated Advantages of Energy Visibility

Real or Near Real Time Energy Monitoring and Targeting

The researcher has also explored if energy managers in the interviewed authorities apply real or near real time energy monitoring and targeting as one of the aspects of Smart Cities or Smart Systems is their ability to make real time monitoring possible. The research has tried to identify if this is something done in LAs, or at least has been thought of, or to identify the reasons making this difficult to implement. Only one interviewed LA's energy manager, Leicester City Council (LCC), performs a near real time monitoring and targeting; in this case day+1 to all its smart meters which are used for gas, electricity, water and district heating. Another LA, Kent County Council (KCC), has the same arrangement but only for its three biggest Council buildings.

a. Benefits

One of the perceived advantages of real time monitoring is its ability to give a fast and instantaneous view of energy consumption across the whole estate portfolio or in specific buildings. The second advantage is when it is used to continuously monitor energy data to identify any unexpected increase in energy consumption which will be investigated in order to eliminate any energy wastage.

b. Challenges

Many challenges to real time monitoring have been identified and some of them have already been discussed in the previous sections of this chapter:

- Time and resource intensive: employees and software need to be allocated to be able to monitor the energy continuously, analyse it, identify any problems and action the solutions
- Need for powerful software that can analyse the half hourly data from large portfolios of buildings
- Smart meters should also be used for gas and especially for water as great savings can be identified (Azennoud et al., 2017)
- It is easier to invest resources in other projects and schemes such as energy efficiency since their savings can easily be achieved and the results are more visible as an example upgrading the lighting; the quality of lights increases, and if the same patterns of using the building are followed, then energy managers will be able to see their energy bills decrease.
- Lack of knowledge transfer between staff members: having the energy data is one thing and being able to use it is another thing. Analysing data without understanding how a building functions might not achieve the intended results. As an example, the energy teams of NCC used to have members of staff who had knowledge of most of the LAs estates and the energy systems installed in them and this helped them give more sense to energy data. These members of staff have retired and their knowledge disappeared with them.
- Need of energy data from sub-meters from big buildings to help in understanding the energy consumption.

Figure 34 summarises the perceived benefits and challenges facing the introduction of real time monitoring in the interviewed LAs.

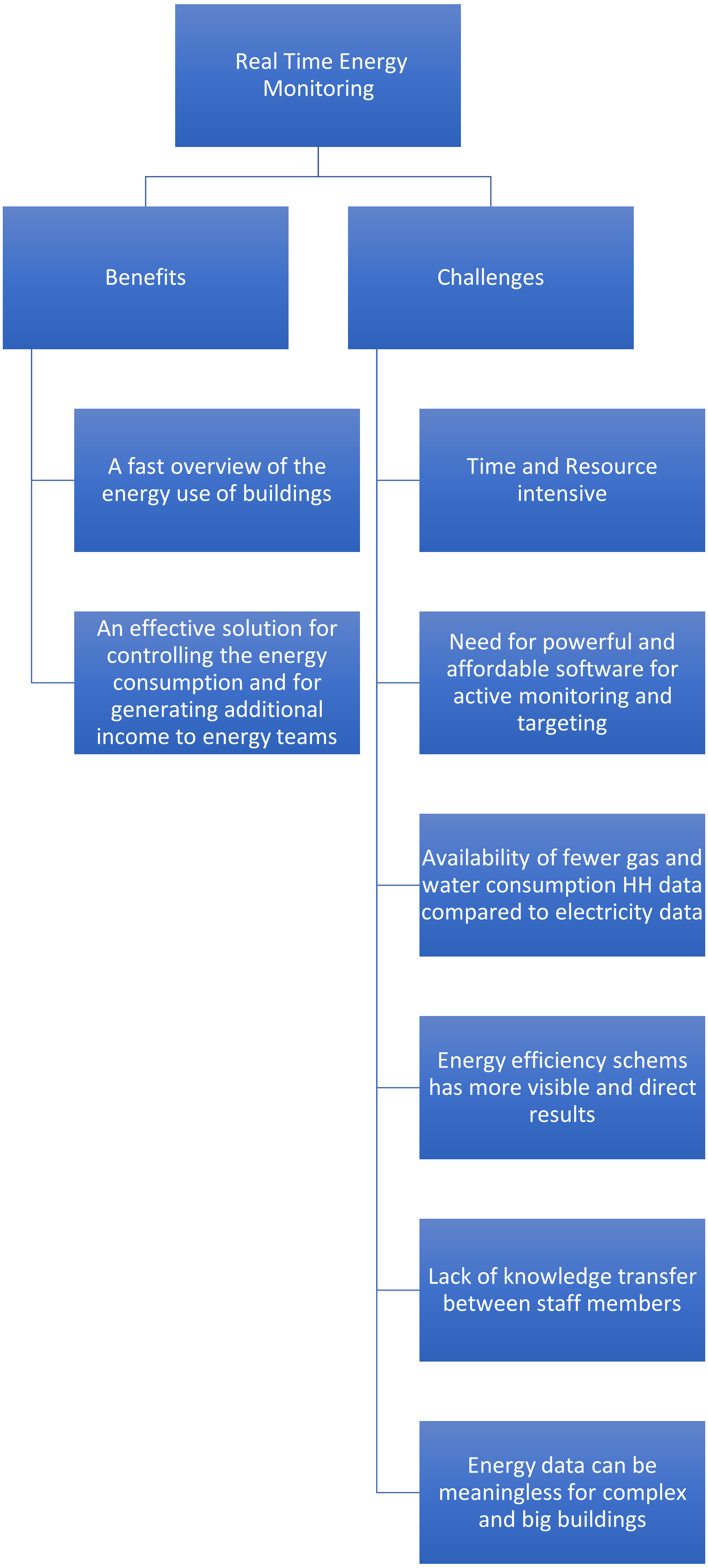


Figure 34: Implementation of Real Time Monitoring in LAs

8.2.2. Discussion around Motivations behind Smart Meters Roll-out in Local Authorities

The previous findings have detailed how energy managers in the interviewed local authorities view the benefits of integrating smart metering in their daily job and the challenges facing them while using them or when they try to roll it out across all their estates and for all commodities, i.e. electricity, gas and water. Though, by looking closely at these findings, it can be deduced that smart meters are in general used to facilitate some of the energy management tasks rather than focusing on reaching and discovering their full potential which can be achieved by implementing real or near real time monitoring for the purpose of identifying energy wastage at the moment of its occurrence and try to eliminate it. It has been seen that the energy data produced by this technology is used to build more accurate feasibility studies, save time on solving energy related queries like bills validation, investigating problems, energy budgeting, etc. It is true that some interviewed managers use them for monitoring time of use and to capacity charges, but this is not a widespread practice in the interviewed LAs.

Smart meters are becoming more and more perceived as one of the tools that energy managers can use for fulfilling their daily duties (i.e. as part of tradition energy management) and hence why they are missing on the potential of additional benefits (e.g. real time monitoring and targeting) which can be a result of an absence of knowledge around how these benefits can be achieved and how to guarantee a return on the investments in these measures. As has been introduced under 5.4.3, Annunziata et al. (2014) found that focusing on a certain number of energy efficiency schemes is a threat to members of staff as they do not acquire knowledge to deal with new technologies. Energy managers tend to invest in technologies that they master and which can achieve straightforward savings; that is why most of the interviewees highlighted that in the current situation they are more interested in energy efficiency schemes and retrofits since their savings are more visible; energy monitoring and demand side management are perceived as the future of energy management. This can be partially explained by the fact that smart meters were deployed in LAs as a response to policy requirements and in some cases as part of trials requested by the LA, and in both instances, energy managers started discovering the benefits of this technology on their own. As was mentioned earlier under 8.2.1, if the policy stressed the necessity of training energy managers on how to use smart meters, then there might have been a wider use of this technology for different energy related practices; i.e. real time energy monitoring other than traditional energy management. As an example, Leicester City Council was part of different trials to rollout smart meters in LAs; these were led by the Carbon Trust or were part of European funded projects:

> *"Leicester City Council have been involved in many FP7 (EU) projects over the last 15 years which have helped them to explore the potential of smart systems and get the best value possible out of them. In part this has led to innovation with software providers developing new reports and tools. For example, building managers now have the option to access their data directly via a proprietary web interface to the analysis software. Rather than the energy management team pushing information to the sites when problems are identified, building managers can now access information on demand and run their own analyses." (*Azennoud et al., 2017, p. 662*)*

This can explain the only systematic approach adopted by an LA which the researcher came across while working on this study. LCC is the only interviewed LA that developed an 'invest to save' scheme based on using smart meters for real time monitoring.

Another finding is that important quantities of data are generated by smart meters on a half hourly basis and energy managers struggle with their analysis because:

a- They couldn't find software which can actively analyse the data to detect any anomalies with the energy systems of the different LA buildings

b- They need to allocate funds and justify them to purchase software and hire members of staff to analyse the data.

This means that even with the existence of modern technologies and sophisticated software, human interaction is still fundamental for the success of these schemes. It also answers one of the questions asked in the introductory chapter about the terminology ‘Smart’ and what makes a system smart. The Smart City relies heavily on technologies and often undermines the role of users. However, in this research, it is perceived that the way energy managers use the half hourly data describes and translates the smartness of the system. For instance, smart meters are used to save time while processing energy related queries; even though this is not one of the main purposes smart meters were developed for, the user found a way to make this technology help with performing his/her duties. While technology can be sophisticated it does not guarantee its smartness; but the interaction between the user and the technology, how it is used, and the results achieved does. There is a need for high-resolution data and for human interaction to make sense of it.

Last, most of these energy efficiency schemes adopted by the LAs are easily funded by monies that the organisation does not have as in the example of SALIX funding. Therefore, it makes sense to make the best use of this ‘free’ available resource to achieve savings to the LA. An example is that NCC and schools in Northamptonshire always wanted to install roof mounted PV systems, but there were not any funding opportunities. However, the moment SALIX added it to their list of fundable technologies, the LA and the schools started installing it. The availability of funds for ‘invest to save’ plays a major role in the technologies and schemes adopted by organisations.

Frequency of Receiving Data and its Usage

This study has explored the different uses of data by energy managers and found that, for most cases, these members of staff rely on historic data and rarely need real time data. In many interviews, the interviewees highlighted that they do need high-resolution data but there is no urge to receive it on a daily basis. The most important thing is to have it stored and ready for access when there is a need for it or when a problem occurs. This is something to be expected as the majority of the interviewed authorities did not implement a real or near real time monitoring system or activity; hence there is no necessity to receive the data on a daily basis. However, if for example, an energy manager decides to prepare a feasibility study for installing a solar roof mounted PV plant, s/he will only need to have access to historic profile data to understand how the building consumes electricity during the different seasons of the year and to identify the perfect size of the future installation.

Collecting data costs money and having a day+1 arrangement costs more than a month+1 one. If data is going to be accessed twice monthly or on a monthly basis and there are no current plans in the LA for real time monitoring, the good decision to save on costs might be to choose the arrangements that better suit the type of activities done in the organisations. The arrangements still include half hourly data which fulfils the requirements of energy managers.

Good governance translates to spending money wisely on the services which are actually used, and in, many cases, having a day+1 arrangement is not necessary. The market place and energy suppliers or data providers often associate smart with real time arrangements and transmit these ideas to their customers in order to sell their services, but the latter should choose the services which better suit their needs. Additionally, good governance means making the best of use of allocated services and in the case of paying for a day+1 arrangement, the organisation should use it for real or near real time monitoring.

8.3. Energy Management Uptake in Local Authorities

This research has found that energy teams exist in most of the interviewed LAs in different forms some with one staff member. The teams have different roles; some of them are only focused on energy management and some include environment management and climate change protection in their role. These teams fall under different directorates like operations, development, public realm or finance. Most of the interviewed teams fall under the growth/development generation, which means that energy management is seen as a catalyst or a tool for empowering the organisation and boosting its development. One of the findings from these interviews, mentioned under 5.8, is that most of these teams perform traditional energy management; i.e. looking after the energy systems installed in the stock of buildings of the organisation in addition to ensuring statutory compliance and procuring energy at a good price. Some of the teams had bigger ambitions; not only to save energy for the organisation but also to generate income streams. The researcher focused on studying this aspect in more detail in one of the interviewed authorities as part of a case study. This LA, for which the researcher is employed, has a good energy management system for many reasons and one is the first local government to obtain an Energy Management System certification under ISO50001:2011 in the UK and as far as the researcher is aware, it is one of two LAs in the UK to currently hold it. Additionally, its energy management scope exceeds the boundaries of the LA and even the boundaries of the County. This means that the researcher had a chance to study closely the reasons for which the energy teams decided to expand the scope of their work and not only focus on traditional energy management.

8.3.1. Policy

Northamptonshire County Council has two energy teams, one falls under the Environment, Development and Transport Directorate and the other one falls under Property which also became part of the same directorate in summer 2017. The Property energy team is the one which is responsible for traditional energy management and has been part of the LA for decades. The other team, which is the Energy & Carbon Management Team (ECMT), is fairly new as it was created in 2010, and is looking at opportunities for generating an income stream for the organisation.

The creation of this team was a result of the willingness of the Cabinet to address the government's climate change targets for 2020, 2030 and 2050. Therefore, the policy – once again – helped in creating the ambition and the need for a structured vision to cut carbon emissions within the LA. It is one thing to have ambition and even employ a manager whose main duties are to drive a carbon reduction programme. It is another thing to get it right and have an impact which resides in embedding energy management in the culture of the organisation or being the spark that ignited the creation of a modern form of this practice. The Energy and Carbon Management Team (ECMT), as it has been seen previously, had many successes and achievements which are not only recognised from within the LA itself but nationally and internationally with a series of awards or big projects awarded to it because institutions believe in its efforts. All of these achievements could not have been accomplished without the vision of the Head of Energy & Carbon Management who was successful in translating it into reality with the help of members of the organisation starting with his team and directors and Councillors.

In many other interviewed LAs, policy played a great role in initiating discussions around carbon savings and energy management.

8.3.2. Human Resources

In an LA, the role of managers may appear to be less important than Councillors since the authority is managed by a board of directors that is led by the Council and its Cabinet. This can be partially true as the main decisions cannot be taken without consulting and getting the approval of Councillors. However, the latter are elected and not employed and therefore might have limited knowledge about specific areas of local authority operations like energy management or transport, etc. This is why they delegate these functions to the board of directors and managers who are employed for accomplishing a specific duty and based on their skills, expertise and knowledge. Collaboration between the two parts of the organisation; i.e. the administrative and the political, is essential to guarantee the success of projects and initiatives. Additionally, the appointed energy manager; i.e. the head of the ECMT, was open to new ideas and new challenges and did not limit his duties to achieve the corporate target of decreasing the carbon reductions by 2% but exceeded it to help other organisations with their energy management to generate income to NCC. Therefore, the energy management buy-in of the member of staff who is responsible for energy is crucial for its success and development. This was the same in the other LAs where initiatives and energy efficiency schemes are driven by the energy managers and energy management teams.

8.3.3. Financial Resources

Having the necessary resources is important for driving energy management but positive results can still be achieved in their absence. The ECMT and its successes in bringing money on a yearly basis to their LA is a live example. The only financial resource available for this team from NCC is the salary of its manager which is small compared to the authority's budget; the team funds itself from the work it carries out and needs to achieve the yearly income target set by the LA. Currently, it is very easy for energy teams to implement energy efficiency schemes since there is a range of external funding opportunities that they can access. However, it is good to have access to internal funds that the energy managers can use to implement projects which are not fundable by external organisations and which they believe can achieve significant savings. The 'invest to save' programme using smart meters in LCC is an example where internal funding was very important; otherwise, this project wouldn't have seen the light of the day.

8.4. Smart Energy Management for Local Authorities

Increased emphasis is being put on the ability of information and communication technology and the digital economy to meet the increasing carbon reduction targets (Bull & Azennoud, 2016). The word 'Smart' is being associated with different systems and often refers to the reliance on automatization or the use of technologies; as an example, smart metering refers to the reliance on automatic meter readers to automatically send meter readings. However, earlier under 8.2.2, the researcher has argued that smartness does not reside only on the use of technologies but on how it is used by human resources to carry out a specific task; i.e. it is the interaction between the user and technology that makes it smart. For instance, the British Standards Institute (BSI) published in 2014 PAS180 "Smart Cities Terminologies' which collates and defines all the vocabulary related to Smart Cities. This document states that there is still no conclusive definition of the term but a working definition should be presented in order to create a common understanding and shift the conversations about the Smart Cities in the direction of solving the issues facing the cities. The proposed working definition is that:

> *"Smart cities is a term denoting the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens"* (British Standards Institute, 2014, p.3).

According to British Standards Institute (BSI), this definition tries to catch the communality in the Smart City strategies in the UK. However, it is up to the cities to define what “Smart” means for their case (British Standards Institute, 2014). In other words, strategies and solutions implemented vary from one setting to another and “Smart” should not necessary mean the integration of readily designed technologies or software without analysing the needs of the organisation and then design a solution that best suits and addresses them. This is why the researcher has argued early that, as an example, linking smart metering to the daily availability and access to the meter reads might be unecessary because there might be no need for it in a specific organisation. This terminology is often used by technology providers to sell their products or to access markets where they do not have a presence. As an example, IBM had been facing difficult times in the 1990s and early 2000s leading it to make strategic changes and shifting their activity focus from hardware design to consultancy and software business. At that time, IBM noticed that urban technologies and cities are a huge untapped market (Soderstrom et al., 2014), hence the development of the Smarter City concept. Smart Cities and Smarter Cities

> *“Both refer to the same idea and are often used interchangeably in literature and online publications. The difference between the two is that ‘smart city’ is legally unprotected [...] while ‘smarter cities’ [...] legally belongs to IBM and refers to the company’s software and campaigns”* (Soderstrom et al., 2014, p.23).

The interviewed LAs energy managers often have the necessary technologies and pieces of software that they need and will help them with their daily duties and sometimes there is no need to acquire newer software just because it is labelled as “Smart”. One example is that energy managers in NCC were studying the possibility to change the energy management software used by the organisation to buy a smarter one. After reviewing the software available in the market, it was noticed that most of them provide the same functionalities with different labels. This is why the decision was made to keep the software that the organisation already has and add to it a package developed by the software provider and which allows a better use of the half hourly meter reads. The reason for making this decision was that the cost of this software was cheap compared to what was available in the market. Additionally, members of staff have been using it for years, are acquainted to it and, most importantly, it does the job it was bought for.

From the findings of this research project, Smart Energy Management (SEM) for a non-domestic energy consumer such as a Local Authority is defined as:

A self-governing management system that integrates ICT and human resources for energy cost saving and income generation within the operations for which the Local Authority is responsible.

In more detail, SEM is the systematic and efficient integration of multiple resources but focusing on the human and ICT ones to embed energy saving activities, and if possible income generating practices, into an organisation. This can be demonstrated by a combination of schemes like periodic energy monitoring and targeting using high-resolution data, energy control, energy efficiency measures, shift to renewable energies, demand side management, knowledge share, focused awareness and training campaigns to develop a self-governed energy management system.

This definition reflects two key aspects of SEM. It entails the role of humans and technologies in developing energy management, and it demands the elaboration of a systematic approach to embed this practice into the culture of the organisation.

The transition from the concept of Smart Energy Management in an LA into an operational system can be enabled due to four scales outlined in Figure 35:

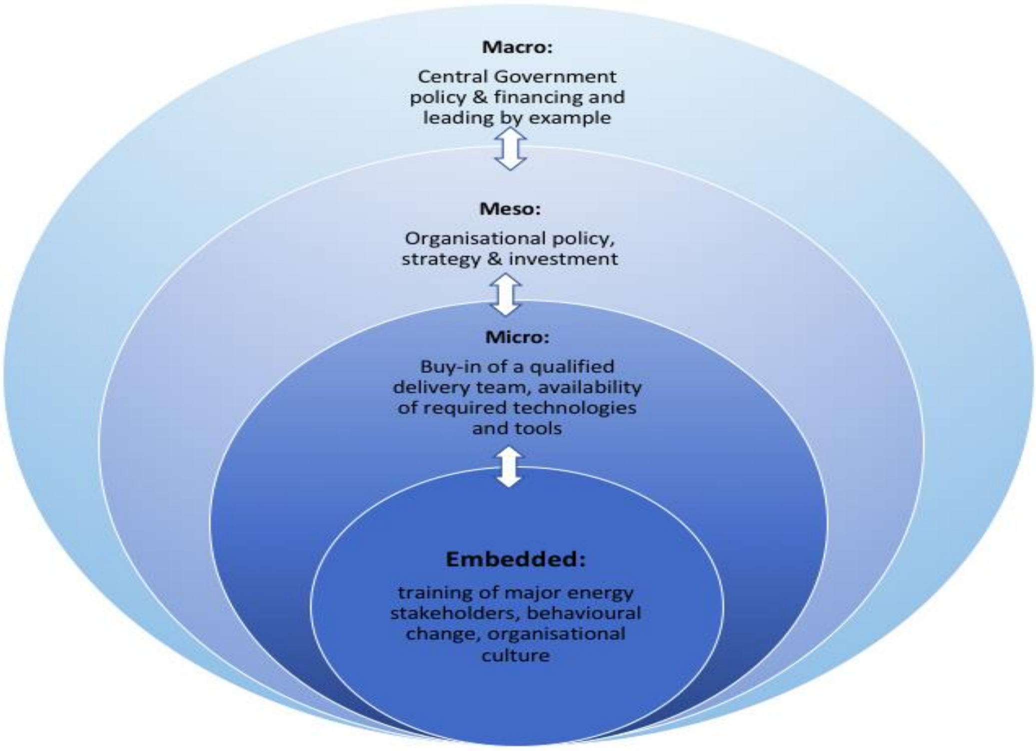


Figure 35: Strategic Levels for Enabling the Incorporation of Smart Energy Management in a Local Authority

Each level has different factors that will help in embedding this practice in the organisation. These are summarised in Table 12:

Level	**Factor**	**Observation**
Macro	Central government policy and legislation	It is seen as one of the triggers which enables the introduction of this practice into the organisation. Is the policy self-explanatory and does it outline a set of procedures to follow? Or can the organisation define how it can address it, and in this case, does it go beyond compliance to implement a system that can easily be integrated within the organisation? Additionally, does the organisation define a set of procedure that will

Macro		allow it to contribute in the design of these policies?
	Central government funding	Availability of funding encourages organisations to implement solutions that can help them control their energy expenditure. Does the availability of funding affect the choice of specific schemes and technologies over others?
	Lead by example	To showcase the effectiveness of specific systems and solutions. Does the organisation understand that the public sector has a moral obligation to adopt solutions that will support governance, and which will serve as a Living Lab to enable other organisations to learn from the implementation of this new system?
Meso	Support from top management	In this case Cabinet and board of directors, and the willingness to experiment with new solutions which will empower good governance.
	Enactment of internal policies and strategies	To trigger the implementation of SEM and ensure its enforcement
	Allocation of internal funding	To provide a suitable environment to ensure the success of the solution
Micro	Buy-in of delivery team	Does the organisation have a highly qualified team with the right expertise that believes in the usefulness of this solution and is this team motivated enough to make it work?
	Availability of resources	Does the organisation have the required tools and data that will enable the implementation of this system?

