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Local Energy Policy and Managing Low Carbon Transition: The Case of Leicester

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Keywords local energy policy, Leicester, energy transition, CHP, intelligent metering.

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Glossary

AIM4SME – Automatic Intelligent Metering for Small and Medium Enterprises

AUKEA – Association of UK Energy Agencies

CAN – Carbon Action Network

CASCADE – Complex Adaptive Systems Cognitive Agents and Distributed Energy

CERT – Carbon Emissions Reduction Target

CESP – Community Energy Saving Programme

CfD – Contract for Difference

CHP – Combined Heat and Power

CRAG – Carbon Rationing Action Group

CRC – Carbon Reduction Commitment

DCLG – Department for Communities and Local Government

DECC – Department for energy and climate change

DEFRA – Department for Environment, Food and Rural Affairs

DH – District Heating

DoE – Department of Energy

DTI – Department for Trade and Industry

EAUE – European Academy of the Urban Environment

ECO – Energy Company Obligation

ESCO – Energy Service Company

EMAS – Eco Management Audit Scheme

EU – European Union

FIT – Feed-In-Tariff

FoE – Friends of the Earth

GWh – Giga Watt hour

HESP – Home Energy Saving Programme

IEMA –Institute of Environmental Management and Assessment

IDeA – Improvement and Development Agency

IM – Intelligent Meter

IMD – Index of Multiple Deprivation

kWh – kilo Watt hour

LAEF Scheme – Local Authority Energy Financing Scheme

LCC – Leicester City Council

LEA – Leicester Energy Agency

LEC – Leicester Energy Company

LGA – Local Government Association

LLSOA – Lower Layer Super Output Area

MLSOA – Middle Layer Super Output Area

MWh – Mega Watt hour

NRF – Neighbourhood Renewal Fund

NUTS – Nomenclature of Territorial Units for Statistics

ONS – Office for National Statistics

RE – Renewable Energy

RHI – Renewable Heat Incentive

RHPP – Renewable Heat Premium Payments

SME – Small and Medium Enterprises

SOA – Super Output Area

ULSOA – Upper Layer Super Output Area

1 Introduction

This research has been carried out to better determine whether the UK national policy agenda is reaching down to the local level. It is framed around a case study of one urban centre: the City of Leicester, England which has been selected due to its record in sustainability, energy efficiency and climate change mitigation. Section 2 of the paper outlines the key demographics and a brief history of Leicester City and its council's (Leicester City Council, LCC) approach to energy policy. The City's energy landscape is explored as is the way it is implementing national energy policy. The investigation is predominantly concerned with gas and electricity; however, limited consideration is also given water consumption and carbon dioxide emissions.

The national picture regarding how the UK is tackling the energy-related issues of efficiency, climate change mitigation and fuel poverty is the topic of Section 3. These national plans require local level action in order to be achieved and locally disaggregated electricity gas consumption data and carbon emissions data is discussed in this section. The gas and electricity data are contextualised through consideration of deprivation experienced in suburbs of Leicester and the city's energy consumption performance relative to other English regions of similar population.

In Section 4 an overview of Leicester City's initiatives focussed on energy policy, climate change mitigation and sustainability is presented. The information gathered for this exercise is used to create a visual representation of the groups and activities involved. This qualitative data has identified the more important energy initiatives in Leicester and detailed analyses of these are presented in Sections 5 and 6.

Section 5 examines Leicester's district heating networks and in particular its recent attempts to modernise, unify and expand those networks. The process LCC has been through to enable this and the difficulties and successes it has faced in doing so are discussed. Section 6 discusses energy data acquisition in the area and the disaggregated monitoring of consumption. Energy data in Leicester is used in two primary modes: live metering of electricity and gas (and water) and also thermal mapping of the city, to identify areas of significant heat loss.

Conclusions are drawn in Section 7 alongside an attempt to characterise the energy consumption and cost savings that are being made in Leicester, relative to its total consumption and costs. This analysis in then used to identify whether the efforts of Leicester City Council, whose reputation identifies it as one of the more successful UK local authorities at tacking energy-related issues, is making a significant impact on energy consumption and cost reduction. The information gathered is also used to suggest how other local authorities might be able to learn from Leicester's achievements.