Embedded	Organisational culture	Does the organisation has a set of procedures that will enable the embedding of this system in its organisational structure, i.e. as part of the induction package of new staff members, training, behavioural change campaigns, etc.?

Table 12: Indicators for Enabling the Embedding of SEM in Local Authorities

The transition towards a Smart Energy Management System can be undertaken in the following steps (Figure 36):

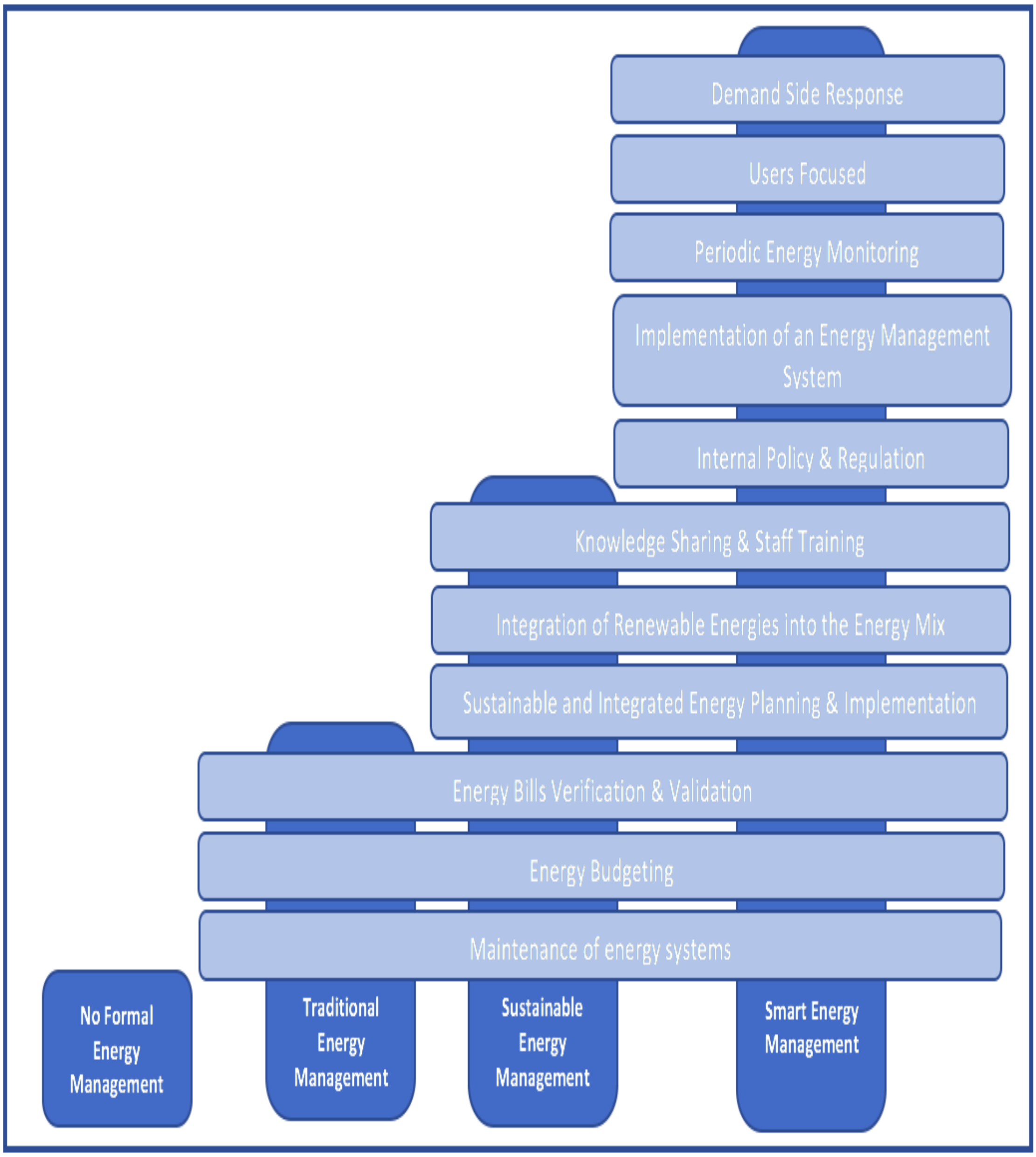


Figure 36: Proposed Transition towards a Smart Energy Management System

Figure 36 summarises the attributes that this research identified in order to move to a Smart Energy Management System and which have all been discussed previously. Some of them are shared with other types of energy management systems. Below is an expansion of these attributes:

- Maintenance of energy systems: consisting of looking after the energy consuming apparels installed in a building, supply registration, change of ownership of supply, etc.
- Energy budgeting: preparing energy budgets for every process or a building or a system.
- Energy bills verification and validation: checking if bills are accurate and release their payments.
- Sustainable integrated energy planning and implementation: including energy as a main aspect when developing projects like constructing a new site and use model that will ensure the sustainability of the actions. The example of SALIX is a sustainable model as the invested money is paid back through energy savings and which is used again for developing other schemes.
- Integration of renewable energies into the energy mix: one important aspect of sustainability is to use resources at a rate that will not lead to their depletion. Renewable energies are an evident choice as they are abundant.
- Knowledge sharing & Staff Training: to enable transfer of knowledge and to ensure continuity. There is also a need to train staff members around simple actions that can help with saving energy.
- Internal policy & regulation: to embed the energy management practice into the culture of the organisation.
- Implementation of an energy management system: to ensure a systematic approach to energy management
- Users focused: to listen to the users of the buildings and develop policies and solutions that at the same time save energy and address their needs.
- Periodic energy monitoring: to identify new saving opportunities, check the effectiveness of implemented schemes and minimise energy wastage.

- Demand side response: to define an efficient time of use of energy to minimise supplier charges and enable the organisation to deliver its services smoothly.

8.5. Findings Validation

As explained in 3.3.1, the researcher has shared these findings with the representatives of the LAs who took part in the first phase of interviews, i.e. representatives of 13 LAs, for informing them about these findings and getting their views and suggestions for improving them. Seven representatives responded to the questionnaire a copy of which can be found under Appendix I. The respondents are from Milton Keynes Council (MKC), Cherwell District Council (CDC), Northamptonshire County Council (NCC), Islington Council (IC), Oxford City Council (OCC), Newcastle City Council (NeCC) and Stadt Nuremberg (SN).

The questionnaire was divided into three parts: a definition of the concept of Smart Energy Management (SEM); indicators for the four levels of the framework enabling the shift from a traditional energy management to SEM and usage of smart meters in LAs for active monitoring and targeting.

8.5.1. Validation of the Definition of the Concept of Smart Energy Management

All the respondents find the definition useful except in one case where the energy manager of MKC suggested adding to the definition what a self-governing management system can mean. In a response to this comment, the researcher argues that a self-governing management system is one that does not depend greatly on the guidance and the involvement of senior management. Clear procedures are put in place, targets are set and job roles are defined; therefore, the system which includes staff members can function without the constant interaction of higher management. An example of such a system can be the Energy Management System (EnMS) developed under ISO50001:2011.

A second comment from the Head of Energy and Carbon Management in NCC suggested mentioning energy earlier in the definition to set the context of energy management from the beginning. Therefore, the definition of SEM becomes:

A self-governing energy management system that integrates ICT and human resources for cost saving and income generation within the operations for which the Local Authority is responsible.

The representative of CDC proposed that the SEM should adapt to the system already in use in the organisations like ISO14000 and ISO90001. This is, of course, crucial for the implantation of the SEM as it builds on the best practice of the organisation.

The energy manager of IS stated that *"consideration should also be given to accessing external funding for research, development & capital and revenue works".* This is one way to operate and generate income that an organisation can rely on.

The representative of OCC suggested including retrofitting and procurement of high efficiency plants and equipment during any new builds.

Finally, the energy manager of SN added:

> *"The term 'Smart' could be narrowed down a bit.*
> *'Smart' in relation to high-resolution energy data means using specialized software to evaluate the large amount of numbers that are collected when high-resolution data is used and generate output that can be used either by technically oriented energy professionals or by building users who 'cause' the energy consumption, or even by people who only deal with the costs of energy.*
> *'Smart' in relation to the combination of HR and ICT means having smart people in the energy management business who are able to combine these very different areas of business. This is by far the most difficult part of it!*
> *Overall a very good definition!"*

The definition focused on the interaction between ICT and HR since this is what makes a system Smart.

8.5.2. Validation of the Four Levels of the SEM Framework and their Factors

Macro Level

The respondents confirmed that policy plays a significant role in pushing for the implementation of schemes or systems or terminating them. For instance, the energy manager of MKC gave the example of how the legislation related to the Carbon Reduction Commitment has been used by some LAs to drive energy efficiency agendas. However, the level of response to these regulations differ from one organisation to another as he explained: "*some chose to respond passively – just comply and pay the tax. The response was often guided by the 'Meso & Micro' drivers, as in the diagram above*". He added that legislation alone is not enough, central funding can be a plus. He also emphasized the importance of the Lead-by-Example factor which he believed can showcase the best practice of the LA and influence to implement such framework.

On the other hand, the representative of CDC gave the example of how the change in legislation and cut in finding, specifically around feed-in-tariffs (FiTs), has affected the installation of PV in his LA as it is now believed that *"the technology is not anymore worth it"*. The representative of OCC added that the "*risk averse nature of local government means it may be a late adopter of new technology having preferred other users to take the initial risks*".

Finally, the Head of Energy & Carbon Management for NCC believed that the policy and legislation factor should include other institutions than Central Government like the EU, G8, etc.

Meso Level

The respondents approved the factors included under the Meso level. They all believed that senior management support is essential for the success of any initiative. The continuous communication between staff members and senior management should be vital. This is why, according to the representative of CDC, one of the strengths of

ISO50001:2011 is that it needs to be signed off yearly by a member of the senior management. However, the representative of NCC believed that schemes implemented by LAs always have the support of senior management; the question is what type of support needs to be provided for facilitating the implementation of SEM. The representative of OCC added that *"Internal policies rarely cover energy management with oversight limited to energy spend"*.

Micro Level

All the respondents felt that the availability of qualified and dedicated staff members and specialised software is essential for the implementation of SEM. The energy manager of MKC added:

> *"Again I agree with this assessment. Smart Energy Management does not spring up in isolation. It requires the two key factors above to be actively supported. It is interesting that the political make-up of the organisation is not particularly important (i.e – left/right/centre), it is the willingness to act, often promoted by a local champion".*

Embedded Level

Respondents found that this level of implementation needs to be designed with attention to different factors. First, according to the representative of NCC, organisational culture can differ from one structure to another within the same organisation especially within large ones. Second, not every structure has the same procedures. Third, the representative of CDC believed that staff members should be the focus for this factor and behavioural change programmes need to be developed periodically

> *"Experience and some work already done by possibly COIN/ Carbon trust highlight that behaviour change programs will need to be re-done every 6 months – 1 year to emphasise the point and account for staff turnover. Additionally, it is my experience that consistent success or at the least updates need to be provided to staff; otherwise, momentum will be lost."*

Fourth the representative of OCC added that induction training and behavioural change campaigns have dropped off due to *"reduced staffing with a reliance instead on employee goodwill to embed this system"*.

Other Factors that Should be Included in the Framework

The representatives of SN and CDC suggested adding sustainability and consistency in order to ensure time saving, resources already deployed for implementing the concept, accounting for what is already in the organisation for the concept to survive more than the term of office for the Councillors and recognising that some strategies cannot be implemented in one legislative period. The representative of NeCC felt that the human factor should be separated from the other factors. Finally, the representative of IC believed that the co-operation factor between LAs should also be considered so as *"to increase the number of feasible projects"*.

8.5.3. Validation of the Main Factors Affecting the Uptake of Active Monitoring and Targeting in LAs

Policy Factor

The researcher has argued that policy is one of the main enablers for the rollout of smart meters and the spreading of its use, but it has lacked information about how to use them for saving energy.

The representatives of NCC, CDC and SN deemed that policy alone is not sufficient for achieving savings from this technology and there should be accompanying programmes implemented to develop expertise within the organisation. The representative of NCC stated that *"from a policy perspective, smart metering is sold to the audience on the basis that you do not have to be trained to benefit"*.

The representative of OCC agreed that the smart meter roll-out programmes have been badly organised with a lot of uncertainty around equipment compatibility and access to data.

Public Funding Factor

The thesis has found that availability of public funding has encouraged LAs to implement energy efficiency schemes while there is no such funding for active targeting and monitoring using high resolution energy data.

Like the researcher, the representatives shared the same view that it is difficult to define payback periods from an active monitoring and targeting scheme as its savings are unknown until the scheme is operational.

The representatives of NCC and CDC believed that public funding can make things easier especially when LAs have limited resources which are used for supporting their day to day activities. The representative of SN stated that this is not the case in Germany as there are funding opportunities for LAs to install smart meters and energy management software. The representative of NeCC added that to secure any funding, a robust business case should be developed. On the other hand, the representative of MKC argued that public funding is harder to source for small scale projects and that the main problem is that financial literacy is poor amongst engineers.

Lack of a Methodology to Quantify Direct and Indirect Savings from Active Monitoring and Targeting

All the respondents agreed that the development of a methodology to quantify saving the active monitoring and targeting activity was necessary. The representative of MKC stated that this is

> *"A slightly chicken & egg situation. If there is no targeting and monitoring, it is impossible (or at least very difficult) to predict savings. If there is no prediction of savings, why bother investing resources in monitoring? This is where statutory benchmarking has been a success; for example, statutory annual DECs for public buildings (and schools). The old saying that you can't manage what you don't measure is true"*.

The representative of SN added that this is important but LAs should focus on first implementing a good energy practice and benefiting from the low hanging fruits in order to prepare the ground for the politicians to consider innovative solutions like SEM.

8.6. Conclusion

This chapter has analysed and summarised the findings from Chapters V, VI and VII and used them to set the scene for how smart meters and energy data have been integrated into the different types of LAs in the UK and how they are used for energy management purposes. Later, a framework has been proposed to make the best use of this technology and to embed energy management in local authorities. ICT and smart systems have revolutionised the world and certainly have an impact on different aspects of energy management. However, does this mean that there should be a blind adoption of every new technology? The researcher has suggested some solutions that can be adopted by different LAs and which can make a case for rolling out smart meters and paying for receiving profile data.

The researcher has also defined what Smart Energy Management means and how it can be integrated in an LA. Policy is a major catalyser for introducing organisations to new practices. However, for their successful adoption, integration and incorporation, policy needs to be combined with financial, organisational and technological factors and the essential buy-in of the leader of the programme.

Finally, these findings have been fed back to the representatives of the LAs who participated in the first phase of data collection in order to capture their view and see if this is something that can be implemented in their organisations.

Chapter IX will be devoted to summarising the journey of this research, presenting the challenges and areas for improvement and suggesting ideas for future work.

IX	General Findings, Contributions and Future Work	
	To reflect on the process of research and to summarise the findings and limitations	- Contribution to knowledge - Future research

Chapter IX: General Findings, Contributions and Future Work

This chapter presents an overview of this study, its key findings (Cf. 9.29.4 and 9.5), and its contribution to knowledge. It displays the strengths and the limitations that faced the researcher in addition to suggestions for future work. A discussion of how this study has addressed the aim of the research and its objectives is also included.

9.1. Introduction

This study has been carried out to explore how recent innovations, including the roll out of smart meters for generating high resolution energy data, can contribute to an effective smart energy management in Local Authorities (LAs). High resolution energy data in this study is the short time series energy data - i.e. periodic meter reads– that is produced by smart meters and similar technologies such as Automatic Meter Readers or data loggers which are capable of collecting and sending this type of data to the building manager and/or the energy supplier. The research has also focused on the concept of ‘Smart’, its academic and industrial definitions and explored the users’ perspective in order to understand what it means to them, the implications for their daily work, and how ‘Smart’ should be looked at in a real-life setting. The study has been carried and has met the following objectives:

- To review the latest developments and trends of energy management in UK Local Authorities (LAs).
- To identify the benefits and challenges for smart meters roll-out in UK LAs.
- To explore the current position regarding smart energy data management in UK LAs.
- To generate a Smart Energy Management framework for UK LAs.

The research question relating to these was: what does smart energy management mean for a Local Authority and how can it support the day to day work of an energy manager?

The researcher could not investigate the use of energy data without looking at energy management, more precisely under what form it exists in LAs and which activities it entails. This is why, even if this practice has not been explicitly mentioned as the aim of the research, it is present throughout the study and one of the key findings is in relation to its development.

The research has achieved its objectives through the development of a framework for Smart Energy Management which includes different mechanisms that enable the best use of high-resolution energy data. This new approach can improve the current approach to the energy management practice since it suggests a self-sufficient and systematic approach in Local Authorities which is to be tested in other authorities to prove its effectiveness. The researcher has shared this framework and these key findings with the interviewees who are part of this study in order to get their views and understand if this can be implemented in their organisations. Chapter VIII presented the findings of this exercise.

9.2. Addressing the Research Objectives and their Outcomes

This section explains how each of the research objectives outlined previously has been met.

9.2.1. Reviewing the latest developments and trends of energy management in UK Local Authorities (LAs)

This objective was met in three key stages. The first one was through underpinning the need for energy management in public sector organisations in general and in one LA in particular. Energy management was identified as an example of good governance. Public sector organisations have a moral responsibility towards tax-payers to use public resources efficiently and effectively. As energy is one of the biggest overheads in Local Authorities regardless of their type, it makes sense to prioritise the establishment of a system that looks at keeping its costs reasonably low. Energy management is a practice intended to ensure the efficient use of commodities. The research has investigated how this practice can be institutionalised; the literature suggests that this can be achieved through an energy management system which proposes a systematic approach and needs the endorsement of and guarantees the interaction between, all levels of the organisation (i.e. cabinet, top management, officers, etc.) to ensure its effectiveness. The researcher found that while policies are an important enabler on their own, they are not enough to push towards the institutionalisation of this practice; he gave the example of the different programmes and initiatives that called for cutting carbon emissions in public organisations like the initiative launched by the Covenant of Mayors for Climate & Energy (COM). Having targets and plans for cutting carbon emissions is not enough and these targets will not be met if there is no systematic integration of energy management into the organisation. This is why there was a need for standards like ISO50001:2011 that will assist these organisations in developing an energy management system and why the European Commission provided funding to launch trials for integrating this standard with the plans required to be developed by the members of the COM. This was intended to enable a systematic approach toward the implementation of strategies that would lead to decreasing energy consumption and cutting carbon emissions. The first phase of the study also looked at defining an energy management system and its benefits. For an effective energy management system, the use of good quality energy is imperative since energy managers cannot manage what they cannot measure.

The second phase of the work was about exploring how different types of local authority in the UK approach energy management and use energy data generally and high-resolution energy data specifically. This was achieved through a series of interviews that identified the form of energy team that existed within these organisations, how they perceive this practice and what their jobs consist of. It was found that most of the interviewed LAs have energy teams and energy management is perceived as a tool for growth and development. Their roles vary from maintaining the building portfolios and procuring energy at low market rates to developing 'invest to save' energy schemes. Some energy teams go a step further to assist other organisations or their communities with energy management through the development of projects which are funded by the EU or the Central Government.

The third stage of the study was through an in-depth case study of a local authority, i.e. Northamptonshire County Council, in order to identify:

- the steps, factors, and processes that the organisation implemented in order to institutionalise this practice and create an energy management system that has now been running for four years with an international certificate; ISO50001:2011,
- how centralised energy management is perceived by different parts of the organisation in order to characterise what is 'smart' and 'smart energy data',

- the drive towards the roll out of smart meters and Automatic Meter reads and subscribing to collect data for non-mandatory half hourly supplies and any related costs, and finally
- how high-resolution energy data is used and what impact it has on energy management.

The study has found that one of the main factors that initiated the institutionalisation of energy management in the organisation is the policy enacted by Central Government in regard to cutting carbon emissions. The second one is hiring a leader for the programme, an energy manager, who has the right expertise, is motivated and has the necessary authority from the Council to work on this task. The third attribute is that energy management is implemented to generate income for the authority which means that the case for endorsing is strong. The last one is to create an energy management system (EnMS) based on ISO50001:2011 in order to move from a system that is reliant on members of staff to manage it to a system of processes that ensure continuity. In other words, the EnMS will not collapse if the manager and his members of staff are not part of the organisation because processes, plans, strategies and policies have all been drafted and endorsed by the organisation which will guarantee their continuity of work.

This finding aligns with the change and transition management concepts discussed earlier in chapter II. The change (i.e. shift towards low carbon organisations) took place mainly because of an external factor (i.e. Central Government policy) and to facilitate the transition, internal factors (i.e. setting up targets and processes under energy management systems and selection of a motivated and a knowledgeable leader to run the programme) had to be addressed.

9.2.2. Identifying the Benefits and Challenges for Smart Meters Roll-out in UK LAs

To achieve this objective it was essential to explore the current uses of smart meters in LAs and their experience in relation to the roll-out of this technology in their organisations. This is why this study has provided a detailed and critical review of the usage trends of energy data by non-domestic energy consumers, specifically in LAs. Firstly, the study described the available sources of energy data then moved to presenting energy meters as these are the norm when it comes to energy metering, i.e. these are the only devices which can be used for billing consumers for their energy use. The thesis then explained the developments in energy metering practice that emerged from technological development and considered how the need for high resolution data and remote data collection led to the introduction of data loggers, then to Automatic Meter Readers (AMRs) and smart meters. The researcher has also located smart meters as a key technology in the context of Smart Cities.

In order to understand which type of data is available to energy managers and how energy data is used, the thesis argued that it is essential to know how this data is generated and which technologies are installed in organisations in the UK. This is why the study started first by looking at these technologies and then moved to the policy context. Currently, in Europe in general and in the UK in particular, legislation is pushing towards the rollout of smart meters for different commodities, mainly electricity and gas, which means that many organisations can have half hourly energy data for their buildings if they wish. However, there are some buildings which fall under mandatory half hourly profiles and managers are compelled to pay for a service which provides this type of data to the electricity suppliers. The study has looked at the UK's smart meter rollout programme and the benefits to consumers; these were primarily the accurate billing and pricing of commodities. However, one of the findings of the literature review was that looking at the goals behind this roll-out programme the main benefits are perceived to be for energy producers and distributors since they will have access to more detailed energy data of consumers and can predict accurately the quantities of data to be produced and transported.

The thesis then looked at the different types of data generated by these technologies and their possible uses which perceived as the motivation for rolling out smart meters and choosing to pay for a service that provides high resolution energy data. These are:

- Policy or legal requirements: some electricity profiles, i.e. mandatory half hourly ones require having smart meters and half hourly energy data for half hourly electricity settlement.
- Technical:
  - Availability of real/near-real time and historic energy data of portfolios of buildings which can be used for different purposes like monitoring energy consumption or identifying the time of use of energy, etc.
  - Fault prevention or early detection of energy related problems
  - More informed energy related maintenance activities
  - Availability of detailed energy data, i.e. profile data for feasibility studies and integration of renewables into the energy mix.
- Financial:
  - The high-resolution energy data will help in detecting energy losses or inefficiencies of the systems, thus reducing the energy consumption which will lead to energy savings and financial savings
  - Ease of verification and validation of bills and fraud or discrepances minimisation as the energy managers will have access to the same data used by the suppliers for billing purposes.
  - Reduction of energy related charges cost (capacity charges, etc.) by adopting time of use strategies
  - Accurate annual energy quantities to buy in advance
- Knowledge share: to disseminate energy related information of a building to its users
- Environmental and Corporate Social Responsibility (CSR): any energy savings consumption will lead to a decrease in carbon emissions which enhances the carbon footprint of the organisation and its reputation.

Policy requirements remain as one of the most important enablers for the adoption of this technology and the generation of high-resolution energy data. However, it doesn’t leave a choice for organisations when they fail to understand the benefits of these technologies.

One of the main findings of the study is that this technology has become one of the ordinary tools that energy managers rely on for their daily activities. It is perceived as a core facilitator rather than a tool for exploring innovative solutions for achieving energy savings.

9.2.3. Exploring the current position regarding smart energy data management in UK LAs.

This objective was also met in four stages. The first one was identifying, through the literature review, how high-resolution energy data can be used. This has been highlighted and summarised under 9.2.2.

The second stage was through the identification of how organisations adapt to change and transition in general through the literature review of the two concepts (Cf. Chapter II). As it has been mentioned under 2.7, LAs are often characterised by a long history of how things are done, and are stabilised through lock-in systems like shared beliefs, institutional commitments, investments in infrastructure, policies and public governance. This is why the third and fourth stage focused on studying how LAs deals with the change induced by the introduction of smart meters.

The third stage explored how different types of LAs in the UK use this type of energy data. This was achieved through a series of interviews with energy managers from different authorities and enabled the researcher to identify some challenges that affect the regular and the periodic use of high resolution energy data for active monitoring and targeting such as: they are resource and time intensive; the need for an energy management software which enables real time monitoring; the difficulty to achieve and perceive savings from this activity; a lack of knowledge transfer between staff members; the need for better high-resolution energy data, i.e. data for processes, systems, machines rather than energy data for the whole building, and finally this type of data is currently better used for 'invest to save' schemes since their savings can be more visible.

The fourth stage consisted of undertaking an in-depth case study in an LA, Northamptonshire County Council. The researcher conducted interviews with different energy stakeholders in the LA, accessed documents like energy contracts, e-mails with energy suppliers and colleagues and internal databases like the one holding the energy data. Section 9.2.1 has highlighted some of the reasons behind undertaking this case study; the others were about identifying if these different stakeholders use energy data in general and high-resolution data specifically and how it is used. One of the main findings is that the budget holders for estates are the ones who are more concerned about energy consumption and at the same time the ones who use the energy data to manage their budgets. Although energy data is available on an internal database that key energy stakeholders or services managers can request access to, not all of them do so for two main reasons: first, they do not know which type of data the database holds, i.e. is it their meter readings or invoices that they receive or profile data from the smart meters? Second, they know that the Property Team is on top of it since they are looking after the organisation's portfolio of buildings and their energy budgets.

9.2.4. Generating a Smart Energy Management framework for UK LAs

This study has addressed this objective in different phases. It started by explaining the concept Smart and linked it to energy management and the energy data within in. It focused on that the Smart City often relies heavily on technology and data in order for it to function. It is frequently linked to technology innovations. The researcher then defined energy management and how energy data is crucial for its functioning. The study has also identified how energy management is used in Local Authorities, which type of energy data they hold and for which activities they are used. The study has presented one case of a LA in order to analyse how energy management has been embedded in the organisation and what benefits were achieved. Based on all these factors, the researcher formulated a definition of 'Smart Energy Management' for local authorities and a framework that will facilitate its adoption. This will be discussed later in the chapter under 9.4.

The thesis has focused on explaining what the concept of 'Smart' can mean for a LA in order to avoid tying it to technological innovations. It has concluded that 'Smart' and the smartness of systems resides in the interaction between its different components; the most sophisticated technology can fail in delivering its objectives if it is misused or if other components of the system are misused.

The study has looked at defining what a 'Smart' system, environment and component of the Smart Local Authority can look like, which is energy and more particularly energy management. Energy is one of the biggest overheads of these organisations, often ranked as the second biggest cost, and if it is managed in a smart way, savings and income generation can be achieved. This is why it is important to identify what Smart can mean for the other systems and components of the LA such as, but not exclusively, waste, transport, education, etc. Once these organisations master this concept and its applications in a relatively small system which is defined by their organisational borders, it can then be scaled up to bigger and more complex systems like the city.

9.3. Conclusions from the Literature Review and How they Inform and are Informed by the Findings from this Research

This thesis has reviewed different concepts that were essential to explain the context of this research. It first started by giving an overview of management of change and transition and it was found that:

- Change often takes place because of external factors and how an organisation addresses it defines how it will perform in future. This is why it is essential to have strategies for change management in place. In this thesis, it has been seen that most of the change in relation with the energy function of LAs took place because of an external factor which is Central Government Policy. The latter had led to the introduction of energy management and smart metering into LAs. The thesis gave examples of LAs that succeeded in implementing energy management in their organisations, benefiting from the full potential of smart meters and other organisations which failed in this task. This is mainly due to the strategies put in place to address the policy (i.e. the change). As an example, Northamptonshire County Council (NCC) has now an effective energy management system because it has created a strategy to address the Climate Change Act 2008. Another example is in relation to Leicester City Council (LCC) which is the only organisation interviewed as part of this study that uses a smart metering system for near real time monitoring. Again, this is due to a strategy that has been put in place and which stated that this technology needs to be used for income generation. An example of an LA that has failed in benefiting from the full potential of this technology is North East Lincolnshire Council (NELC) which implemented it to be statutory compliant. This meant that it only has smart meters installed in specific buildings and not across the whole building portfolio.

- Once change management and transition management strategies are put in place; transition and innovation will take place and it is driven by staff members who should first understand why this change is happening and accept it before they can transit to the new environment (C.f. Chapter II). Throughout this study, it has been seen that the transition toward energy efficient LAs is led by small energy teams and highly skilled energy managers who want to make a change to how energy is managed in their organisations for different reasons one of which is achieving financial savings. It is true that the transition towards energy management has been triggered by an external factor, policy, but the actual transition happened thanks to dedicated members of staff who believed in the necessity of saving energy and who, of course, needed and had the support of senior management. The niche in this context is the energy team within the organisation. As an example, NCC decided to decrease their carbon emissions but it was the energy team who designed the programme to meet this target and worked on different programmes to ensure continuity.
- Good governance can introduce the energy management practice into Local Authorities as the latter have the obligation to use public money effectively and this practice is one way to ensure it. However, for the effective implementation of energy management, internal resources and processes need to be put in place like trainings, mechanisms for decision making, capital

funds, etc. to allow energy managers to establish and run the energy system smoothly and effectively.

- The modern world is characterised by the appearance of continuous technological advancements which will often have an impact on how things are done and will trigger change that needs to be addressed by organisations. However, the latter need to have internal mechanisms to assess whether to enrol and adopt these technological innovations or to upgrade internal systems. Additionally, organisations need to assess the full potential of these new technologies and try to maximise their benefits and minimise their payback periods. It has been seen repeatedly that smart meters are used most of the time for traditional energy management and this is mainly due to two reasons: the first is that the LAs were pushed to roll them out. Secondly, there was an absence of programmes that explain to energy managers how they can use them to improve their energy management practice.

9.4. Contributions to Knowledge

This section will present the findings that arose from the analysis of the data used in this research. The study has offered contributions in four areas which most of them are practical contributions:

- It has employed a multi-methods approach to study different concepts in a specific setting which is Local Authorities.

This is mainly a methodological contribution as the researcher has used an approach that integrates quantitative and qualitative data to explore the application of energy management and the usage of energy data and to define the concept of ‘Smart’ for a specific setting which is local authorities. This was addressed in two iterative phases where each phase fed information into the other. The first phase consisted of interviewing energy managers in different types of LAs in the UK in order to understand how energy management is perceived in these organisations and to identify the reasons behind rolling out smart meters to generate half hourly energy data and the uses of the latter. This was achieved by conducting interviews with seventeen energy stakeholders, mainly energy managers, from thirteen LAs. The second phase was a case study that focused on one organisation to carry out an in-depth study of energy management and energy data. This phase also consisted of interviewing nine energy stakeholders of the LA which have different job responsibilities and different positions in the organisational structure. In addition, this phase used different methods to collect data which are:

- An energy matrix in order to have a holistic view of energy management in Northamptonshire County Council and which informed the process of preparing the interviews which are part of this phase. Thanks to the findings from this energy matrix, the researcher had extensive knowledge of the energy management system of the organisation which enabled him to discuss it with the interviewees from a position of strength, i.e. a position where the researcher can argue and analyse the responses of the interviewees while conducting the interviews and challenge their responses which led to more detailed and accurate responses.
- Exploring documents like contracts.
- Informal chats with different staff members.

Both phases were undertaken in parallel which allowed the findings from one phase to feed into the other phase. The approach adopted in this research is not based on an existing model, and it is deemed to be successful for this study as these local authorities, at the end of the day, have a similar operational model in the way some findings can be generalised to all of them. As an example, all of the LAs which were part of this study have smart meters for most of their properties including ones which fall under the non-mandatory half hourly profiles, one exception had them only for their estate that is mandatory half hourly; the researcher, in this case, can ask the interviewee from this LA why it is the exception. This wouldn't have been possible if the interviewed organisations belonged to different sectors.

- The study has provided an account of energy management and energy data management in Local Authorities drawn from the literature. This also offers an empirical contribution to knowledge as the research examined and identified the activities implemented as part of energy management in LAs on one hand, and evidence of the institutionalisation of this practice in one LA on the other hand.

This was achieved by first presenting the rationale behind the rise of energy management; the increase in energy prices especially oil prices urged the need to control the cost of energy in organisations. This practice has developed and is now widely used in organisations for different purposes: procuring energy at low tariffs, minimising the cost of production of services, etc. Its development can be divided into two aspects. The first one is the technological development where processes have been automated and led to the creation of software that helps in using energy efficiently. The second aspect is more strategic where a standard, i.e. ISO50001:2011, has been developed to facilitate the integration of this practice in organisations. The study has then looked at identifying some of the components of efficient energy management which facilitate its integration into local authorities and the policy related to it in the UK. The study has found that this practice is on the agenda of the European Commission and there were different trials for embedding energy management in LAs. In the UK, policy played a great role in pushing LAs to consider it. The thesis suggests a different perspective for integrating energy management into public sector organisations in general; this approaches it as an example of good governance and utilising public resources efficiently.

The study has also presented an extensive overview of energy data and its uses in general, and in LAs in particular; it has presented its sources and under which from it is available in LAs. The study has looked at explaining why smart metering and half hourly energy data is becoming a trend in the UK and linked it to policy and the Smart Meter Rollout programme. The research then identified the main motivations and benefits sought by LAs when it comes to using this technology and these are: financial, technical and regulatory.

- The study has examined different types of Local Authorities to identify evidence of adopting energy management and high-resolution energy data and their uses.

This was achieved by first defining how the interviewed energy managers or energy stakeholders from the thirteen LAs perceive their job, if their organisations have energy teams and what their role include. Most of the duties of these teams have been covered by the literature but the research focused on differentiating between the duties that fall under the traditional energy management and those which cover operations like energy procurement, maintenance of energy systems in buildings, and registration of energy supplies and the modern energy management which includes installing renewable energies or implementing energy efficiency schemes using the latest solutions like Light Emitting Diode (LED). Additionally, the study has highlighted on one of the most important factors that encourages LAs to implement energy efficiency or installing renewable energies and which is the availability of public funding.

Second, the researcher looked at the motivations that encouraged the interviewees to rollout smart meters in their organisations and for their using high-resolution energy data. The study looked at the frequency of collecting and accessing this type of data and for which purposes. It was to understand how these data inform energy related decision making and if it was used for real time monitoring. The research has found that smart meters and high-resolution energy data are becoming fundamental tools for energy management to carry out their duties. It was also found that real time monitoring is not sought in the present as it is difficult to prepare ‘invest to save’ feasibility studies and it is complex to quantify the savings from this activity unlike other ‘invest to save’ schemes like retrofitting.

Third, the researcher has studied in depth how energy management was institutionalised in a Local Authority and how high-resolution energy data is used in detail. It has been found that policy standards and human resources played a major role in embedding the practice in the organisation. First, the national policies pushed the LA to think about ways to decrease its carbon emissions; the solution was to create a position for an energy manager to overlook the work of all the energy stakeholders of the LA. Second, the hired member of staff had the ambition to make this practice more organised and profitable. Third, the ISO50001:2011 standard led to creating an Energy Management System that is capable to guarantee continuity of energy management since it is no more 100% dependent on one person, i.e. the Head of Energy & Carbon Management but on a combination of methods, procedures and strategies which are drafted and reviewed yearly.

- The study has developed a Smart Energy Management framework for Local Authorities and defined the different factors that can enable its embedding within these organisations.

The research has explored the factors that enable the successful institutionalisation of energy management in a Local Authority and has defined the motivations sought by energy managers in different LAs and the activities that they perform as part of this practice. The study has also explored how energy data is used in most of the interviewed LAs and identified one case where these are used for active monitoring and targeting and actually achieve financial savings. Finally, the research has given an overview of the concepts of 'Smart' and 'Smart Cities' and what it could mean to a LA. Based on these findings, the study has suggested and defined a new concept which is Smart Energy Management (SEM) as

> *"A self-governing energy management system that integrates ICT and human resources for cost saving and income generation within the operations for which the Local Authority is responsible".*

This can be demonstrated by a combination of schemes like periodic energy monitoring and targeting using high-resolution data, energy control, energy efficiency, shift to renewable energies and demand side management to develop a self-governed energy management system.

In addition to this, the study has outlined four levels that will enable the institutionalisation of this concept in LAs and these are:

- Macro: legislation & Central Government policy, Central Government financing opportunities, and leading by example by the public sector

- Meso: support and endorsement of top management of the organisation
- Miso: availability of high-resolution energy data
- Embedded: highly qualified and motivated members of staff to lead and implement the programme

Last, the research has defined the attributes of SEM as:

- Maintenance of energy systems
- Energy budgeting
- Energy bills verification and validation
- Sustainable integrated energy planning and implementation
- Integration of renewable energies into the energy mix
- Knowledge sharing
- Internal policy & regulation
- Implementation of an energy management system
- Users focused
- Periodic energy monitoring
- Demand side response

- The study has examined the concept of "Smart" and how the concept of "Smart Energy Management" can help in transitioning into a Smart Local Authority.

The thesis has looked at the concept of "Smart Cities" and identified how literature relates it heavily to the use of technologies. The researcher has arrived at the conclusion that this concept and "Smart" solutions focus on software and associated technologies. This is why while conducting the study, the researcher has focused on perceiving the role of technology in energy management and how it is perceived by energy stakeholders. For sure, technology is an enabler, but the focus should be on human resources as staff members are the ones who will translate the smartness of these solutions into practice. In other words, the smartness of these innovations and concepts reside in how they are used.

At the end of the study, the researcher has linked energy management back to the concept of "Smart Systems" (like Smart Cities, Smart Towns and Smart LAs) to suggest that a similar approach can be implemented for the other characteristics or components of this type of organisations like, and not exclusively, transport and waste. The suggested approach relies on an integration of sensors and software and human factors to help the managers make the right decisions for the systems they are managing.

All these contributions helped with assessing the gas in the literature by providing live examples of the application of the energy management practice in LAs and presented how smart meters and HH energy data are actually used by these organisations.

9.5. Implications of the Research and Recommendations

The study has two main implications for Local Authorities: the integration of Smart Energy Management into Local Authorities organisational culture and the requirement for a multi-layered approach for integrating a Smart system/approach that translates Smart Local Authority Ambitions into practice.

9.5.1. Implication One: Need for Integrating of Smart Energy Management into Local Authorities Organisational Culture

Within the findings of this study, it is suggested that the embedding of Smart Energy Management in an LA can have many benefits. First, it will create a systematic approach to manage energy. Second, it will allow continual improvement and therefore look for new opportunities to save energy. As an example, an organisation cannot only rely on building refurbishment to reduce the energy cost, because there will come a time where all works have been done. This creates new opportunities for starting and exploring new energy efficiency schemes and implementing new solutions like Demand Side Management or active monitoring and targeting. Third, it creates capability and knowledge within the organisation as there is a need to train members of staff to run the system. Fourth, energy is available in most aspects of the LA and a SEM will allow it to be addressed in a more formal way.

9.5.2. Implication Two: Requirement for a Multi-layer Approach for Integrating a Smart System/Approach that Translates Smart Local Authority Ambitions into Practice

The study has proposed a framework (Cf. 8.4) which can facilitate the transition from traditional energy management into Smart Energy Management. This framework includes factors and aspects from outside of the organisation's boundaries like national policy, external funding or international standards and from the inside and which touch on and take into consideration every constituent of the organisation. It is not only specific to energy but can be used for other resources or services as its core is focusing on a systematic integration and transition rather than focusing on a subject; in this study, it is energy. Furthermore, the study has stressed the necessity to identify what the concept of 'Smart' means for the organisation rather than adopting ready-made solutions and approaches in order to avoid implementing strategies that might fail since they were not tailored to address specific issues.

9.6. Limitations of the Research

The researcher has followed research ethics to produce a rigorous study, but he acknowledges that there are some limitations which can be addressed in future work:

First, the researcher has an engineering, i.e. technical background, and his job position is also linked to the technical and managerial aspects of energy management, which might have influenced the direction of the research and its findings as the study has sometimes focused more on addressing technical solutions. Energy management is a broad concept, and the study had to focus on some aspects which are technical and managerial but acknowledges the importance of other aspects like people's role in implementing this practice. The researcher, through his proposed definition of Smart Energy Management and the related framework, has focused on highlighting the importance of the integration of human and technical solutions. The study has also looked at defining the role of energy managers within their organisations, explaining how important their role is and exploring the effect of smart systems on the organisation's stakeholders including members of staff. However, when it came to identifying energy saving solutions, the research has tended to focus on technical solutions and briefly looked at the human related solutions like behaviour change. The study has stressed the fact that much importance should be given to members of staff as they are the ones who drive these systems; therefore, they should be included in designing the solutions, they should be well trained and, most importantly, be able to voice their concerns and suggestions. This is why the case study in Northamptonshire County Council focused on interviewing members of staff at different levels of the organisation in order to get their view of centralised energy management and to identify how the proposed concept can elaborate on the role of people.

Second, this study has looked at defining the financial benefits and costs of rolling out smart meters and using them for energy management in one LA. However, the researcher has found some difficulties in addressing this point. Nevertheless, through the case study of NCC, the research was successful in quantifying the direct costs of rolling out the meters, staffing and data reporting for one LA; this was presented under the Northamptonshire County Council's case study. The difficulty lies in assessing the savings; the energy data produced by this technology is used in many processes and schemes and, as it has been stated in the thesis, helps save time and gives insight into the energy profile of buildings; these benefits are difficult to quantify and monetise. The interviewees also claimed that smart meters help in achieving energy savings but none of them has been successful in quantifying them. This links back to one of the points discussed under 8.2.2 which highlighted the importance of designing 'invest to save' programmes which explain in detail the reasons behind rolling out this technology and the potential savings based on detailed feasibility studies, in addition to the role and the necessity of including this knowledge by the Central Government in their Smart Meter Rollout Programme.

Third, although the researcher has been more interested in identifying the perception of energy managers from different types of LAs in regard to energy management and smart meters usage, he could have interviewed more LAs from each type to have a larger sample. However, by looking at the results of the interviews, the interviewees often have a similar perception and a wider sample appeared unnecessary.

9.7. Recommendations for Local Authorities in Relation with Energy Management

Based on the previous chapters and the discussion above, the thesis has a number of recommendations for more efficient energy management in Local Authorities:

- A successful implementation and integration of energy management in LAs means creating a system that has the support (administrative and financial) of the leadership and which first builds on all the internal capabilities that the organisation has before seeking support from outside the organisation. It needs to be led by a motivated member of staff who has both the knowledge of how the organisation works and knowledge related to energy management. The system needs to be valid for the whole organisation including all its employees but needs to focus on the main energy stakeholders as they understand the energy systems better and can have a better impact. The Smart Energy Management Framework (SEM) framework is useful in a way it defines the characteristics and the factors (both external and internal) that needs to be taken into consideration in order to facilitate the integration of this practice into the LA.
- Continual improvement of the energy management system is necessary to guarantee the persistent achievement of energy savings. However, this can only be achieved by exploring new solutions which can be new processes or new technologies or new management practices, etc. The organisation, through its management systems needs to have mechanisms put in place to assess these new solutions and see how they can first address the organisation's needs (e.g. list capabilities of the new solution and match it with the needs of the LA), second maximise their benefits (e.g. use the full capabilities of the systems) and third combine them and build on what is already available (e.g. knowledge capture mechanisms) in the organisation in order to avoid investing in new solutions that will achieve exactly the same results that can be reached with the systems already put in place. These mechanisms can also allow the organisation to embrace change and always keep modernising itself.

9.8. Future Research

This section presents ways in which future research can be undertaken following the recommendations arising from this study.

- The research has introduced and explained the factors that can enable the integration of energy management in general and Smart Energy Management in specific into an organisation. This framework needs to be further tested in future research in order to assess its validity.
- The study has suggested that the Smart Energy Management framework can help in translating smart city ambitions into practice; further research is needed to explore if it can be replicated in various areas other than the energy one in local authorities like transport or waste management as an example.
- This study could be replicated to other public-sector organisations which have access to public funds like Central Government departments, or the NHS, etc. This study has taken into consideration the advantages and barriers facing LAs as public-sector institutions, but further research should identify if these apply for public institutions in general or additional factors need to be taken into consideration.
- The study has concluded that smart meters and high-resolution data became necessary tools for energy managers as they perceive that they can help in achieving energy savings. Further research can look at methods to verify if savings are actually achieved thanks to these technologies, and to quantify them.
- The study has found that active energy monitoring and targeting is not a priority for energy managers. Further research can look at ways to encourage these managers to start 'invest to save schemes' using this activity.
- In this study, and an associated paper, the researcher has reviewed the UK's Smart Meters Rollout programme; one of the findings is that the focus of this programme was not the customers or the users of technology and that there were no intentions for helping users in using this technology in the way it will enable them to achieve great savings.