2 Leicester City

Leicester is situated in the East Midlands of England; it is the 11th largest city in the UK with a population of 329,900[1] and approximately 2,800 socially rented houses. Leicester City Council (LCC) is a single tier unitary authority with 22 wards and 54 councillors representing them. Since 6th May 2011 the city has had a directly elected mayor Sir Peter Soulsby, and has generally been controlled by the Labour party since the 1970's. Exceptions are that following the 1976 election the Conservative party held a majority and in 2003 no overall control was won by any party. After that election Conservative and Liberal Democrat councillors agreed to form a coalition council, which collapsed the following year. A second attempt to form the coalition was made in 2005, but also suffered difficulties with some Liberal Democrat councillors then shifting their support to the Labour opposition. The following 2007 and 2011 local elections have seen a landslide win for Labour councillors. Presently 52 of the 54 councillors are from the Labour party, with a single Conservative and a single Liberal Democrat representative. Leicester's 2008 carbon emissions amounted to 1.9 million tonnes (Leicester Partnership, 2010) and LCC's own emissions for 2008/9 were 66,179 tonnes of carbon dioxide (Department for Energy and Climate Change (DECC), 2010a). Among other environmental objectives, LCC has set itself a target of reducing the council and schools' carbon dioxide emissions to 50% of 2008/09 levels by 2025/6 and to reduce city-wide emissions to 50% of 1990 levels by the same date (LCC, 2010a). It additionally intends to meet an interim goal of cutting the city's carbon emissions to 1.6 million tonnes by 2013 (LCC, 2009a). Many of the groups actively pursuing a sustainability agenda in Leicester have agreed to work together and in so doing have formed a non-legally binding partnership, *One Leicester*.

Leicester City was awarded the UK's first "Environment City" in 1990 and later, in 1996, was named Europe's "Sustainable city" (Roberts, 2000). In 1990 the City adopted a Friends of the Earth target of a 50% reduction in energy (and CO2) use by 2025 (see Fleming and Webber, 2004); this preceded the introduction of a national policy target. Indeed Leicester was one of 12 cities globally to receive Local Government Honours at the 1992 Rio Earth Summit.[2] Fleming and Weber (2004) discuss a substantial improvement in the City's energy efficiency between 1996 and1999 with annual savings of 86,667 MWh (312 TJ), equal to 6.0% of Leicester's 2009 electricity demand. Central UK Government recognises Leicester City and its council as being "impressive" in terms of energy efficiency (House of Lords, 2005) and the city is currently one of the 11 board member cities of European Energy Cities network, which has 1000 towns and cities as members.[3] Reasons for this include bottom-up local initiatives such as the setting of local carbon emission reduction targets, upgrading the District Heating (DH) scheme, installing solar power, data collection and energy management systems and an energy centre for use by businesses and the public. Notable efforts have also been made in school education to highlight ongoing climate change issues and how to tackle and manage them (Charnley et.al., 2010).

Over a four year period Forum for the Future focussed on how the UK's twenty largest cities addressed sustainability issues. This assessment examined three major topics: environmental

[1] Source: ONS Census website. http://www.ons.gov.uk/ons/interactive/vp2-2011-census-comparator/index.html, Accessed 14 September 2012.
[2] See ICLEI (1993, p.15).
[3] See http://www.energy-cities.eu/, Accessed 14 September 2012.

performance, quality of life and future-proofing. From this Forum for the Future rank ordered each city relative to the others, with the lowest ranked city deemed to be the best performer. Table 1 summarises their conclusions (Forum for the Future, 2010a). During this four year period Leicester has improved relative to other cities year-on-year. It is the city whose rank has improved the most and was Britain's second most sustainable city in 2010.

In the 2010 assessment Leicester was placed first in the environmental performance category, and third for future-proofing, while it was adjudged to lag behind in terms of quality of life, achieving only 15th. For climate change, a subcategory of future-proofing, Leicester was ranked 9th (Forum for the Future, 2010b) compared with 2009 when it was second in climate change and first overall for future-proofing. In particular it was noted that the One Leicester Partnership was an important strategic step to have taken in the city to tackle issues encompassed by the future-proofing category (Forum for the Future, 2009).

Table 1: Sustainability index for 20 largest UK cities. Lower values indicate a better sustainability performance relative to the other cities. (Data taken from Forum for the Future (2010a)).