9.9. Conclusion

This chapter has presented a summary of the thesis, an overview of its findings and where the latter were linked to the research aim and objectives. The research has also explained how the research objectives were achieved. The chapter has identified the research limitations and explained how the researcher addressed them and tried to limit their effect on the study. Last, these limitations have been used to identify areas for future research.

This study has looked at energy management as a practice that is essential for governance in Local Authorities. This practice was linked to technological innovation to understand how the latter affects it. It was also linked to the concepts of “Smart” and “Smart City” as they were the starting points of this thesis. This is why this study focused on defining “Smart” and proposed a new concept which is “Smart Energy Management”.

References

- 50001seaps.eu. (2017) ISO 50001 and Sustainable Energy Planning. Integrating a Sustainable Energy Action Plan with an Energy Management System. Available on: http://www.50001seaps.eu/fileadmin/user_upload/Materials/WP6/D.6.13/50000and1-SEAPs_Booklet-A5_EN.pdf [Accessed on: 11/12/2017]

- Abd Aziz, M. A., Rahman, H. A., Alam, M. M. & Said, J. (2015) Enhancement of the Accountability of Public Sectors through Integrity System. Internal Control System and Leadership Practices: A Review Study. *Procedia Economics and Finance*, 28. pp. 163-169.

- Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. (2005) A Review of Intervention Studies aimed at Household Energy Conservation. *Journal of Environmental Psychology*, 25. pp. 273- 291.

- Adams, G. and Schvaneveldt, J. (1991) *Understanding Research Methods* (2nd edition). New York: Longman.

- Ahmad, M. W., Mourshed, M., Mundow, D., Sisinni, M., & Rezgui, Y. (2016) Building Energy Metering and Environmental Monitoring: A State of the Art Review and Directions for Future Research. *Energy and Buildings*, 120 (5). pp. 85-102.

- Allmark, P. J., Boote, J., Chambers, E., Clarke, A., McDonnell, A., Thompson, A. & Tod, A. (2009) Ethical Issues in the Use of in-depth Interviews: Literature Review and Discussion. *Research ethics review*, 5 (2). pp. 48-54.

- Andone, D., Holotescu, C., & Grosseck, G. (2014) Learning Communities in Smart Cities: Case Studies. *2014 International Conference on Web and Open Access to Learning (ICWOAL)*. pp. 1-4.

- Angelidou, M. (2015) Smart Cities: A Conjuncture of Four Forces. *Cities*, 47. op. 95-106.

- Annunziata, E., Rizzi, F. & Frey, M. (2014) Enhancing energy efficiency in public buildings: The role of local energy audit programmes. *Energy Policy*, 69. pp. 364-373.
- Aoun, C. (2013) The Smart City Cornerstone: Urban Efficiency. *Schneider Electric White Paper*.

- Atikol, U (n.d.) Energy Management & Utilization: Energy Audit. *EMU Energy Research Centre.* Available online on:

https://www.coursehero.com/file/27415191/ME547-UA-CH3-Energy-Audit-2015pdf/ [Accessed on: 10/10/2017]

- Atkins, L. & Wallac, S. (2012) *Qualitative Research in Education*. SAGE Publication.

- Azennoud, M., Bull, R., Lemon, M., & Perry, D. (2017) How Can the Process of Adopting Energy Management in Organisations Inform Water Management Practice? *Journal of Clean Technologies*, 5 (5). pp. 417–421.

- Azennoud, M., Stuart, G., Bull, R., Lemon, M., and Perry, D. (2017) Smart Energy Management: How Does the Use of Smart Meters Help in Achieving Energy Savings: Case Studies from Two Local Authorities in the UK. *ECEEE Summer Study Conference Proceedings 2017*. pp 657-666.

- BBC. (2016) What does it mean to be an Academy School? Available on: https://www.bbc.co.uk/news/education-13274090 [Accessed on: 19/01/2018]

- BBC. (2018) Sajid Javid orders Probe into County Council's Finances. Available on: http://www3.northamptonshire.gov.uk/councilservices/council-and-democracy/performance-and-plans/Documents/CodeOfCorporateGovernance.pdf [Accessed on: 15/01/2018]

- Becker, L. J., Seligman, C., Fazio, R. H. & Darley, J. M. (1981) Relating Attitudes to Residential Energy Use. *Environment and Behavior*, 13(5). pp. 590-609.

- Benedetti, M., Cesarotti, V. & Introna, V. (2017) From Energy Targets Setting to Energy-aware Operations Control and Back: An Advanced Methodology for Energy Efficient Manufacturing, *Journal of Cleaner Production*, 167. pp. 1518-1533.

- Bhattacharjee, K. (2014) Use of Monitoring & Targeting in Building an Energy Management Program in Small & Midsized Companies. *World Energy Engineering Congress*. pp. 1295-1299.

- Bijker, W. (1987) The Social Construction of Bakelite: Toward a Theory of Invention. In The social Construction of Technological Systems: New directions in the Sociology and History of Technology, edited by Wiebe Bijker, Thomas Hughes, and Trevor Pinch, pp. 17-50. Cambridge, MA: MIT Press.

- Bird, K. (2012) ISO launches ISO 50001 Energy Management Standard. *International Organisation for Standardisation.* Available online on: https://www.iso.org/news/2011/06/Ref1434.html [Accessed on: 10/09/2017]

- Bolchini, C., Geronazzo, A. & Quintarelli, E. (2017) Smart buildings: A Monitoring and Data Analysis Methodological Framework. *Building and Environment*, 121. pp. 93-105.

- Borg, N., Mills, E., Martin, N. & Jeffrey, H. (1998) Energy Management in the Government Sector-An International Review. Available online on: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.396.5628&rep=rep1&type=pdf [Accessed on: 10/12/2017]

- Bourn, J. (2007) The carbon Trust: Accelerating the Move to a Low Carbon Economy. *The National Audit Office.* Available on: https://www.nao.org.uk/wp-content/uploads/2007/11/07087.pdf [Accessed on: 19/12/2017]

- Bridges, W. (1986) Managing Organizational Transitions. *Organizational Dynamics*, *158 (1)*. pp. 24-33

- Bridges, W. (1991) *Managing Transitions: Making the Most of Change*. Addison-Wesley.

- British Standards Institute. (2014). Smart Cities – Vocabulary. *BSI Standards Limited 2014.* Available online on: http://shop.bsigroup.com/upload/PASs/Free-Download/PAS180.pdf [Accessed on: 18/09/2017]

- British Standards Institute. (2016) PAS180:2014. Smart Cities – Vocabulary. Available on: http://shop.bsigroup.com/upload/PASs/Free-Download/PAS180.pdf [Accessed on: 10/02/2018]

- British Standards Institute. (n.d.) How Certification to Several Management System Standards Has Helped Drive Business Efficiencies and Cost Savings at an Award-Winning Factory. Available on: https://www.bsigroup.com/LocalFiles/en-GB/iso-50001/case-studies/BSI_Tata_220414_WR.PDF [Accessed on: 12/12/2017]

- British Standards Institute. (n.d.) Sheffield Hallam University Reduces Carbon Emissions by 11 per cent and Total Energy Savings by £10,000 per Month. Available on: https://www.bsigroup.com/Documents/iso-50001/case-studies/BSI-ISO-50001-case-study-Sheffield-Hallam-University-UK-EN.pdf [Accessed on: 12/12/2017]

- Brown, N. & Wright, A. J. (2007) New Approaches to the Gathering, Analysis and Interpretation of Half Hourly Energy Metering Data from Buildings. *International Journal of Low Carbon Technologies*, 2(1). pp 80-96.

- Brown S. L. & Eisenhardt K. M. (1998) *Competing on the Edge: Strategy as Structured Chaos*. HBR Press, Boston.

- Bryman, A. (2008). *Social Research Methods*. Oxford University Press.

- Bryman, B. and Bell, E. (2011) *Business Research Methods*, 3rd ed. Oxford: Oxford University Press.

- Building Research Energy Conservation Support Unit. (1995) Organisational Aspects of Energy Management: a Self-Assessment Manual for Managers. Available online on: https://www.cibse.org/getmedia/fdeaa402-198f-488a-9aed-3933e440e437/GPG167-Organisational-Aspects-of-Energy-Management-a-Self-assess-Manual-for-Managers.pdf.aspx [Accessed on: 09/05/2018]

- Bull, R. and Azennoud, M. (2016) Smart Participation- Social Learning: A Model of Participation. *Energy – Proceedings of the Institution of Civil Engineers*, 169 (8). pp. 93-101.

- Bull, R., Lemon, M., Everitt, D. & Stuart G. (2015) Moving beyond Feedback: Energy Behaviour and Local Engagement in the United Kingdom. *Energy Research & Social Science*, 8. pp. 32-40.

- Burgoon, M. (2012) Energy Management: What's Next for Manufacturing? *Plant Engineering.*
- Burnes, B. (2004) *Managing Change: A Strategic Approach to Organisational Dynamics (4th edition)*. Harlow: Prentice Hall.

- Burns, R. (2000) *Introduction to Research Methods*. London: Sage Publications Limited.

- Burte, H. (2014) The 'Smart City' Card. *Economic & Political Weekly*, 49 (11). pp. 22-25.

- Bushe, G. R. & Marshak, R. J. (2009) Revisioning Organisation Development: Diagnostic and Dialogic Premises and Patterns of Practice. *Journal of Applied Behavioural Science, 45(3)*. pp.348–368.

- By, R. T. (2005) Organisational Change Management: A Critical Review. *Journal of change management, 5 (4)*. pp. 369–380. Available on: https://www.researchgate.net/publication/233604011_Organizational_Change_Management_A_Critical_Review [Accessed on: 13/11/2018]

- By, R. T., Burnes, B., & Oswick, C. (2011) Change Management: The Road Ahead. *Journal of Change Management, 11 (1)*. pp: 1–6. Available on:

https://www.researchgate.net/publication/211383466_Change_Management_The_Road_Ahead [Accessed on: 14/11/2018]

- Caller, M. (2018) Northamptonshire County Council Best Value Inspection January – March 2018. Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/690731/Best_Value_Inspection_NCC.pdf [Accessed on: 24/04/2018]

- Callon, M. (1987) Society in the Making: the Study of Technology as a Tool for Sociological Analysis. In: Bijker, W.E., Hughes, T.P., Pinch, T.J. (Eds.), The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. MIT Press, Cambridge, MA. pp. 83–103.

- Calvillo, C.F., Sánchez-Miralles, A., & Villar, J. (2016) Energy Management and Planning in Smart Cities. *Renewable and Sustainable Energy Reviews*, 55 (3). pp. 273-287.

- Cao, G. & Pietiläinen (FI), J. (2013) Data Collection Systems for the Management of Building Energy System. *International Energy Association.* Available online on: http://www.iea-ebc.org/Data/publications/EBC_Annex_53_Appendix_Volume_4.pdf [Accessed on: 11/10/2017]

- Carbon Trust (2007). Advanced Metering for SMEs Carbon and Cost Savings. Available on: https://www.carbontrust.com/resources/reports/technology/advanced-metering- for-smes/ [Accessed: 20/12/2016]

- Carbon Trust. (2005) GPG352: An introductory guide to energy performance assessment. *The Carbon Trust.*

- Carbon Trust. (2010) Monitoring and Targeting. Available online on: https://www.carbontrust.com/media/31683/ctg008_monitoring_and_targeting.pdf [Accessed on: 25/10/2017]

- Carbon Trust. (2011). Energy Surveys: A Practical Guide to Identifying Energy Saving Opportunities. *The Carbon Trust.* Available online on: https://www.carbontrust.com/resources/guides/energy-efficiency/energy-surveys/#docdownload-7028 [Accessed on: 10/10/2017]

- Carbon Trust. (2012). Metering: Introducing the Techniques and Technology for Energy Data Management. *The Carbon Trust.* Available online on: https://www.carbontrust.com/media/31679/ctv027_metering_technology_overview.pdf [Accessed on: 10/09/2017]

- Carbon Trust. (2014) Automatic Monitoring and Targeting (AMT) Equipment and Systems. Available online on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/376176/ECA756_Automatic_monitoring_and_targeting__AMT__equipment___systems.pdf [Accessed on: 26/10/2017]

- Carbon Trust. (n.d.) Energy Management Self-Assessment Tool. Available online on: https://www.carbontrust.com/resources/tools/energy-management-self-assessment-tool/ [Accessed on: 09/05/2018]

- Carbon Trust. (n.d.) Local Government: Energy efficiency and carbon saving advice for local government organisations. Available online on: https://www.carbontrust.com/resources/guides/sector-based-advice/local-government/ [Accessed on: 09/12/2017]

- Carbon Trust. (n.d.) Local Government: Energy Efficiency and Carbon Saving Advice for Local Government Organisations. Available online on: https://www.carbontrust.com/resources/guides/sector-based-advice/local-government/ [Accessed on: 16/01/2018]
- Carbon Trust. (n.d.) The Carbon Trust Standard. 10 years of Certifying Real Reductions. Available online on: https://www.carbontrust.com/client-services/certification/carbon-trust-standard/ [Accessed on: 09/05/2018]

- Carnall, C. A. (2007). *Managing Change in Organisations (*5th edition). Pearson Education Limited.

- Castro, C. J. & Silva, G. V. (2017) Good Governance Practices Applied to the Public Sector: Analysis of Five Federal Public Universities Accountability. *Espacios*, 38.

- CBI Ministry of Foreign Affairs. (2013) CBI Product Factsheet: for Electronic Components for Smart Meters in Sweden, Denmark, Italy, UK, France and Spain. [Online] Available on: https://www.cbi.eu/sites/default/files/market_information/researches/product-factsheet-smart-meters-italy-uk-denmark-sweden-spain-france-electronics-electrical-engineering-2013.pdf [Accessed: 08/12/2017]

- Centre for Excellence in Learning, University of Victoria (n.d.) *Managing Change and Transition: An Overview.* Available on: https://www.adelaide.edu.au/hr/docs/pdp-nav-change-transition.pdf [Accessed on: 15/11/2018]

- CHILDE, V. G. (1950) The Urban Revolution. *The Town Planning Review*, 21(1). pp. 3-17.

- Chiu, D., Stewart, C., & McManus, B. (2012) Electric Grid Balancing Through Low Cost Workload Migration. *ACM SIGMETRICS Performance Evaluation Review*, 40 (12). pp. 48-52.

- Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., Scholl, H. J. (2011) Understanding smart cities: An integrative framework. In *Proceedings of the Annual Hawaii International Conference on System Sciences*. pp. 2289-2297.

- Citizens Advice Scotland. (2016) Smart Move: Taking Stock of the Smart Meter Rollout Programme in Scotland. [Online] Available on: https://www.cas.org.uk/system/files/publications/smart_move_-_taking_stock_of_the_smart_meter_rollout_programme_in_scotland.pdf [Accessed: 18/11/2017]

- City of Cape Town. (2009) *Development Issues in Cape Town*. Available online on: www.capetown.gov.za [Accessed on: 16/09/2017]

- Committee on Climate Change. (2012) How Local Authorities can Reduce Emissions and Manage Climate Risk. Available online on: https://www.theccc.org.uk/wp-content/uploads/2012/05/1584_CCC_LA-Report_bookmarked_1b.pdf [Accessed on: 16/01/2018]

- Copiello, S. (2017) Building Energy Efficiency: A Research Branch Made of Paradoxes. *Renewable and Sustainable Energy Reviews*, 69 (3). pp. 1064-1076.

- Covenant of Mayors for Climate & Energy. (n.d.) Covenant Community. Available online on: https://www.covenantofmayors.eu/about/covenant-community/signatories.html [Accessed on: 10/12/2017]

- Covenant of Mayors. (2013) Baseline Emission Inventory & Sustainable Energy Action Plan Development. Available online on: https://www.covenantofmayors.eu/about/covenant-community/signatories.html [Accessed on: 10/12/2017]

- Creswell, J. W. (2013) *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*, 3rd ed. Washington DC: Sage.

- Croner. (2017) Energy Audits: In-depth. *Croner-i Ltd*. Available online on: https://app.croneri.co.uk/topics/energy-audits/indepth?product=139 [Accessed on: 12/10/2017]

- Cross, R., Baker, W., & Parker, A. (2003) What creates Energy in Organizations? *MIT Sloan Management Review*, 44. pp. 51-56.

- Crotty, M. (1998) *The Foundations of Social Research: Meaning and Perspective in the Research Process*. SAGE Publications Limited.

- Crown Gas & Power. (2012) Project Nexus – TPI Information. Available online on: https://www.gasgovernance.co.uk/sites/default/files/ggf/UNC514D.pdf [Accessed on: 23/11/2017]

- Darby, S. (2006) The Effectiveness of Feedback on Energy Consumption. *Environmental Change Institute, University of Oxford*. Available online on: http://www.eci.ox.ac.uk/research/energy/downloads/smart-metering-report.pdf [Accessed on: 27/11/2017]

- Darby, S. (2010) Smart Metering: what Potential for Householder Engagement? *Building Research & Information*, 38 (5). pp. 442-457.

- Darby, S. J. (2016) SME022: Written Evidence. *UK Parliament*. Crown Gas & Power. (2012) Project Nexus – TPI Information. Available online on: http://data.parliament.uk/WrittenEvidence/CommitteeEvidence.svc/EvidenceDocument/Science%20and%20Technology/Smart%20meters/written/32026.html [Accessed on: 23/11/2017]

- Davenport, T. H. (1994) Saving it's Soul: Human Centered Information Management. *Harvard Business Review*. 72 (2). pp. 119-131.

- Davis, J., Edgar, T., Porter, J., Bernaden, J. & Sarli, M. (2012) Smart Manufacturing: Manufacturing Intelligence and Demand-dynamic Performance. *Computers & Chemical Engineering*, 47 (12). pp. 145-156.

- De Jong, M., Joss, S., Schraven, D., Zhan, C., & Weijnen, M. (2015) Sustainable Smart Resilient-Low Carbon Eco Knowledge Cities: Making Sense of a Multitude of Concepts Promoting Sustainable Urbanization. *Journal of Cleaner Production*, 109 (12). pp. 25-38.

- Delbridge, R. & Kirkpatrick, I. (1994) Theory and Practice of Participant Observation. In V. Wass and P. Wells (eds.) *Principles and Practice in Business and Management Research*. Aldershot: Dartmouth. pp. 35-62.

- Denscombe M. (1998) *The Good Research Guide: For Small-scale Social Research Projects*. Buckingham: Open University Press.

- Denzin, N. & Lincoln, Y. (2000) *Introduction: The Discipline and Practice of Qualitative Research*. Thousand Oaks, CA: Sage.

- Department for Business, Energy & Industrial Strategy. (2016) Smart Meter Roll-out Cost-Benefit Analysis: Part I. [Online] Available on: https://www.gov.uk/government/uploads/

system/uploads/attachment_data/file/567167/OFFS-EN_2016_smart_meters_cost-benefit-update_Part_I_FINAL_VERSION.PDF [Accessed on: 21/12/2016]

- Department for Business, Environment and Industrial Strategy & Environment Agency. (2015) CRC Energy Efficiency Scheme. *UK Government.* Available on: https://www.gov.uk/government/collections/crc-energy-efficiency-scheme [Accessed on: 14/12/2017]

- Department for Business, Environment and Industrial Strategy. (2017) Leading by example: cutting energy bills and carbon emissions in the public and higher education sectors. *UK Government.* Available on: https://www.gov.uk/government/collections/crc-energy-efficiency-scheme [Accessed on: 15/12/2017]

- Department for Communities and Local Government. (2015) Improving the Energy Efficiency of our Buildings. A guide to Display Energy Certificates and Advisory Reports for Public Buildings. *UK Government.* Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/452481/DEC_Guidance__rev_July_2015_.pdf [Accessed on: 14/12/2017]

- Department for Communities and Local Government. (2017) A Guide to Energy Performance Certificates for the Construction, Sale and Let of Non Dwellings. Improving the Energy Efficiency of our Buildings. *UK Government.* Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666186/A_guide_to_energy_performance_certificates_for_the_construction_sale_and_let_of_non-dwellings.pdf [Accessed on: 14/12/2017]

- Department for Digital, Culture, Media & Sport. (2015) Libraries as a Statutory Service. Available on: https://www.gov.uk/government/publications/guidance-on-libraries-as-a-statutory-service/libraries-as-a-statutory-service [Accessed on: 07/12/2017]

- Department of Energy & Climate Change (2012) *The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK.* Available online on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf [Accessed on: 13/10/2017]

- Department of Energy and Climate Change. (2012) Improving Energy Efficiency in Buildings: Resources Guide for Local Authorities. *UK Government.* Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/

attachment_data/file/65578/6746-improving-energy-efficiency-in-buildings-resource.pdf [Accessed on: 15/12/2017]

- Department of Energy and Climate Change. (2014) Smart Metering Implementation Programme. *UK Government.* Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65578/6746-improving-energy-efficiency-in-buildings-resource.pdf [Accessed on: 19/12/2017]

- Department of Health. (n.d.) The New Public Health Role of Local Authorities. *UK Government.* Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/213009/Public-health-role-of-local-authorities-factsheet.pdf [Accessed on: 05/12/2017]

- Department of the Environment, Transport and the Regions. (1998) Monitoring and Targeting in Small and Medium-sized Companies. UK *Department of Environment, Transport and the Regions.* Available online on: https://www.cibse.org/getmedia/d4175625-9844-4027-b591-e9ab9b4de837/EES8-Application-of-Monitoring-and-Targeting-to-Energy-Management-1989-(EEO).pdf.aspx [Accessed on: 24/11/2017]

- Dodman, D., McGranahan, G., & Dalal-Clayto, B. (2013) Integrating the Environment in Urban Planning and Management: Key principles and Approaches for Cities in the 21st Century. *UNEP.* Available online on: http://www.citiesalliance.org/sites/citiesalliance.org/files/publications/integrating_the_environment.pdf [Accessed on: 16/09/2017]

- Droege, P. (2002) Renewable Energy and the City: Urban Life in an Age of Fossil Fuel Depletion and Climate Change. *Bulletin of Science, Technology & Society*, 22(2). pp. 87–99.

- Drucker, P. F. (1998) The Discipline of Innovation. *Leader to Leader*, 1998. pp. 13-15.

- Drucker, P. (1999) Drucker on Financial Services : Innovate or Die. *The Economist*, 352. pp: 25-28.

- Duranton, G & Puga, D. (2013) The growth of Cities. Duranton, Gilles and Puga, Diego, The Growth of Cities (August 2013). *CEPR Discussion Paper No. DP9590*. Available online on: https://www.oecd.org/eco/growth/Growth_of_cities_Duranton.pdf [Accessed on: 10/06/2018]

- Eccleston, C., March, F., Cohen, T. (2017) *Inside Energy: Developing and Managing and ISO 50001 Energy Management System*. New York: CRC Press.

- Efficiency Valuation Organisation. (2007) International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1.

- Ehrhardt-Martinez, K. (2011) The Persistance of Feedback-Induced Energy Savings. Available online on: https://web.stanford.edu/group/peec/cgi-bin/docs/behavior/research/Ehrhardt-Martinez%202011%20-%20Feedback%20and%20Persistence%20Paper.pdf [Accessed on: 27/11/2017]

- Elexon. (2013) Load profiles and their use in Electricity Settlement. [Online] Available on: https://www.elexon.co.uk/wp-content/uploads/2013/11/load_profiles_v2.0_cgi.pdf [Accessed on: 10/11/2017]

- Elexon. (2017) Balancing and Settlement Code: Code of Practice One. Available online on: https://www.elexon.co.uk/wp-content/uploads/2017/02/CoP1_Issue2_v11.0.pdf [Accessed on: 18/10/2017]

- Ellis, C. (n.d.). *History of Cities and City Planning*. Available online on: http://www.art.net/~hopkins/Don/simcity/manual/history.html [Accessed on: 12/09/2017]

- Energy Cities and Climate Alliance. (2013) Guidebook to Accelerate the Implementation of the Covenant of Mayors via National Clubs. Available online on: http://www.energy-cities.eu/IMG/pdf/net-com_publishable_report.pdf [Accessed on: 10/12/2017]

- Energy Information Administration. (2017) International Energy Outlook 2016. Chapter 6: Building Sector Energy Consumption. *US Government.* Available online on: https://www.eia.gov/outlooks/ieo/pdf/buildings.pdf [Accessed on: 10/06/2018]

- European Commission. (n.d.) Good Practice in Energy Efficiency. For a Sustainable, Safer and more Competitive Europe. Available on: https://ec.europa.eu/energy/sites/ener/files/documents/good_practice_in_ee_-web.pdf [Accessed on: 15/12/2017]

- European Commission. (n.d.) Supporting Local Authorities in the Development and Integration of SEAPs with Energy Management Systems According to ISO 50001. Available on: https://ec.europa.eu/energy/intelligent/projects/en/projects/50000-and-1-seaps [Accessed on: 11/12/2017]

- Evans, B., Joas, M., Sundback, S. & Theobald, K. (2005). Governing local sustainability. *Journal of Environment Planning and Management*, 49 (6). pp. 849-867.

- Eysi, D. (2016) The Usefulness of Qualitative and Quantitative Approaches and Methods in Researching Problem-Solving Ability in Science Education Curriculum. *Journal of Education and Practice*, 7. pp. 91-100.

- Faruqui, A., Sergici, S. & Sharif, A. (2009) The Impact of Informational Feedback on Energy Consumption – A Survey of the Experimental Evidence. *Energy*, 35 (4). pp. 1598-1608.

- Ferreira, V., Alves, L., Fleming, P., Stuart, G., Patel, P., Webber, P. & Conway, S. (2007) "Low Hanging Fruits" or Cost-effective Energy and Water Savings using Intelligent Metering and Monitoring Systems? *ECEEE 2007 Summer Study*. pp. 739-742.

- Ferrigno, L., Morello, R., Paciello, V. &, Pietrosanto, A. (2013) Remote Metering in Public Networks. *Metrology & Measurement Systems*, XX (4). pp. 705-714.

- First for Wellbeing. (n.d.) Northamptonshire Population. *Northamptonshire County Council.* Available on: https://www.nao.org.uk/wp-content/uploads/2007/11/07087.pdf [Accessed on: 19/05/2018]

- Fluke (n.d.) Fluke 1738 Advanced Power Logger. *Fluke Corporation.* Available online on: http://en-us.fluke.com/products/power-and-energy-loggers/fluke-1738-advanced-power-logger.html [Accessed on: 12/04/2018]

- Fudge, S., & Peters, M. (2009). Motivating Carbon Reduction in the UK: the Role of Local Government as an Agent of Social Change. J*ournal of Integrative Environmental Sciences, 6(2)*. pp. 103-120.

- Fudge, S., Peters, M. & Woodman, B. (2016) Local Authorities as Niche Actors: the Case of Energy Governance in the UK. *Environmental Innovation and Societal Transitions, 18 (1).* pp. 117.

- Fudge, S., Peters, M., Hoffman, S., Wehrmeyer, W., (Eds.), (2013) *The Global Challenge of Sustainable Living: Opportunities, Barriers, Policy and Practice*. Edward Elgar Ltd., Cheltenham.

- Geels, F. W. (2002) Technological Transitions as Evolutionary Reconfiguration Processes: a Multi-Level Perspective and a Case-Study. *Research Policy, 31*(8). pp. 1257–1274.

- Geels, F. W. (2011) The multi-Level Perspective on Sustainability Transitions: Responses to Seven Criticisms. *Environmental Innovation and Societal Transitions*, *1*(1). pp. 24–40.

- Genus, A., & Coles, A. M. (2008) Rethinking the Multi-Level Perspective of Technological Transitions. *Research Policy*, *37*(9). pp. 1436–1445.

- Gill, J. and Johnson, P. (2002) *Research Methods for Managers*, 3rd ed. London: Sage.

- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008) Methods of Data Collection in Qualitative Research: Interviews and Focus Groups. *Bdj*, 204 (3). pp. 291-295.

- Gotel, D. G. & Hale D. K. (1989) The Application of Monitoring & Targeting to Energy Management. *UK Secretary of State for Energy.* Available online on: https://www.cibse.org/getmedia/d4175625-9844-4027-b591-e9ab9b4de837/EES8-Application-of-Monitoring-and-Targeting-to-Energy-Management-1989-(EEO).pdf.aspx [Accessed on: 23/11/2017]

- Gov.uk. (n.d.) Understand how your Council Works. *UK Government.* Available on: https://www.gov.uk/understand-how-your-council-works [Accessed on: 03/12/2017]

- Gov.wales. (2015) Unitary Authorities. *Welsh Government.* Available on: https://gov.wales/topics/localgovernment/unitary-authorities/?lang=en [Accessed on: 03/12/2017]

- Guttman, B. S. (2004). The Real Method of Scientific Discovery. *Skeptical Inquirer*, 28. pp. 45-47.

- Hargreaves, T., Nye, M. & Burgess, J. (2010). Making Energy Visible: a Qualitative Field Study of how Householders Interact with Feedback from Smart Energy Monitors. *Energy Policy*, 38. pp.6111-6119.

- Hastings, A., Bailey, N., Bramley, G., Gannon, M. & Watkins, D. (2015) The Cost of the Cuts: The Impact on Local Government and Poorer Communities. *Joseph Rowntree Foundation.* Available on: https://www.jrf.org.uk/sites/default/files/jrf/migrated/files/Summary-Final.pdf [Accessed on: 07/12/2017]

- Hermes, J. (2013) The New Role of Energy Managers. *Energy Manager Today.* Available on: https://www.energymanagertoday.com/the-new-role-of-energy-managers-093892/ [Accessed on: 12/12/2017]

- Hinkelmann, k. & Witshcel, F. (n.d.) How to Choose a Research Methodology? *University of Applied Sciences Northwestern Switzerland.*

Available online on: http://knut.hinkelmann.ch/lectures/project2013/p1_5_how-to-choose-a-research-methodology.pdf [Accessed on: 03/10/2017]

- HM Government Department for Environment Food and Rural Affairs. (2008) Future Water: The Government's Water Strategy for England. Available online on: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69346/pb13562-future-water-080204.pdf [Accessed on: 23/01/2017]

- HM Government. (2010). The Building Regulations 2010: Conservation of Fuel and Power (L2A). Available online on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/540328/BR_PDF_AD_L2A_2013_with_2016_amendments.pdf [Accessed on: 25/10/2017]

- HM Government. (2010). The Building Regulations 2010: Conservation of Fuel and Power (L2B). Available online on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/540329/BR_PDF_AD_L2B_2013_with_2016_amendments.pdf [Accessed on: 25/10/2017]

- Höjer, M., & Wangel, J. (2014) Smart Sustainable Cities: Definition and Challenges. *Advances in Intelligent Systems and Computing*, 310(8). pp. 333-349.

- House of Commons. (2016) Evidence Check: Smart Metering of Electricity and Gas. Available online on: https://publications.parliament.uk/pa/cm201617/cmselect/cmsctech/161/161.pdf [Accessed on: 23/01/2017]

- Huber, A., & Mayer, I. (2015) Is this a Smart City? Narratives of City Smartness and their Critical Assessment. *ECEEE Summer Study Proceedings*, 4-154-15. pp. 817-823.

- Husar, M., Ondrejicka, V. & Ceren, S. (2017) Smart Cities and the Idea of Smartness in Urban Development – A Critical Review. *IOP Conference Series: Materials Science and Engineering*, *245*(8).

- International Energy Agency (n.d.) *Energy Efficiency*. Available online on: https://www.iea.org/topics/energyefficiency/ [Accessed on: 13/10/2017]

- International Monetary Fund. (2016) Corruption: Costs and Mitigation Strategies. Available on: http://www.imf.org/external/pubs/ft/sdn/2016/sdn1605.pdf [Accessed on: 06/12/2017]

- International Organisation for Standardisation. (2011) *Energy Management Systems: Requirements with Guidance for Use.*

- International Organisation for Standardisation. (n.d.) Energy Management Systems: Requirements with Guidance for Use. Available online on: https://www.iso.org/iso-50001-energy-management.html [Accessed on: 11/12/2017]

- International Organisation for Standardisation. (n.d.) ISO50001 – Energy Management. Available online on: https://www.iso.org/iso-50001-energy-management.html [Accessed on: 10/12/2017]

- International Organisation for Standardisation. (n.d.). ISO 50001:2011. Energy Management Systems - Requirements with Guidance for Use. Available online on: https://www.iso.org/standard/51297.html [Accessed on: 17/01/2018]

- Kamenders, A., Rosa, M., & Kass, K. (2017) Low Carbon Municipalities. The Impact of Energy Management on Climate Mitigation at Local Scale. *Energy Procedia*, 128. pp. 172-178.

- Keele, R. (2011) *Nursing Research and Evidence-Based Practice: Ten Steps to Success.* Sudbury, MA: Jones & Bartlett Learning.

- Kelley, K., Clark, B., Brown, V. & Sitzia, J. (2003) Good Practice in the Conduct and Reporting of Survey Research. *International Journal for Quality in Health Care*, 15 (4). pp. 261-266.

- Kelly, S. & Pollitt, M. (2011) The Local Dimension of Energy. *University of Cambridge.* Available on: https://www.repository.cam.ac.uk/bitstream/handle/1810/241873/cwpe1114.pdf;jsessionid=AE628862CE12A94AD13A254812C4173C?sequence=1 [Accessed on: 15/12/2017]

- Kemp, R. P. M., Rip, A., & Schot, J. (2001) Constructing Transition Paths Through the Management of Niches. In R. Garud, & P. Karnoe (Eds.), *Path Dependence and Creation.* pp. 269-299. Mahwa (N.J.) and London: Lawrence Erlbaum.

- Kennett, S. (2014) Which Local Authorities in the UK are Top for Energy Efficiency? Available on: https://www.2degreesnetwork.com/groups/2degrees-community/resources/which-local-authorities-uk-top-energy-efficiency/ [Accessed on: 15/12/2017]

- Khan, M. F., Jain, A., Aranuchalam, V. & Paventhan, A. (2014) Communication Technologies for Smart Metering Infrastructure. *2014 IEEE*

Students' Conference on Electrical, Electronics and Computer Science (SCEECS). pp. 1-5.

- Kim, T., Hong, H. & Magerko, B. (2010) Designing for Persuasion: Toward Ambient Ecovisualization for Awareness. *Persuasive Technology Proceedings*, 6137. pp. 106-116.

- Kissock, J. K. & Eger, C. (2008) Measuring Industrial Energy Savings. *Applied Energy*, 85(5). pp. 347-361.

- Krippendorf, K. (1980) *Content Analysis: An Introduction to its Methodology*. Beverly Hills, CA: Sage.

- Kvale S. & Brinkmann S. (2009) *Interviews: Learning the Craft of Qualitative Research Interviewing*. Newbury Park, London: Sage.

- Kvale, S. (1996) *Interviews: An introduction to Qualitative Research Interviewing*. Thousand Oaks, CA: Sage.

- LASER (2018). Cost Avoidance Report for Northamptonshire County Council.

- Lee, D., & Cheng, C. (2016) Energy Savings by Energy Management Systems: A Review. *Renewable and Sustainable Energy Reviews*, 56(4). pp. 760–777.

- Lekamge, S., & Marasinghe, A. (2013) Developing a Smart City Model that Ensures the Optimum Utilization of Existing Resources in Cities of all Sizes. In *Proceedings - 2013 International Conference on Biometrics and Kansei Engineering, ICBAKE 2013*. pp. 202-207.

- Leung, L. (2015) Validity, Reliability, and Generalizability in Qualitative Research. *Journal of Family Medicine and Primary Care*, 4(3). pp. 324–327.

- Local Government and Communities Directorate. (2017) Local Authorities: factsheet. *Scottish Government*. Available on: https://beta.gov.scot/publications/local-authorities-factsheet/ [Accessed on: 03/12/2017]

- Local Government Association. (2016) The Potential for Energy Efficiency and Renewable Energy. Available online on: https://www.local.gov.uk/sites/default/files/documents/download-potential-energy-9f8.pdf [Accessed on: 09/12/2017]

- Local Government Association. (2016) What is Local Government? Available online on: https://www.local.gov.uk/about/what-local-government [Accessed on: 30/06/2018]

- Local Government Association. (n.d.) The Councillor's Role. Available on: https://www.local.gov.uk/our-support/guidance-and-resources/councillors-guide-201718/councillors-role [Accessed on: 03/12/2017]

- Local Government Group. (2010) Local Government Structure Overview. Available on: https://www.local.gov.uk/sites/default/files/documents/local-government-structur-634.pdf [Accessed on: 03/12/2017]

- Local Government Shared Services. (n.d.) About LGSS. Available on: https://www.lgss.co.uk/about/ [Accessed on: 16/01/2018]

- Loorbach, D.A, & Rotmans, J. (2010) The Practice of Transition Management: Examples and Lessons from Four Distinct Cases. *Futures: the Journal of Policy, Planning and Futures Studies, 42(3)*. pp: 237–246.

- Mahmudi, A. M. & Saremi H. R. (2015) The Role of Citizen Participant in Urban Management (Case Study: Aligudarz City). *American Journal of Engineering Research*, 4 (1). pp. 70-75.

- Mallaburn, P. (2016) A New Approach to Non-Domestic Energy Efficiency Policy. A Report for the Committee on the Climate Change. *UCL Energy Institute.* Available on: https://www.theccc.org.uk/wp-content/uploads/2016/10/A-new-approach-to-non-domestic-energy-efficiency.pdf [Accessed on: 14/12/2017]

- Malaviya, P. & Wadhwa, S. (2005) Innovation Management in Organizational Context: an Empirical Study. *Global Journal of Flexible Systems Management*, 6 (2). pp.1-14.

- Manville, C., Cochrane, G., Cave, J., Millard, J., Kevin Pederson, J., Thaarup, R. K., Kotterink, B. (2014) Mapping Smart Cities in the EU. *European Union, Directorate General for Internal Policies*.

- Marimon, F., & Casadesús, M. (2017) Reasons to Adopt ISO 50001 Energy Management System. *Sustainability*, 9 (10).

- Matsumoto, E. (n.d.) Milestones: Weston Meters. *Engineering and Technology History Wiki.* Available online on: http://ethw.org/Milestones:Weston_Meters [Accessed on: 16/10/2017]

- Mauro, P. (1995) Corruption and Growth. *Quarterly Journal of Economics*, 110. pp 681-712.

- McCalley, L. T. & Midden, C. J. H. (2002) Energy Conservation through Product-integrated Feedback: the Roles of Goalsetting and Social Orientation. *Journal of Economic Psychology*, 23(5). pp. 589-603.

- McHann, S. E. (2013) Grid analytics: How much data do you really need? *Rural Electric Power Conference*. pp. 5-8.

- McQueen, R. A., & Knussen, C. (2002) *Research Methods for Social Science: A Practical Introduction*. Prentice Hall.

- Milward, B. H. & Provan, K. G. (2000) Governing the Hollow State. *Journal of Public Administration Research and Theory*, 10 (4). pp. 359-380.

- Ministry of Housing, Communities & Local Government. (2011) Local Government Structure and Elections. Available on: https://www.gov.uk/guidance/local-government-structure-and-elections [Accessed on: 03/12/2017]

- Ministry of Housing, Communities & Local Government. (2011) Review of Local Government Statutory Duties: Summary of Responses. Available on: https://www.gov.uk/government/publications/review-of-local-government-statutory-duties-summary-of-responses--2 [Accessed on: 03/12/2017]

- Molina-Solana, M. Ros, M., Ruiz, M. D., Gomez-Romero, J. & Martin-Bautista, M. (2017) Data Science for Building Energy Management: A Review. *Renewable and Sustainable Energy Reviews*, 70. pp. 598-609.

- Molina-Solana, M., Ros, M., Ruiz, M. D., Gómez-Romero, J., & Martin-Bautista, M. J. (2017) Data Science for Building Energy Management: A Review. *Renewable and Sustainable Energy Reviews*, 70 (4). pp. 598–609.

- Morgan, D. L. (2007) Paradigm Lost and Pragmatism Regained. *Journal of Mixed Methods Research*, 1(1). pp. 48-76.

- Morris, E. (2010) Schools still need Local Authorities. *The Guardian*. Available on: https://www.theguardian.com/education/2010/jun/22/schools-local-education-authorities [Accessed on: 18/01/2018]

- Morris, T. and Wood, S. (1991) Testing the Survey Method: Continuity and Change in British Industrial Relations. *Work Employment and Society*, (5). pp. 259-82.

- Morse KCB, A. (2014) The Impact of Funding Reductions on Local Authorities. *National Audit Office*. Available online on: https://www.nao.org.uk/wp-content/uploads/2014/11/Impact-of-funding-reductions-on-local-authorities.pdf [Accessed on: 18/09/2017]

- Morvaj, B., Lugaric, L., & Krajcar, S. (2011) Demonstrating Smart Buildings and Smart Grid Features in a Smart Energy City. In *Proceedings of the 2011 3rd International Youth Conference on Energetics (IYCE)*. pp. 1-8.

- MSEI (2006) The History of the Electricity Meter. *Metering & Smart Energy International.* Available online on: https://www.metering.com/top-stories/the-history-of-the-electricity-meter/ [Accessed on: 15/10/2017]

- Mumford, L. (1937) What is a City. *Architectural Record*, LXXXII (11), in IEEE Spectrum (1976). pp. 93-96.

- Mungiu-Pippidi, A. (2010) EU as a Good Governance Promoter. *Romanian Journal of Political Science*, 10.

- Murray, A., Minevich, M., & Abdoullaev, A. (2011) Being Smart about Smart Cities. *Knowledge Management World*, 9(11). pp. 20-23.

- Nadel, S. (2017) How Many Billions do US Businesses and Individuals Invest in Energy Efficiency Each Year? *ACEEE.* Available on: http://aceee.org/blog/2017/07/how-many-billions-do-us-businesses [Accessed on: 14/12/2017]

- Naess, P. (2001) Urban Planning and Sustainable Development. *European Planning Studies*, 9(4). pp. 503-524.

- National Audit Office. (2014) Electricity Balancing Services. Available online on: https://www.nao.org.uk/wp-content/uploads/2014/05/Electricity-Balancing-Services.pdf [Accessed on: 21/11/2017]

- National Geographic. (n.d.) The Development of Agriculture: The farming Revolution. *National Geographic Society.* Available online on: https://genographic.nationalgeographic.com/development-of-agriculture/ [Accessed on: 12/09/2017]

- Neenan, B. (2009) Residential Electricity Use Feedback: A Research Synthesis and Economic Framework. *Report 1016844*. Palo Alto, CA: Electric Power Research Institute. Available online on: http://www.energycollection.us/Energy-Efficiency/Residential-Electricity-Use-Feedback.pdf [Accessed on: 27/11/2017]

- Nelson, R. R., & Winter, S. G. (1977) In search of Useful Theory of Innovation. *Research Policy, 6*. pp. 36–76

- Nidirect.gov.uk. (n.d.) Local Councils. *Northern Irish Government.* Available on: https://www.nidirect.gov.uk/articles/local-councils [Accessed on: 03/12/2017]

- Northampton County Association of Local Councils. (2014) Local Councils. Available on: http://www.northantscalc.com/local-councils.html [Accessed on: 04/01/2018]

- Northamptonshire County Council. (2010) Local Code of Corporate Governance. Available on: http://www3.northamptonshire.gov.uk/councilservices/council-and-democracy/performance-and-plans/Documents/CodeOfCorporateGovernance.pdf [Accessed on: 04/01/2018]

- Northamptonshire County Council. (2016) Articles of the Constitution. Available on: https://cmis.northamptonshire.gov.uk/cmis5live/Document.ashx?czJKcaeAi5tUFL1DTL2UE4zNRBcoShgo=35yyuGpoxu3aYB91CmbShNlccJBi%2FbbE9uVn3eccRYPoBXMejvqf8w%3D%3D&rUzwRPf%2BZ3zd4E7Ikn8Lyw%3D%3D=pwRE6AGJFLDNlh225F5QMaQWCtPHwdhUfCZ%2FLUQzgA2uL5jNRG4jdQ%3D%3D&mCTIbCubSFfXsDGW9IXnlg%3D%3D=hFflUdN3100%3D&kCx1AnS9%2FpWZQ40DXFvdEw%3D%3D=hFflUdN3100%3D&uJovDxwdjMPoYv%2BAJvYtyA%3D%3D=ctNJFf55vVA%3D&FgPlIEJYlotS%2BYGoBi5olA%3D%3D=NHdURQburHA%3D&d9Qjj0ag1Pd993jsyOJqFvmyB7X0CSQK=ctNJFf55vVA%3D&WGewmoAfeNR9xqBux0r1Q8Za60lavYmz=ctNJFf55vVA%3D&WGewmoAfeNQ16B2MHuCpMRKZMwaG1PaO=ctNJFf55vVA%3D [Accessed on: 08/12/2017]

- Northamptonshire County Council. (2016) Council Plan 2016-2020: Appendix A. Available on: https://www3.northamptonshire.gov.uk/councilservices/council-and-democracy/performance-and-plans/Documents/Council%20Plan/Council%20plan%202016.pdf [Accessed on: 15/01/2018]

- Northamptonshire County Council. (n.d.) Code of Corporate Governance. Available on: http://www3.northamptonshire.gov.uk/councilservices/council-and-democracy/performance-and-plans/Pages/code-of-corporate-governance.aspx [Accessed on: 04/01/2018]

- Northamptonshire County Council. (n.d.) Northamptonshire Climate Change Strategy 2014-2017. Available on: https://www3.northamptonshire.gov.uk/councilservices/environment-and-planning/climate-change/Documents/Northamptonshire%20CCS%202014-2017%20Final.pdf [Accessed on: 17/01/2018]

- O'Rielly, K. & Jeswiet, J. (2015) The Need for Better Energy Monitoring within Industry. *Procedia CIRP*, 29. pp.74–79.

- Office of Gas and Electricity Markets. (2014) Balancing and Settlement Code (BSC) P272: Mandatory Half Hourly Settlement for Profiles Classes 5-8. Available online on: https://www.ofgem.gov.uk/publications-and-updates/balancing-and-settlement-code-bsc-p272-mandatory-half-hourly-settlement-profile-classes-5-8 [Accessed on: 23/11/2017]

- Office of Gas and Electricity Markets. (2014) Electricity Settlement Reform – Moving to Half-hourly Settlement. Available online on: https://www.ofgem.gov.uk/sites/default/files/docs/2014/04/electricity_settlement_launch_statement_0.pdf [Accessed on: 20/11/2017]

- Office of Gas and Electricity Markets. (2015) Uniform Network Code (UNC) 514: Extending the Daily Metered 'Voluntary' Service to Project Nexus Implementation Date Plus Six Months (UNC514). Available online on: https://www.gasgovernance.co.uk/sites/default/files/ggf/UNC514D.pdf [Accessed on: 23/11/2017]

- Office of Gas and Electricity Markets. (n.d.) Fact Sheet: Meter Accuracy & Billing Disputes. Available online on: https://www.ofgem.gov.uk/ofgem-publications/42361/5875-factsheetmeteraccuracy-and-billingdisputes-pdf [Accessed on: 10/11/2017]

- Office of Gas and Electricity Markets. (n.d.) Uniform Network Code. Available online on: https://www.ofgem.gov.uk/licences-industry-codes-and-standards/industry-codes/gas-codes/uniform-network-code [Accessed on: 23/11/2017]

- Official Journal of the European Union. (2006) Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-use Efficiency and Energy services and Repealing Council Directive 93/76/EEC. Available on: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0032 [Accessed on: 23/12/2016]

- Official Journal of the European Union. (2009) DIRECTIVE 2009/72/EC of the European Parliament and of the Council of 13 July 2009 Concerning Common Rules for the Internal Market in Electricity and Repealing Directive 2003/54/EC. Available on: http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32009L0072 [Accessed on: 23/12/2016]

- Official Journal of the European Union. (2012) Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, Amending Directives 2009/125/EC and 2010/30/EU and Repealing Directives 2004/8/EC and 2006/32/EC. Available on: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0027 [Accessed on: 23/12/2016]

- Official Journal of the European Union. (2012) Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, Amending Directives 2009/125/EC and 2010/30/EU and Repealing Directives 2004/8/EC and 2006/32/EC. Available on: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF [Accessed on: 11/12/2017]

- Oppenheim, A. N. (2000) *Questionnaire Design, Interviewing and Attitude Measurement*. London: Continuum International.

- Oung, K. (2013) *Energy Management in Business: The Manager's Guide to Maximising and Sustaining Energy Reduction*. Ashgate Publishing Limited.

- Patel, K. L. & Patel, S. M. (2016) Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges. *International Journal of Engineering Science & Computing*, 6 (5), pp. 6122-6131.

- Pattison, S. D. (2006) Eliminating Silos in Government. *Governing the States and Localities.* Available online on: http://www.governing.com/columns/mgmt-insights/Eliminating-Silos-in-Government.html [Accessed on: 14/09/2017]

- Perry, D. (2010) Challenging Times and Targets Ahead. In The Carbon Reduction Commitment. *The ENDS Special Report.* Available on: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjJhLnQ-4fbAhUBuRQKHYodAEMQFggrMAA&url=https%3A%2F%2Fwww.endsreport.com%2Freports%2Fdownload%2F%3FreportID%3D26588&usg=AOvVaw3ODNUVEIYjSrMQ_lTus-Le [Accessed on: 18/01/2018]

- Perry, D. (2016). Cabinet Paper: Energy Procurement Risk Management Strategy.

- Pitt, D. (2013) Electrical Power Measurement: the Impact of Part L2 of the Building Regulations. *EATON.* Available online on: http://www.eaton.uk.com/ecm/idcplg?IdcService=GET_FILE&allowInterrupt=1&RevisionSelectionMethod=LatestReleased&noSaveAs=0&Rendition=Primary&dDocName=PCT_489707 [Accessed on: 25/10/2017]

- Politics.co.uk. (n.d.) Regional Development Agencies. Available on: http://www.politics.co.uk/reference/regional-development-agencies [Accessed on: 04/12/2017]

- Porter, N., Claassen, M., & Timmermans, J. (2015) Transition Experiments in Amsterdam: Conceptual and Empirical Analysis of Two Transition Experiments in the WATERgraafsmeer Program. *Technological Forecasting and Social Change, 90*. pp: 525–537.

- Raman, B. (2012) Overview of Single Phase Induction Type Energy Meter. *Electric Engineering Portal.* Available online on: http://electrical-engineering-portal.com/overview-of-single-phase-induction-type-energy-meter [Accessed on: 15/04/2018]

- Rao, P., Muller, M. R., & Gunn, G. (2017). Conducting a Metering Assessment to Identify Submetering Needs at a Manufacturing Facility. *CIRP Journal of Manufacturing Science and Technology*, 18 (8). pp. 107–114.

- Rapp, F., & Rat-Fischer, C. (2012) Worldwide City Concepts Analysis: Analysis Mapping of Over 30 City Concepts Dealing with Sustainability Issues. *3rd Global Forum on Urban Resilience and Adaptation*. pp. 1-13.

- Reichertz, J. (2009) Abduction: The Logic of Discovery of Grounded Theory. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 11(1).

- Richards, P., Fell, M., & White, E. (2014). Smart Meters. House of Commons Library. Available online on: http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06179 [Accessed on: 18/04/2017]

- Rind, D. (1999). Complexity and Climate. *Science*, 284 (4). pp.105-107, April 1999.

- Rip, A., Schot, J., & Misa, T. J. (1995) Constructive Technology Assessment: A New Paradigm for Managing Technology in Society. In Managing Technology in Society. The Approach of Constructive Technology Assessment (pp. 1-12). London, New York: Pinter Publishers.

- Risser, R. (n.d.) ISO50001: Energy Management System. *International Energy Association.* Available online on: https://www.iea.org/media/workshops/2010/emakworkshop2/9ROLANDRISSER_USDOE.pdf [Accessed on: 11/09/2017]

- Robson, C. (2002) *Real World Research*. UK: Blackwell Publishing.

- Robson, C. (2011) *Real World Research, Third Edition*. UK: John Wiley & Sons Ltd.

- Rohdin, P. & Thollander, P. (2006) Barriers to and Driving Forces for Energy Efficiency in the Non-energy Intensive Manufacturing Industry in Sweden. *Energy*, 31. pp. 1836-1844.

- SALIX. (2017) Local Authorities. Applications and Expressions of Interest are Welcomed. Available on: https://www.salixfinance.co.uk/loans/england-local-authorities [Accessed on: 15/12/2017]

- Salminen, A. & Ikola-Norrbacka, R. (2010) Trust, Good Governance and Unethical Actions in Finnish Public Administration. *International Journal of Public Sector Management*, 23(7). pp. 647–668.

- Sandford, M. (2018) Local Government in England: Structures. *House of Commons Library*. Available on: http://researchbriefings.files.parliament.uk/documents/SN07104/SN07104.pdf [Accessed on: 03/05/2018]

- Saunders, M., Lewis, P. & Thornhill, A. (2009) *Research Methods for Business Students. Fifth ed*. Essex, UK: Parson Education Limited.

- Scharpf, F. W. (1997) *Games Real Actors Play: Actor-Centered Institutionalism in Policy*. Westview Press.

- Schiller T. (2007) Direct Democracy and Theories of Participatory Democracy—Some Observations. In: Pállinger Z.T., Kaufmann B., Marxer W., Schiller T. (eds) *Direct Democracy in Europe*. Wiesbaden: VS Verlag für Sozialwissenschaften.

- Senior, B. (2002) *Organisational Change (2nd edition)*. London: Prentice Hall.

- Sheffield Hallam University. (n.d.) What is Governance? Available on: https://www.shu.ac.uk/about-us/governance-and-strategy/governance [Accessed on: 06/12/2017]

- Shelton, T., Zook, M., & Wiig, A. (2015) The 'Actually Existing Smart City'. *Cambridge Journal of Regions Economy and Society*, 8(1). pp. 13-25.

- Shen, B., Prince, L. & Lu, H. (2012) Energy Audit Practices in China: National and Local Experiences and Issues. *Energy Policy*, (46). pp. 346-358.

- Shrouf, F., & Miragliotta, G. (2015). Energy Management Based on Internet of Things: Practices and Framework for Adoption in Production Management. *Journal of Cleaner Production*, 100 (8). pp. 235-246.

- Silverman, D. (2001) *Interpreting Qualitative Data*. London: Sage Publications.

- Silverman, D. (2006) *Doing Qualitative Research*. London: Sage Publications.

- Smart Energy GB. (n.d.) About the Rollout: Who's Doing What? [Online] Available on: https://www.smartener- gygb.org/en/the-bigger-picture/about-the-rollout/roles- and-responsibilities/government [Accessed: 08/02/2016]

- Smith, A., Stirling, A., & Berkhout, F. (2005) The governance of Sustainable Socio-Technical Transitions. *Research Policy (34).* pp. 1491–1510.

- Smith, C. B., & Parmenter, K. E. (2016) Chapter 1 - Introduction. In Smith, C. B. & Parmenter, K. E. (Eds.). *Energy Management Principles: Applications, Benefits, Savings.* Oxford: Elsevier.

- Soderstrom, O., Paasche T. & Klauser, F. (2014) Smart Cities as Corporate Storytelling. *City*,18. pp. 307-320.

- Söderström, O., Paasche, T., & Klauser, F. (2014) Smart cities as corporate storytelling. *City*, 18(3). pp.307-320.

- South East Midland Local Enterprise Partnership. (2016) NEP and SEMLEP merge to form one Local Enterprise Partnership. Available on: https://www.semlep.com/news/2016/nep-and-semlep-merge-to-form-one-local-enterprise-partnership/ [Accessed on: 03/05/2018]

- Soyaltin, D. (2017) *Europeanisation, Good Governance and Corruption in the Public Sector: The Case of Turkey*. Taylor & Francis.

- SSI (2003) Energy Meter. *Small Industries Service Institute.* Available online on: http://www.iea-ebc.org/Data/publications/EBC_Annex_53_Appendix_Volume_4.pdf [Accessed on: 11/10/2017]

- Stake, R. E. (1995) *The art of case study research*. Thousand Oaks, CA: Sage Publications.

- Stan, L. (2009). Content Analysis. In A. J. Mills, G. Durepos, & E. Wiebe (eds.) *Encyclopedia of case study research*. Thousand Oaks, CA: Sage Publications.

- Steward, F., Coles, A. M., & McNally, R. (2004) Technology Transition as a Process of Innovation Network Reconfiguration. *In: Proceedings on Innovation Sustainability and Policy Conference*. pp. 23–25.

- Stuart, G., Snape, R. & Fleming, P. (2016) Closing the Feedback Loop: a Systems Approach to Supporting Community-wide Behaviour Change in Non-domestic Buildings. *ACEEE Summer Study on Energy Efficiency in Buildings.* pp. 1-12.

- Svennevig, J. (2001). Abduction as a Methodological Approach to the Study of Spoken Interaction. *Norskrift*. pp.1-22.

- Tashakkori, A. & Teddlie, C. (eds) (2003) *Handbook of Mixed Methods in Social and Behavioural Research*. Thousand Oaks, CA: Sage.

- The Chartered Institute of Public Finance & Accountancy. (2007) Delivering Good Governance in Local Government: Guidance Note for English Authorities. Available on: http://www.solace.org.uk/knowledge/reports_guides/goodgovernance-England-2007-02.pdf [Accessed on: 06/12/2017]

- The Chartered Institute of Public Finance & Accountancy. (2016) Delivering Good Governance in Local Government: Framework. Available on: http://aylesburyvale.moderngov.co.uk/documents/s7049/Good%20Governance%20AGS%20report%20June%202017.pdf [Accessed on: 06/12/2017]

- The European Energy Award. (n.d.) Welcome to the European Energy Award. Available on: http://www.european-energy-award.org/home/ [Accessed on: 15/12/2017]

- The Local Enterprise Partnership Network (2013). Local Enterprise Partnerships. Politics.co.uk. (n.d.) Regional Development Agencies. Available on: http://www.lepnetwork.org.uk/leps/ [Accessed on: 04/12/2017]

- The National Archives. (1988) Education Reform Act 1988. *UK Government.* Available on: http://www.legislation.gov.uk/ukpga/1988/40/contents [Accessed on: 18/01/2018]

- The National Archives. (n.d.) Local Area Agreement. *UK Government.* Available on: http://webarchive.nationalarchives.gov.uk/+/http://www.dh.gov.uk/en/SocialCare/Socialcarereform/Localareaagreements/index.htm?PageOperation=email [Accessed on: 18/01/2018]

- The Organisation for Economic Co-operation and Development. (2012). The Future of Eco-innovation: the Role of Business Models in Green Transformation. *OECD Background Paper*.

- The University of Adelaide (n.d.) *Understanding Change and Transition*. Available on: https://www.adelaide.edu.au/hr/docs/pdp-nav-change-transition.pdf [Accessed on: 14/11/2018]

- Thurrock Council. (n.d.) Cabinet: Role of a Cabinet Member. Available on: https://www.thurrock.gov.uk/cabinet/role-of-cabinet-member [Accessed on: 16/01/2018]

- Tidd, J., Bessant, J. & Pavitt, K. (2005) *Managing Innovation : Integrating Technological, Market and Organisational Change, 3rd edition*. John Wiley & Sons, Ltd.

- Tingey, M., Webb, J. & Hawkey, D. (2017) Local Authority Engagement in UK Energy Systems: Highlights from Early Findings. *UKERC, London and The ETI, Loughborough*. Available on: http://www.ukerc.ac.uk/publications/local-authority-engagemnet-in-uk-energy-systems-highlights-from-early-findings-.html [Accessed on: 15/12/2017]

- Ueno, T., Tsuji, K. & Nakano, Y.(2006) Effectiveness of Displaying Energy Consumption Data in Residential Buildings: To Know Is to Change. *ACEEE Summer Study on Energy Efficiency in Buildings*. pp. 264-277.

- UK Government. (n.d.) Appendix 5.1: Smart meter roll-out in Great Britain. Available on: https://assets.publishing.service.gov.uk/media/56ebdf4ded915d117a000004/Appendix_5.1_-_Smart_meter_roll-out_in_Great_Britain.pdf [Accessed on: 19/12/2017]

- UK Government. (n.d.). Types of School. Available on: https://www.gov.uk/types-of-school [Accessed on: 19/01/2018]

- United Nations Committee of Experts on Public Administration. (2006) Definition of Basic Concepts and Terminologies in Governance and Public Administration. Available on: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan022332.pdf [Accessed on: 06/12/2017]

- United Nations Environment Programme. (2007) *Sustainable Buildings and Construction Initiative Buildings and Climate Change: Status, Challenges and Opportunities*. Paris: UNEP.

- United Nations. (2012) Governance and Development. Available on: http://www.un.org/millenniumgoals/pdf/Think%20Pieces/7_governance.pdf [Accessed on: 06/12/2017]

- United Nations. (2015) World's Population Increasingly Urban with more than Half Living in Urban Areas. Available on: http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html [Accessed on: 06/06/2018]

- Van Dam, S., Bakker, C. & Van Hal, J. (2010) Home Energy Monitors: Impact Over the Medium-term. *Building Research & Information*, 38 (5). pp. 458-469.

- VAN DER WALDT, G. (2007) *Municipal Management: Serving the People*. Cape Town, Juta.

- Van Staden M. (2017) Sustainable Energy Transition: Local Governments as Key Actors. In: Uyar T. (eds) Towards 100% Renewable Energy. Springer Proceedings in Energy. Springer, Cham.

- Vanolo, a. (2013) Smart Mentality: The Smart City as Disciplinary Strategy. *Urban Studies*, 51(5). pp. 883–898.

- Weber, R. (1990) *Basic Content Analysis*. London: Sage.

- Weber, R. (2004). Editor's Comments: The Rhetoric of Positivism versus Interpretivism: A Personal View. *MIS Quarterly*, 28(1). pp. Iii-Xii.

- Willis, H. L., & Philipson, L. (2005). *Understanding Electric Utilities and De-Regulation*. CRC Press.

- Woodhouse, J. & Dempsey, N. (2016) Public Libraries. *House of Commons Library.* Available on: http://researchbriefings.files.parliament.uk/documents/SN05875/SN05875.pdf [Accessed on: 07/05/2018]

- Woodrum, E. (1984) Mainstreaming Content Analysis in the Social Sciences: Methodological Advantages, Obstacles and Solutions. *Social Science Research*, 13 (3). pp. 1-19.

- YIN, R. K. (2003) Case Study Research: Design and Methods, 3rd ed. California, USA: AGE Publications.

- YIN, R.K. (2009) *Case Study Research: Design and Methods*. Fourth ed. California, USA: Sage Publications.

Appendices

Appendix A: Information Sheet & Consent Form for the 1st Set of Questionnaires

Smart Cities: Supporting a Step Change in Local Governments

Dear Participant,

Thank you for your willingness to take part in this interview. Would you please take the time to read this information sheet and sign the attached consent form before starting this interview?

Information Sheet for Research Participants

The aim of this research is to explore how energy data management can support a Smart Local Authority.

The research will be seeking to understand how the introduction of smart meters and the data generated on them can help energy managers, in different levels of local authority's hierarchy, in their daily energy management tasks and in decision making. Smart meters and the analysis of the data generated come at a cost, so how these will be offset? On another level, the research will seek to identify how site managers perceive energy management and how they monitor their site's energy usage.

This project is funded by Northamptonshire County Council which is the upper tier local authority for Northamptonshire.

You have been invited to participate in this interview because you work for a local authority and have a relationship with energy management.

This session, with your approval, will be recorded. Any name or sensitive data or personal information will not appear in the research and will be handled under the terms of the Data Protection Act 1998.

The collected data will be only accessible by the research team. This data might be used in publication but anonymity of the interviewee, suppliers, clients, etc. will be respected.

The data will be held securely and disposed of when it is no more needed for the research.

Participation in this research is completely voluntary and you have the right to withdraw whenever you want.

If you have any queries specifically about Data Protection Issues you may contact Fraser Marshall, Records Manager, Kimberlin Library, De Montfort University, The Gateway, Leicester LE1 9BH, UK Tel: 0116 257 7655, email: fmarshall@dmu.ac.uk.

Yours sincerely,

Marouane Azennoud

Contact Details

Marouane Azennoud Tel.: 079 12 89 20 40 email: p14187075@myemail.ac.uk

Dr Richard Bull Tel.: 0116 207 8063 email: rbull@dmu.ac.uk

Prof Mark Lemon Tel.: 0116 257 7977 email: mlemon@dmu.ac.uk

Dr Graeme Stuart Tel.: 0116 257 7964 email: gstuart@dmu.ac.uk

Dr Darren Perry Tel.: 01604 366948 email: daperry@northamptonshire.gov.uk

Consent Form

Please put a tick or a cross in the relevant boxes

I, ________________________ [participant's name] agree that this questionnaire material may be used by the research team at De Montfort University [Marouane Azennoud].

I have received a copy of the *Information Sheet for Research Participants*, and I have read and understood this.

I agree that the contents of the questionnaire may be used in a variety of ways throughout the life of the research project and afterwards: in discussion with other researchers, in any ensuing presentations, reports, publications, websites, broadcasts and in teaching.

Please use this space if you would like to qualify your consent to the use of the interview in any way:

I understand that I can withdraw consent for this questionnaire to be used at any point by contacting any member of the research team.

I have received a copy of this statement.

Signature of participant ____________________________ Date ________________

Signature of researcher ____________________________ Date ________________

Contact information

Marouane Azennoud

P14187075@myemail.dmu.ac.uk

Institute of Energy and Sustainable Development

De Montfort University

Queens Building

The Gateway

Leicester LE1 9BH

Appendix B: List of Questions for the 2nd Set of Interviews

List of Questions for the LAs

- What is your job role within the LA?

- Do you have an energy management team (or similar) within the LA? If yes, who is responsible for it and how many team members does it have?

- Could you please explain the governance of energy related decision making (i.e. hierarchy of energy related decision making)?

- How many buildings are included in your energy management scope? What is their main usage?

- Do you use smart meters? If yes, when did you start using them and for which utilities are they used for?

- Do you receive half hourly meter reads?
    - If yes:
        - What was the motivation to start using them?
        - Who collects them? (Is it your organisation energy supplier, etc.?)
        - What is the purpose of collecting the half hourly energy consumption?
        - Do you pay to have access to these meters readings? How do you access them (i.e. do you use a specific system)? What is the cost of having this arrangement? Is there a way in which you cover the costs of the arrangement?
        - Who is responsible for analysing the half hourly energy consumption?
        - How do you use the results of this analysis? Do you utilise real time (or near-real time) monitoring of energy consumption?
        - Do the results of this analysis inform your decision making?
    - If not:
        - Why do you not use half hourly meter reads?

- How do you make energy related decisions? Do you feel that half hourly meter readings would improve energy-related decision making?
- Are you planning to use them in the future? If so, what is the motivation?

Appendix C: List of Questions to NCC Members of Staff taking part in this Study

List of Questions for the participants

- What is your job role? Under which team or organisation do you fall? what does your job consist of?

- What is your relationship (or your team, or organisation) with NCC?

- How many sites/buildings are you managing or looking after? And which utilities do they use?

- Do you know what energy management and energy monitoring mean?

- Do you apply energy management approaches in your sites (i.e. energy efficiency. Energy budgeting, etc.)?

- Could you please explain the governance of energy related decision making (i.e. hierarchy of energy related decision making)?

- Do you have access to the energy data of your sites like half hourly meter reads or utilities invoices or systemslink?

- Do you use the energy data for energy monitoring and controlling the sites energy consumption?

- How do you control the energy consumption of your sites? Do you have a set of measures that site managers need to follow like switching off lights at the end of the day, heating control, etc.?

- If your site faces any problem in relation with energy, how do you act to resolve it?

NCC has been shifting into a central energy management for all its properties, what do you think of this approach and how does it affect energy management of your sites?

Appendix D: List of Questions for a Councillor from Northamptonshire County Council

List of Questions for Councillor

- What is your job role? What does your job consist of? Which Cabinet Portfolio do you look after?

- How do you perceive the concepts of energy management and energy monitoring? (Your view)

- Does the Council see any benefits from implementing energy management and energy monitoring?

- I understand that the creation of the role of 'Head of Energy & Carbon Management' was a Cabinet decision to address the targets set in the Climate Change Act 2008, can you please explain the rationale behind this decision and/or the benefits of having this role within the Council?

- How does the Cabinet interact with the Head of Energy & Carbon Management? Also, how does Cabinet interact with the energy team in the Property Department? Do you see any issues or challenges?

- In terms of governance, how do you see energy related decision making? Do you have any views? (e.g. energy contracts, energy efficiency projects, etc.)

- Does the Cabinet have any plans to reduce the energy consumption of NCC? Are you aware of any Energy Efficiency schemes for NCC properties?

- From my work experience and my previous research interviews with members of staff, I have the impression that NCC has been shifting into a central energy management model for all its properties (e.g. energy budgets held by service i.e. property and not by the service area). What do you think of this approach?

    - Many NCC sites now do not have site managers or clerks, what do you perceive to be the effect on energy management for these sites, if any?
    - Does the political affiliation of the leading party in the Cabinet have any influence on energy management?

- There are examples of Councils that have started big projects to generate energy from Renewable Energies e.g. solar, wind, waste, etc., are similar schemes proposed for Northamptonshire?

- Is there anything that you would like to add that can support my research?

Thank you for your time.

Appendix E: Interviews Summary

	Kent County Council (KCC)	Milton Keynes Council (MKC)	North East Lincolnshire Council (NELC)	Buckinghamshire County Council (BCC)
Interviewee's Job Role & Duties	Energy Manager: Responsible for Energy Efficiency for KCC's estate (incl Schools), managing the SALIX fund for the County, work with community groups to set up energy projects, & works also on capital projects (ex: district heating system)	Senior Practioner (Energy Manager): responsible for all aspects of energy usage and moving towards sustainability, monitoring and paying all energy bills for MKC (excl. schools), produce DECs and ARs for MKC and Schools (way to collect data), managing a SALIX fund, & provides energy and billing advice to schools	Strategic Commissioning Lead for Energy & Environment: concentrate less on services and focus more on outcomes of planning where energy is one the aspects to focus on.	Energy & Resource officer
Type of Authority	Two tier authority where KCC is the upper Tier	One tier authority	One tier Authority	Two tier authority where BCC is the upper Tier
Seize of the Buildings Portfolio	Between 400-500 buildings not including Fire The County also has 612 schools where most of them buy energy through the Council under the LASER Basket	150 Authority buildings, 35 sheltered housing schemes with 30 flats each, between 200-300 landlords in Council houses 3 buildings of the 150 which consumes 80% of the energy cost 57 HH sites incl. schools Procures energy for all MKC buildings, schools and academies (except of 4 schools) through LASER.	Around 190 meters for gas & electricity but it is a changing portfolio because of rationalisation plans. Majority of Property buildings fall under mandatory HH metering. The authority procures energy (electricity & gas) for its buildings and the schools which agreed to be part of its energy basket through Ecova which is a	430 buildings from Council buildings (e.g. Depots, HQ, Laundries, and Libraries), schools and Academies

			subsidiary of ENGIE	
Size of the Energy Team	There is no Energy Management Team, the energy manager is the only member of the Council responsible for energy management but he gets lot of help from LASER who supervises energy procurement	4 FT incl the energy manager + a vacancy	The Authority has an Energy & Carbon Team which consists of Portfolio holders, elected member, legal officer, the interviewee and two representatives from ENGIE which counts as an Energy team and has a responsibility of developing and governing energy related projects and a low carbon economy. There is a plan of developing a team to look at delivering energy management within the authority. ENGIE is a strategic partner for the Regeneration plan and is responsible for the operational aspect of energy.	The energy management team is included in the Environment department. The team has 7 members
Council Hierarchy	The energy manager is a member of the Stable Business & Communities team which is under the Growth, Environment & Transport Directorate	The team falls under the Public Realm directorate (everything that affects public life)	Director of Finance & Resources who is a member of The Council Leadership Team	Transport, Economy, and Environment unit

Energy Related Decision Making	Size of the project and its cost are the main criteria used to decide whether a project should go to full Council meeting for vote (ex: £40 M Street Lighting Project) or the energy manager can decide on his own if the project is beneficial for KCC & its schools	If the project cost is more than £2,000, it needs to have Council's approval because most projects are capital projects	In the case of a key decision (high financial value, can affect the whole Council, etc.), the Council needs to approve it. If a manager is going to spend money in the limits of his/her budget, s/he does not need to go to Council for approving the project.	Head of energy & resources (1) Strategic energy advisor (1)/ Energy manager (1) Energy & resources officer (4)
'Smart' Meter Roll-out	LASER has managed the roll-out of smart meters and it has been done in different phases. 1st meter was installed around 2012. 50-60% of KCC buildings have electricity Smart Meters HH metering in mandatory HH buildings	Under the LASER contract, there is a requirement to move to at least AMRs 80% of electricity AMRs are installed (the remaining 20% does not have AMRs because of technical issues) 30% of gas AMRs are installed 1st AMR installed in 2011	The interviewee has just came back recently to this job position and does not know when the first Smart meter was installed. Smart meters are only using for mandatory HH sites	Smart meters have been used since 2010 mostly for electricity for buildings with high energy consumption.
Motivation	Installed two Solar systems in the two biggest buildings and at the same time installed electricity, gas and water smart meters to record the electricity, gas and water use & the solar production	Reduction in energy billing errors and estimation (the team pays around 14,000 bills/year) Compliance with CRC to reduce its cost Carbon Accreditation	Address legal requirements for metering	Better control of energy demand throughout efficient use of data and for reporting purposes. In addition, access to HH data supports the team to search for energy saving opportunities.

Hindrance	Time and cost for installing smart meters through all the estate	NA	Capital investment needed to get resources and meters in place	
Funding	The Council paid for the installation of the meters in the beginning in three corporate buildings to have a better quality of meters then LASER took over the roll out electricity meters Funded the installation of water smart meters in three buildings Funded some trials for gas smart meters	It was funded as part of an invest to save programme		
Process of data collection, analysis and use	KCC is using Systemslink to look at the direct/ profile and invoice energy data of their buildings KCC only gets HH direct/day+1 data for only mandatory HH sites KCC does not pay to receive direct/day+1 HH data and relies on historic data	Since the main purpose is to verify bills, the team is happy with receiving HH meter readings monthly or even quarterly The team does not pay for real time/day+1 HH data except when it is mandatory HH The data is used to verify bills and generate DECs	The energy data is stored under Team Sigma software	
Energy monitoring and analysis technology	KCC is monitoring near real time consumption for only the three biggest Council's buildings using the Stark software (ex: the direct	HH data is fed to a software called Team Sigma which automatically compares the bills and the actual consumption and if a large difference is spotted, it	The authority uses Team Sigma for accessing energy data and paying bills but it is not used at its full potential, i.e. monitoring live energy data.	Collecting HH data helps the team to assess with accuracy the energy performance of a building

	energy consumption and PV production is displayed on a screen in the office) KCC uses historic data to monitor and to study the feasibility of an energy efficiency project in a building as they help in creating a case study LASER uses historic data to monitor the capacity charges in order to decrease them	notifies the team to review it The team monitors their energy consumption yearly using degree days and year on year consumption The HH data is also used when the team wants to install RE	The authority has plans to deploy Sentinel as part of a European project to monitor its energy use in real time. The interviewee has a report which ranks buildings related to their energy consumption and prioritises buildings which needs energy efficiency measures. The data is used in a proactive way.	and explore solutions to reduce energy demand. Data is fed and accessed through Systemslink.
Savings	NA	NA	NA	
Conclusion & Way forward	Cost, time and people make it unaffordable to have real time monitoring. Even if the Council pays for real time data, it will still be difficult to monitor it as it is a time and man intensive activity. The future is AI for processing energy data. KCC is running a trial with Aston University related to monitoring and processing HH real time/day+1 energy data using AI to see how it can help in reducing energy cost and what type of energy savings can be achieved.	Having real time/day+1 is labour intensive Cost of accessing the data HH data can be easily used to monitor gas consumption rather than electricity consumption (exe. for a building, you might have one or two buildings which are consuming gas but for electricity you will have hundreds of devices consuming it) "In the hierarchy of things to do with limited resources, AMR is good to have but making best use of AMR is fairly low down in the list of priorities. So, we as authorities, we do want AMRs because you do not know when the	Local Authorities are driven by financial pressures. Money should be spent on the low hanging fruits (energy efficiency) and invested wisely to get the best return but there are examples where the authority make investments where the aim is to set the example. Under the European project, the Council will invest in upgrading buildings meters and controls infrastructure	

	The focus is making the buildings efficient using the SALIX fund in order to decrease the yearly £3.5 M spend on the energy and once this phase is completed, KCC will look to save energy by real time monitoring it.	next problem is gonna occur, and if a problem occurs on a site and it got AMR, you can get into it straight away”. Makes best use of what the authority has: AMR has an immediate impact when is used for billing on costs and resources use for the administration of electricity and gas accounts The future of real time data is when it will be associated with DSR.		

	Newcastle City Council (NeCC)	**Cherwell District Council (CDC)**	**Oxford City Council (OCC)**	**Derbyshire County Council (DCC)**
Interviewee’s Job Role & Duties	Energy Services Manager – Energy management for Council’s building, procurement of energy for the LA, schools and academies, advice to domestic tenants through the LA’s tenants management organisation	The interviewee is now the Sustainability Officer for CDC but has been previously the Energy officer for CDC and South Northamptonshire Council	2 members of staff took part in this interview who are: - The Energy & Carbon Manager - The Energy Management Officer	Energy & Carbon Manager within the Corporate Landlord in Property Division. This role is a strategic one and the duty of the manager is provided advice on energy policy and legislation and to work on larger energy projects like solar farms and heat networks. The energy manager is also responsible for the energy contracts.

Type of Authority	One tier Authority	District Council in Oxfordshire	Two tier authority where OCC is the lower tier	Two tier authority where DCC is the upper tier
Seize of the Buildings Portfolio	550-600 buildings	12 council buildings in addition to 6 indirectly managed leisure centres	100 sites inc. 20 large energy consuming sites	Approx. 700 buildings, about 400 of which are schools. The remaining include: libraries, homes for elderly, offices and depots.
Size of the Energy Team	The team includes a climate change role. It constitutes of 8 members, 4 doing the traditional energy management and the remaining working on the energy advice for domestic tenants The team procures energy (electricity & gas) through a public buying group called NEP and is studying the procurement of water under the new available frameworks which were the result of the deregulation of the water market for the non domestic sectors in the UK	The team included one member (the interviewee). However, the role is vacant at the time of the interview. The interviewee still performs some energy management tasks from time to time with the help of the facilities team. The energy officer was managing the energy contracts (energy bought through LASER). He also working on reducing the carbon footprint through renewable energies (PV & district heating) and energy efficiency schemes (lights upgrading, controls, pipes insulation). These measures were funded by CDC.	The team is called Energy & Natural Resources and have 4 members. The team has as a main task to drive down the natural resources consumption. This is achieved through the application of energy efficiency schemes which are funded by SALIX. Additionally, the Council has its own fund called SALIX^{+} and is used to fund renewable energy generation, water efficiency, and transport related schemes. The team also manages the energy and water contracts.	The Carbon and Energy Management Team was split up 2 years ago and resulted in having an Energy & Carbon Manager (the interviewee) and 2.5 FTE Energy Officers who sit with M&E Design in the Property Division. These officers have an operational role in a way they generate in an income through managing the council's energy supply contracts for schools and corporate sites, carrying out DECs for schools and corporate sites and also by providing an energy management service for Derbyshire Fire

				and Rescue Service.
Council Hierarchy	The team falls under the Operations Directorate		The team falls under the Community Service Directorate	The team sits within Economy, Transport and Communities
Energy Related Decision Making	The energy manager has a day to day delegated authority for day to day operations, management of the energy contracts, and for short payback projects like SALIX schemes. The energy manager seeks approval for his yearly budget form the Council where he presents projects he will work on. An example is the PV project where he built a business case based on the high returns from FITs a couple years ago. Once the budget is approved by the Council, the energy manager had the authority to install PV and he had to coordinate with the Finance team.		The energy manager has a day to day delegated authority for day to day operations, management of the energy contracts, and for short payback projects like SALIX schemes. These schemes are developed with the help of the facility team. The energy manager seeks approval from senior management for decisions related to leisure centres since they are managed by 3rd parties; business cases should be presented and approved. The energy manager should seek approval from the City Executive Board for energy and water procurement approach since they are large scale decisions, and for the carbon management strategy which is 4-5 years road map.	Big decisions need to go to the cabinet for approval.

'Smart' Meter Roll-out	Starting 2011, the Council started experimenting smart meters to build a case for smart meters roll out for electricity. Electricity smart meters are rolled out in all Council's buildings except for buildings facing technical problems Gas smart meters were installed in 2014 in most corporate buildings as part of the gas procurement contract renewal No water smart meters installed	First smart meters were installed in leisure centres because they are under mandatory HH. In 2012, smart meters were installed as part of the refurbishment of the museum. 4 meters are being installed as part of P272.	The first smart meters were installed 10 years ago in the 5 largest energy consuming building as part of a trial with other LAs such us Leicester City Council under the Data Bird programme. 80%-90% of the largest sites have smart meters 8 sites have water smart meter. In some sites a water sub-meter is installed just after the main meter to be sure to get the correct reading The headquarter has electricity, gas and water sub-meters are installed on each floor	The first smart meters for electricity and gas were installed in 2009 for corporate estates. Most of these buildings have now smart meters except when it is technically impossible to install them. Only few schools have smart meters installed in them.
Motivation	Energy data collection to increase frequency of receiving data.	The museum had a BMS installed under the redevelopment programme and the smart meter is part of the system	The main motivation was to develop energy management as a best practice approach since you can't manage what you can't measure. The second motivation is to generate some revenue as part of CRC. The 3rd motivation is to conform with the legislation.	The smart meters were firstly installed as part of the CRC. Another motivation was and improved energy management in order to prevent energy wastage
Funding				
Process of data collection, analysis and use	The council receives HH data on a weekly basis for NHH	The Council has access to HH meter reads on request	The Council receives HH data on a day+1 basis for electricity (HH & NHH), gas and water	The Council receives HH data both for HH and NHH sites. Some of these data are

	sites and day+1 for HH sites The Council uses Systemslink to access their HH data		The Council uses Team Sigma and supplier's software (Stark) to access the data	received weekly on Systemslink and the remaining monthly. The data is collected by the supplier and MOPs and fed to Systemslink.
Energy monitoring and analysis technology	The Council selects a group of sites annually. These targeted sites are monitored weekly and their occupation and energy usage is analysed. A report is produced at the end of the year suggesting measures to reduce their energy consumption. The energy data is also used to understand time of day usage for some buildings and the supplier's charges associated with it. The findings will be used to investigate DSR options.	HH meter reads are requested every three months from the energy supplier to explore any inefficient energy use	Profile data from the water smart meters is to monitor the consumption especially during the night. The profile data gives more clarity and in an easier way. Understanding the water consumption at similar depth will require surveyors to walk around a site constantly and every day. Periodic checks are done to monitor if data is flowing as expected. Data is used for monitoring and targeting (both active and reactive monitoring). Data is downloaded weekly and monitored by comparing it to historic consumption/expected consumption and degree days. Data is also used for bills validation and reconciliation	The profile data are used for improved energy management and to identify any energy wastage. As an example, in the past, the energy team has trained and encouraged sites managers to access their profile data to learn about their energy consumption
Hindrance	The Council are still to find a system that can enable real time/day +1 monitoring. In addition, the	The changes in the Council staff members had led to lose the expertise of managing the BMS and its smart meter.	The problems highlighted by the monitoring and targeting exercise takes lot of time to action them or to	Limited resources to look at sites individually There is more support to do

	team is under stress and there need to be additional members to action the findings from the monitoring activity Smart meters alone is not sufficient, there should also be data from sub-meters especially for big buildings. The energy manager investigated the option of installing electricity sub-meters but it was very expensive since there is a need to make changes to existing electricity circuits. Though, it is cheaper to install sub-meters at construction or refurnishing a building.	Even if any inefficient use of energy is spotted, there is no one to action the solutions The Council does not have an energy management software to receive the HH meter reads and to monitor the energy consumption on more frequent basis. The absence of such system is due to the inability to produce a business case that justifies the need for it. There is a need of sub-meters to better understand the energy consumption in larger buildings or in buildings with multiple tenants/users	identify the source of the problem The sub-meters in the headquarter have been installed as part of the building regulations and they haven't been installed properly. Sometimes, it is impossible to access the meter reads.	energy efficiency rather than energy management because energy efficiency has more visible solutions.
Savings				
Conclusion & Way forward	Active monitoring is done on a weekly basis for a group of buildings selected yearly Sub-metering is essential to understand the energy consumption of the building	A business case advocating the need for an energy management software might be prepared to be presented to the Council. A member staff visits on monthly basis the 7 PV systems and the 3 biomass boiler systems to collect meter readings even	Install more sub-meters and water smart meters to have more profile data Having the profile data is useful even if it is not used because it will be easier to use it to investigate the source of the problem than other measures.	The energy manager will be working with property staff to encourage them to start using the energy data on a regular basis to monitor the

	The Council is thinking about roll out of Water Smart Meters as part of a framework The Council is willing to get ISO50001	though these systems have HH capable meters. Therefore, having a software that collects automatically these HH meter reads will save the cost of these site visits and will minimise the percentage of inaccurate meter reads. Additionally, with the changes in legislation, more and more council buildings are under the mandatory HH where the Council pays anyways for the HH data. Therefore, the cost of a software is minimal compared to the cost paid for site visits and mandatory HH.		energy consumption. Additionally, DCC is taking part of the EDI-Net project in order to benefit from the capabilities of the software offered by this project to help use the HH data for energy monitoring.

	Cork County Council (CCC)	Stadt Nurnberg (SN)	Islington Council (IC)
Interviewee's Job Role & Duties	Executive Engineer – Energy management for the Council's buildings	Energy manager for the LA.	Energy officer whose primary role is the purchase of electricity and gas for the Council's portfolio and their external clients. He is also responsible for the selling of the Council's electricity generation from an Energy Centre which is a Combined Heat and Power plant. Additionally, the officer is responsible for the Systemslink Energy Manager database, which holds all the Council's electricity and gas consumption and cost data, going back to 15 years for some sites
Type of Authority	Two tier authority in the Republic of Ireland where CCC is the upper tier	This is the City Council (Municipality) for the City of Nurnberg	The LA for the London Borough of Islington

Seize of the Buildings Portfolio	180 buildings which mainly use electricity and oil	330 buildings most of which are schools or childcare facilities	The Council is responsible for managing the energy for its own buildings, parks, schools, leisure centres as well as having some 3,500 landlord supplies serving its Housing stock. The gas consumption primarily provides heating and hot water to these sites (the Council has some 5,000 dwellings supplied by a communal plant).
Size of the Energy Team	The team constitutes of 3 members: senior executive engineer, executive engineer and executive technician.	The team has a leader and constitutes of 11 members, 8 of them are full timers.	Energy Services Team – constitutes of 11 members in addition to their manager
Council Hierarchy	The team falls under the Environment Department.	The team falls under the Building Department	The team falls under the Environment and Generation Directorate
Energy Related Decision Making	All new buildings of the Council should have an A3 Building Energy Rating or better. Moreover, the Council has to achieve a 3% yearly energy efficiency savings. All Council departments needs to report the energy savings to the Environment department. The energy team can provide advice to other teams on how to implement energy efficiency projects.	The Energy Management Team develops and updates energy related buildings standards which go for City Council approval before they are implemented and enforced in the region. The team also provides advice to projects managers when constructing new buildings or renovating the old ones. In addition, the team scrutinises the energy efficiency measures and their economic feasibility for every new project.	The Lead Member for Environment & Regeneration sets targets for energy related projects/schemes which will attain the goals of the Council. Monthly meetings are held between the Lead Member, the Director of Environment and Generation and other senior officers including the Energy Services Manager, to report on the progress of schemes and as a forum to put forward new projects and business cases. In addition to the aspirational goals of the Council, the authority also has certain statutory obligations with regards to energy, primarily the annual mandatory Carbon Reduction Commitment (CRC) reporting and purchasing of carbon credits and Energy issues relating to Planning, Section 106 and Carbon Offset funds.
'Smart' Meter Roll-out	CCC started using smart meters in 2014 and installed them in 6 buildings/campuses for electricity, oil and gas	The council use data loggers for measuring electricity, heat and water. In addition, 30 buildings have an AMR system	The Council has installed between 2010-2014 AMRs in the 40 largest gas consuming sites. In addition, the Council has Smart Meters installed for both gas and electricity on many of the large energy consuming sites.
Motivation	The motivation was to record the energy usage more frequently. These meter reads will be analysed in order to	Improvement of Energy Management	The AMRs have been installed to gain concessions within the CRC. In addition, these meters provide detailed consumption figures

	help in understanding the energy consumption patterns to come up with plans to reduce energy usage	Better ability to develop energy efficiency measures Quicker reactions to technical failures in buildings	which can serve different purposes.
Funding/Cost		The cost of a data logger is £1385. An additional £4.5 is paid per logger monthly to send the data files to the users. ST believes that once AMRs are rolled out by an independent entity, it will only have to pay for the cost of purchasing the data	
Process of data collection, analysis and use	CCC have HH meter reads from the smart meters of the 6 buildings. These meter reads are collected by the energy supplier and an external consultant.	ST have its own AMR and data logging system which provides HH data	The HH data is collected by the suppliers and accessed via their web portals. The data is also fed to Systemslink. The HH data is used to analyse buildings performance/highlight wastage., it allows for accurate calculation of potential savings to be made. The data is also used for Energy Audits of buildings, benchmarking building performance against industry norms as well as invoice validation and to provide accurate data for energy procurement purposes. The results of the analysis are used as an evidence in prioritising projects/interventions and calculating savings.
Energy monitoring and analysis technology	The data is accessed online and analysed to monitor accurate use, control energy consumption and establish energy drivers. The data is analysed using excel. The data is also used to assess the feasibility of proposed changes in operations.	The energy controlling group which is part the energy management team is responsible for analysing the energy data to detect any anomalies in energy consumption and to provide statistics to develop energy efficiency measures	The data is analysed with the help of Systemslink which has a suite of reports that can be produced using HH data and can be downloaded in Excel for further analysis. The energy team does not have access to Real Time data (data can be accessed 2 days after it has been generated).
Hindrance	Smart meters are not installed in the majority of buildings due to their cost		
Savings			

Conclusion & Way forward	The use of smart meters for recording half hourly energy consumption help in making energy related decisions. This is why the Council is planning to allocate a budget to install smart meters and receive HH meter reads for large energy consuming buildings	ST is planning to install AMRs in buildings that consumes 80% of the total energy budget for the City Council. Currently, 30 buildings out of 120 have been equipped with this technology. ST is aware that it is not fully exploiting the potential of these meters and HH meter reads; this is why it is currently implementing the EDI-net system to regularly inform building users about any problems with their energy consumption. In addition, ST is planning to implement automatic alarms and analyse on a weekly basis the energy data. Other groups of buildings will be analysed more frequently and benchmarked to find the best buildings for intensified monitoring and for energy efficiency measures.	Smart meters are mainly used to help with day to day energy management tasks.

Appendix F: Interviews Analysis

13 LAs took part in these interviews.

Type of Interviews:

7 Face to face (NCC, LCC, KCC, NELC, OCC, CDC, MKC). 4 Written Responses (BCC, CCC, IC, ST). 2 Telephone (NeCC, DCC)

Types of Local Governments and their location:

11 LAs are located in England. 1 in Ireland (CCC). 1 Germany (ST)

7 two-tier authorities (NCC, DCC, KCC, BCC, CCC, CDC, OCC). 5 unitary authorities (LCC, NeCC, MKC, IC, NELC). 1 municipality (ST)

5 County Councils (NCC, KCC, DCC, BCC, CCC). 3 City Councils (OCC, LCC, NeCC). 1 District Council (CDC). 1 London Borough (IC). 1 Municipality (ST)

Number of Interviewees and job roles:

17 interviewees

3 Heads of Energy/Environment Department (NCC, NELC, LCC)

7 Energy managers (NeCC, OCC, LCC, DCC, KCC, MKC, ST)

1 Energy Contracts Manager (NCC)

6 Energy/Environment/Sustainability Management Officers (CDC, OCC, BCC, CCC, NCC, IC)

Authorities with an Energy Management Team or equivalent and their place in the organisation's hierarchy:

11 Authorities have an Energy Management Team. These teams have different roles which can be related to environment, climate change, natural resources management.

Energy teams fall under the following Directorates:

7 Growth/Development/Generation, Transport, Economy (KCC, NCC, LCC, BCC, DCC, CCC & IC)

2 Public Realm/Community Service (MKC, OCC)

1 Finance & Resources (NELC)

1 Operations (NeCC)

Authorities with Energy Efficiency Projects:

- SALIX: KCC, MKC, OCC, NCC
- European projects: NCC, MKC, NELC
- Large Renewable Projects: NELC, DCC, IC, LCC, NCC

Strategic Roles:

- NELC, DCC, NCC

Smart Meters/AMRs Roll-out:

- Trial of a new technology/system to define how it can help with energy management or prepare a case study to roll it out (NCC, LCC, NeCC, OCC)
- Supplier/Procurement organisation suggestion or part of a procurement contract (KCC, NCC, MKC)
- 1 Council (SN) uses data loggers in most buildings
- Smart meters are installed in Most Buildings (KCC, NCC, LCC, OCC, DCC) except when there is a technical problem (NCC, NeCC, DCC)
- LAs with Gas smart meters: NCC, LCC, KCC, NeCC, OCC, CCC, IC
- LAs with Water smart meters: LCC, KCC, NeCC, OCC, CCC
- 1 Authority has smart meters only installed for mandatory HH (NELC)

Primary Motivations:

- Better visibility of energy use (KCC, BCC, OCC, DCC, CCC, IC, NCC) generation (KCC)
- Increasing Frequency of receiving data (NeCC)

- Reduction in energy billing errors and estimation (MKC)
- CRC compliance and Carbon accreditation (MKC, OCC, DCC, IC)
- Statutory/Legal requirements (NELC, OCC)
- Quicker reactions to technical failures in buildings (SN, LCC)
- Better ability to develop energy efficiency measures (SN, DCC, BCC)

HH Data Availability Arrangements:

- Availability of HH data on a day +1 basis for HH mandatory sites (NCC, LCC, KCC, MKC, NeCC, OCC)
- Availability of HH data on a day +1 basis for nHH mandatory sites (NCC, LCC, OCC)
- Availability of HH data on a day+2 basis (IC)
- Availability of HH data on a weekly basis HH mandatory sites (DCC)
- Availability of HH data on a weekly basis for nHH mandatory sites (NeCC)
- Availability of HH data on a monthly basis for nHH mandatory sites (MKC, DCC)
- Availability of HH data on request (CDC)

HH Data Access & Analysis:

- 10 LAs access their HH Data via an Energy Management System (NCC, LCC, KCC, MKC, NELC, BCC, NeCC, OCC, DCC & IC)
- Active/near real-time monitoring for main buildings (KCC, LCC)
- Periodic monitoring:
    - Weekly (NeCC, OCC)
    - Montly (NCC)
    - Each 3 Months (CDC)
    - Yearly (MKC)

Purposes of HH Data Analysis:

Monitoring of capacity Charges and time of day use (KCC, NeCC, NCC)
Preparation of feasibility studies and case studies of energy efficiency projects (KCC, MKC, NELC, BCC, NeCC, CCC, SN, IC, NCC)
Bills verification (MKC, OCC, IC, NCC)
Performance monitoring (BCC, DCC, CCC, IC, LCC, CDC)
Time saving compared to having to survey buildings to collect energy data (OCC)
Energy Audits (IC)

Barriers Inhibiting the Use of Half Hourly Data:

- Smart meters roll out is Resources and time demanding (KCC, NELC, CCC)
- The need of a system that enables real time monitoring (NeCC, CDC)
- The need for additional staff or efforts to monitor the energy consumption and action the findings from the monitoring activity which sometimes is difficult to find their cause (KCC, NeCC, CDC, OCC, DCC, NCC)
- Smart sub-meters are fundamental to better analyse the energy consumption especially for large buildings (NeCC, CDC, MKC, OCC)
- Lack of knowledge transfer between staff members (CDC)
- The primary focus of energy managers is energy efficiency because it has visible and direct results (DCC, NELC, MKC, KCC, IC)

Conclusions:

- Councils pay for receiving HH data. The data is not used for active monitoring and targeting as it requires additional costs and time (KCC, MKC, ST, DCC, OCC, NCC)
- Energy managers' current focus is to make their buildings energy efficient and benefit from available interest free public funds to invest in these

projects. Their future focus will be active monitoring and targeting using HH data or when it will be used with DSR (KCC, MKC, NELC)

- Sub metering is essential to understand the energy consumption of the building (NeCC, MKC, OCC, CDC)
- HH data analysis can be more effective if used for managing the gas consumption in the case of sub-meters' absence (MKC)
- There is a need for powerful and affordable software for active monitoring and targeting (KCC, CDC, DCC, NCC, ST)
- Having access to a history of HH data of a building is good since it will help in investigating problems affecting these sites. These problems can be technical like a sudden increase in energy consumption or financial like incorrect billing (MKC, OCC)
- Active monitoring and targeting can be an effective solution for controlling the energy consumption and for generating additional income to energy teams (LCC)

Appendix G: An Example of a SALIX Case Study

Northamptonshire County Council

my county council

Croyland Primary School in Wellingborough used their **Salix 100% interest-free** capital loan of **£35,690** to install a 30 kW solar PV system. The school wanted to carry out this project to bring their energy bills down and reduce the school's environmental impact. An interactive display will also provide a practical educational tool for their students. The school own the system so a twenty year revenue stream from Feed-In-Tariff payments will also be achieved.

Summary

Total loan value

£35,690

Annual £ savings/benefits

£5,107

Annual savings tonnes of CO_2

13.4

Project payback

7 years

Equivalent to the amount of CO_2 emitted by an average household over 376 days*

NCC will help you:

- ✓ Benefit from NCC energy-efficiency expertise
- ✓ Verify contractors' quotations and estimated savings
- ✓ Comply with planning regulations
- ✓ Complete all funding application process
- ✓ Significantly reduce annual energy costs
- ✓ Generate a 20 year income stream from FIT payments
- ✓ Procure EPC and Structural surveys
- ✓ Obtain DNO Approval

To find energy efficiency advice for your school contact;
lowcarbon@northamptonshire.gov.uk
01604 366948

climate INTEGRATED SOLUTIONS

SALIX SOLVING ENERGY EFFICIENCY FINANCE IN THE PUBLIC SECTOR

* http://www.yousustain.com/footprint/howmuchco2

Appendix H: Energy Management Matrix: List of Questions

Management Commitment

This section identifies whether there is a clear statement of policy that shows the commitment of management to the efficient use of energy, an associated written strategy and whether there are suitable allocations of responsibility for energy management with adequate resources assigned.

Energy policy

Characteristic	Score		Notes
	Actual	Max	
A written energy policy (may be part of an environmental or sustainability policy)	2	2	*Energy Policy is signed by the Head of Energy & Carbon Management*
Agreed by senior management	2	2	
Communicated to all employees	1	1	*Available on the web and sent to major energy stakeholdors in the organisation*
Recently written, or reviewed and revised (within 3 years)	1	1	*Reviewed Annually*
Contains a commitment to the development / deployment of quantitative improvement targets	1	2	*A policy is generic and does not necessarily need to include quantitative improvement targers. The Council as a whole has its own yearly target*
Contains a commitment to annual reporting (public or to all employees)	1	1	*As part of statutory requirement*
Includes a date for review/revision	1	1	*Dates are available on the energy management system booklet of NCC*
Total Score	**9**	**of 10 maximum**	

Energy strategy

Characteristic	Score		Notes
	Actual	Max	
A written strategy document consistent with the energy policy	2	4	*No strategy document but strategy decision is made by the cabinet (key decisions) and delegated to the interviewee, strategies for new projects are included in cabinet papers*
Agreed by senior management	2	2	
Includes a live Action Plan for implementation	3	3	
Includes a date for review/revision	1	1	
Total Score	**8**	**of 10 maximum**	

Organisational structure

Characteristic	Score		Notes
	Actual	Max	
A manager at board (or equivalent) level has responsibility for energy	3	3	*The interviewee*
Appointment of person with designated responsibility for energy	3	3	*The interviewee*
Clear job description and assigned adequate resources for designated person	2	3	*The interviewee has a job description with an income target of £350 but without a budget*
Regular management meetings to review energy use	2	2	*different levels: within the team, senior managers, cabinet*
Local energy 'managers' or champions appointed	1	1	*A group of significant energy users and these support the EnMS*
Total Score	**11**	**of 12 maximum**	

Regulatory Compliance

This section identifies whether there is a clear understanding of the organisation's legal obligations in respect of energy and carbon emissions, and that these obligations are being managed effectively.

Regulatory compliance

Characteristic	Score		Notes
	Actual	Max	
Formal review completed to determine which regulations are applicable and which are not.	2	2	*At least yearly*
Senior management have reviewed and understand the organisation's legal obligations.	2	2	*Subscription to an external service that sends update in relation to legal obligations*
A compliance plan is in place, including identified responsible staff.	2	2	
Processes are in place to ensure the organisation keeps up to date with relevant developments	2	2	
The organisation is compliant	2	2	*It has to be otherwise it won't be certified with ISO50001:2011*
Total Score	**10**	**of 10 maximum**	

Procurement and Investment

This section identifies whether the organisation's procurement and investment policies and procedures provide active support for improvements to energy efficiency.

Procurement policy

Characteristic	Score		Notes
	Actual	Max	
General policy is to include consideration of energy consumption in all procurement.	4	4	
Energy performance is specified in new buildings, IT projects, process plant etc	3	3	*example: new HQ but it was a weak area in the past*
Specific procurement policies used for particular products, e.g. lighting, motors etc.	1	3	*No specification but needs to be stated in the procurement process: energy efficient goods need to be purchased when possible otherwise energy will become a barrier*
Total Score	**8**	**of 10 maximum**	

Investment procedures

Characteristic	Score		Notes
	Actual	Max	
Capital investment procedure exists to obtain funding for energy efficiency	4	4	*A fund is set up with SALIX Finance*
Clear payback (or other) investment threshold for energy efficiency*	3	3	*between 5 years and 10 years depending on projects*
All capital funding requests assessed for energy impact by person with responsibility for energy	3	3	
Do maintenance budgets include repairs to save energy	0	2	*The organisation follows a reactive maintenance i.e. these are reactive budgets*
Total Score	**10**	**of 12 maximum**	

**if criteria are too restricting , acting as a major barrier for energy efficiency investment, mark down.*

Energy Information Systems & Identifying Opportunities

This section identifies whether there are systematic procedures for monitoring and understanding energy consumption, setting suitable improvement targets, and identifying savings opportunities.

Monitoring and analysing energy use

Characteristic	Score		Notes
	Actual	Max	
Regular collection of energy consumption and cost data	4	4	
Analysis of consumption against energy drivers (production, temperature, etc.) and time	4	4	
Regular and appropriate reporting	2	3	*minimum reporting*
Comparison of energy data with utility bills	2	2	
CO_2 emissions calculated/analysed	1	1	*quarterly reporting for a specific group of buildings and annual carbon footprint for the whole organisation*
Total Score	**13**	**of 14 maximum**	

Target setting

Characteristic	Score		Notes
	Actual	Max	
Energy saving targets based on analysis	0	3	*There is a global target that is used by the team and specific targets will create energy as barrier to change and not as an aid*
Targets challenging, but achievable	3	4	*Have always been achievable*
Performance compared with appropriate benchmarks (internal or external)	3	3	
Total Score	**6**	**of 10 maximum**	

Opportunities identification

Characteristic	Score		Notes
	Actual	Max	
Metering, Monitoring and Targeting (MM&T) system actively used to identify savings opportunities	2	4	*not used proactively but property use them in a proactive way (monthly)for a very large portfolio*
Site energy surveys undertaken regularly	4	4	*part of DECs or investment projects or identification for energy area improvements*
Other information used; e.g. energy certificates, asset registers, etc.	2	2	*e.g. condition data of buildings, property data*
Total Score	**8**	**of 10 maximum**	

Culture & Communications

This section identifies whether the opportunities afforded through involving staff in energy efficiency, and in communicating progress both internally and externally are being taken advantage of.

Staff engagement and training

Characteristic	Score		Notes
	Actual	Max	
Appropriate training for staff key to energy management, e.g. maintenance, boiler-house, caretakers, security, etc	3	4	*The organisation could do more but it's not a necissity at the moment*
Awareness campaigns held regularly	3	3	*Sceptical about their effectiveness*
Wider active staff involvement initiatives (e.g. via 'green' programmes, quality improvement, etc)	2	2	*The interviewee is part of the procurement process of a new Place service provider*
Energy included in staff induction training	0	1	
Total Score	8	of 10 maximum	

Appendix I: Findings Validation Questionnaire

Findings Validation Questionnaire

Following your participation in the research entitled "Smart Energy Management: Supporting a Step Change in Local Authorities", and as promised during the interview process, this document has been produced to summarise and validate the main findings of the study. It would be appreciated if you can complete the following document as this could inform future research in this area.

The following findings are the results of the analysis of interviews with 24 energy stakeholders mainly energy managers from 13 Local Authorities LAs.

I would also like to take this opportunity to personally thank yourself and your organisation for the support and assistance in the research and greatly appreciate any feedback received.

Overview

The thesis titled "Smart Energy Management: Supporting a Step Change in Local Authorities" examined the development of energy management in LAs and the uptake of energy monitoring and targeting using high resolution data by their energy teams. This research defined Smart Energy Management 'SEM' and developed a framework.

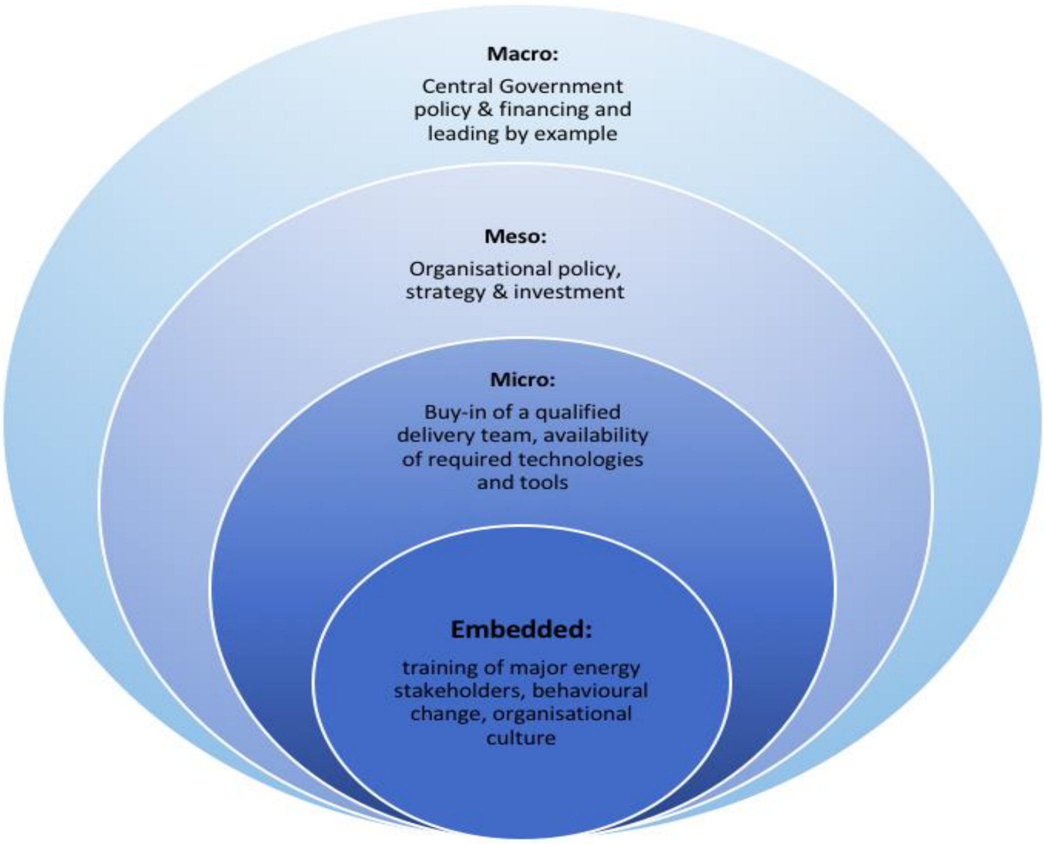
Finding 1- SEM is defined as:

A self-governing management system that integrates ICT and human resources for energy cost saving and income generation within the operations for which the Local Authority is responsible.

In more detail, SEM is the systematic and efficient integration of multiple resources but focusing on the human and ICT ones to embed energy saving activities, and if possible income generating practices, into an organisation. This can be demonstrated by a combination of schemes like periodic energy monitoring and targeting using high-resolution data, energy control, energy efficiency measures, shift to renewable energies, demand side management, knowledge share, and focused awareness and training campaigns to develop a self-governed energy management system.

<u>Can you please comment on this definition and suggest how it can be improved?</u>

Finding 2 - The transition from the concept of Smart Energy Management in an LA into an operational system can be enabled due to four factors as described in the framework below:



Strategic Levels for Enabling the Incorporation of Smart Energy Management in a Local Authority

The indicators for the four levels are detailed below:

<u>Can you please comment on each factor?</u>

Factor	Indicator	Observation
	Central government policy and legislation	It is seen as one of the triggers which enables the introduction of this practice into the organisation. Is the policy self-explanatory and does it outline a set of procedures to follow? Or can the organisation define how it can address it, and in this case, does it go beyond compliance to implement a system that can easily be integrated within the organisation? Additionally, does the organisation define a set

Macro		of procedure that will allow it to contribute in the design of these policies?
	Central government funding	Availability of funding encourages organisations to implement solutions that can help them control their energy expenditure. Does the availability of funding affect the choice of specific schemes and technologies over others?
	Lead by example	To showcase the effectiveness of specific systems and solutions. Does the organisation understand that the public sector has a moral obligation to adopt solutions that will support governance, and which will serve as a Living Lab to enable other organisations to learn from the implementation of this new system?

Comment:

	Support from top management	In this case Cabinet and board of directors, and the willingness to experiment new solutions which will empower good governance.
Meso	Enactment of internal policies and strategies	To trigger the implementation of SEM and ensure its enforcement
	Allocation of internal funding	To provide a suitable environment to ensure the success of the solution

Comment:

Micro	Buy-in of delivery team	does the organisation have a highly qualified team with the right expertise who believes in the usefulness of this solution and is this team motivated enough to make it work?
	Availability of resources	Does the organisation have the required tools and data that will enable the implementation of this system?

Comment:

Embedded	Organisational culture	Does the organisation has a set of procedures that will enable the embedding of this system in its organisational structure, i.e. as part of the induction package of new staff members, training, behavioural change campaigns, etc.?

Comment:

Are there other indicators to add to the framework?

Finding 3 – Active monitoring and targeting

Please could you comment on each of the following observations about active targeting and monitoring?

- Policy is perceived as one of the most important enablers of this framework. In the past, it played a significant role in pushing carbon saving agendas and in encouraging the uptake of energy management. The same goes with enrolling smart meters; the UK Smart Meter Rollout programme was an enabler for spreading the use of this technology. Though, the policy and the programme failed in detailing how these can be used for saving energy. No formal training or programmes have been developed to assist energy managers with using this technology. This is why energy managers from most of the interviewed LAs are using these devices to assist them with their day to day tasks.

Comment:

- There is no public funding available and which is easily accessible like SALIX for developing 'invest to save' programmes using active monitoring and targeting with smart meters.
    - Organisations should provide adequate resources to enable the implementation of this scheme. In this study, the researcher came across one LA that developed an active targeting and monitoring

Comment:

➔ **The inability to quantify the direct and indirect savings from the active targeting and monitoring activity, the absence of guidance, training and funding makes it difficult to develop invest to save programmes devoted to implementing this practice.**

Comment:

Thank you for your help,

Contact Details

Marouane Azennoud Tel: 079 12 89 20 40 email: p14187075@myemail.ac.uk
Dr Richard Bull Tel: 0116 207 8063 email: rbull@dmu.ac.uk
Prof Mark Lemon Tel: 0116 257 7977 email: mlemon@dmu.ac.uk
Dr Graeme Stuart Tel: 0116 257 7964 email: gstuart@dmu.ac.uk
Dr Darren Perry Tel: 01604 366948 email: daperry@northamptonshire.gov.uk

PS: Please note that these findings are still not published, if you are willing to use them, can you please use this reference: Azennoud, M 2018, 'Smart Energy Management: Supporting a Step Change in Local Authorities', PhD Thesis, De Montfort University, UK.