City	**Overall rank each year**			
	2007	**2008**	**2009**	**2010**
Birmingham	19	19	17	15
Bradford	9	10	16	18
Brighton	1	2	3	3
Bristol	3	1	2	4
Cardiff	6	5	10	11
Coventry	17	14	11	7
Derby*	-	-	-	17
Edinburgh	2	6	7	9
Glasgow	15	18	19	19
Hull	18	20	20	20
Leeds	5	13	6	6
Leicester	**14**	**8**	**4**	**2**
Liverpool	20	17	15	14
London	10	9	5	5
Manchester	12	15	14	13
Newcastle	8	4	1	1
Nottingham	11	10	8	12
Plymouth	4	3	12	8
Sheffield	2	7	9	10
Sunderland	13	12	13	16

**Derby grew larger than and replaced Wolverhampton in this list during 2010.*

Both Leicester city and the council (LCC) have a good reputation with regard to sustainability, energy efficiency and climate change mitigation activities. For these reasons it has been selected as a case study city to assess the execution of energy policy at the local level. The specific goals of the following paper are to quantify the impact energy initiatives are having on total energy consumption and also to identify what makes initiatives successful, with the aim of understanding how similar initiatives can be put into practice in other areas.

3 A national perspective on UK energy policy

Two aspects of the national situation that help 'locate' Leicester's local energy policy are discussed in this section: the recent, present and near-term energy policy goals of the UK Government and national data for the consumption of gas and electrical energy. The quantitative analysis is contextualised using UK data about the relative level of deprivation in local areas.

3.1 UK national energy policy

The UK has a framework of policies to tackle climate change, reduce energy bills and raise the standard of living for UK residents. Legislative milestones include the Government's intention that all new homes constructed from 2016 and new non-domestic buildings from 2019 onwards will be zero carbon. In the domestic context fuel poverty is also an issue high on the government agenda. The following subsections summarise major UK government energy policies which have a direct impact at the local authority level.

3.1.1 Fuel poverty

The UK government defines a household as being in fuel poverty when more than 10% of the household income is spent on energy costs and the issue has recently been subjected to independent review (Hills, 2012). Among its recommendations, the review suggests a change in how fuel poverty is defined; of particular interest to the present study is that fuel poverty ties in closely to energy efficiency issues. There is a tendency for fuel poor households to have low incomes and also for their houses to have poor energy efficiency characteristics compared to other houses. The particular difficulty in solving this problem is that the costs of putting in place measures to reduce energy consumed without reducing energy-demanding activities is prohibitively high compared to household income. This has significant implications for government led attempts to tackle energy poverty and raises the possibility that more deprived householders will not be financially well positioned to make energy efficiency improvements without support. Fuel poor households will therefore tend to hold the greatest opportunities for energy efficiency improvements to be made, but mechanisms will need to be in place to enable such gains to be financially possible for the householders.

3.1.2 Corporate investment obligations

The Home Energy Saving Programme (HESP) was an umbrella name for the Carbon Emissions Reduction Target (CERT) and the Community Energy Saving Programme (CESP) (McBurney, 2010). These programmes, which finished at the end of 2012, are being replaced by the Green Deal and Energy Company Obligation (ECO) which were introduced following the 2011 Energy Act (Mallaburn and Eyre, forthcoming). Both CESP and CERT were administered by Ofgem, the UK electricity and gas regulator. CESP targeted households in low income areas with the aim of improving their energy efficiency standards and reducing fuel bills while CERT was a government target for getting large domestic suppliers of energy to make carbon emission savings through the uptake of low carbon energy solutions.

CERT, formerly known as the Energy Efficiency Commitment, was intended to help the UK meet its legally binding target within the Kyoto protocol. It was an obligation placed on gas and electricity suppliers whereas CESP was an obligation on gas and electricity suppliers and generators. The CESP was the smaller of the two schemes with approximately £350 million to be invested over 3 years (2009–2012) compared with the £5 billion expected to be invested through the CERT over 4 years (2008-12). The latter was intended to save a lifetime total of 293 million tonnes of carbon emissions, compared to 19.25 million tonnes by CESP.

CESP had a “whole house” and community focus with additional credit being given to companies that followed these intended approaches rather than cherry picking single, easier savings in households and within communities. It targeted the 10% most deprived areas of the UK as defined by the Department for Communities and Local Government (DCLG), see Section 3.2. The obligated companies were responsible for reporting the carbon emission cuts they had made to Ofgem. When reporting improvements under CESP, for example, the companies could refer to Ofgem’s own calculator for estimating the emissions saved (Ofgem, 2010); for less standardised improvements, such as district heating schemes, the company concerned was responsible for estimating the carbon emissions individual schemes would save. They also had to supply appropriate supporting evidence to back their claims. The carbon emissions saved under the CESP were estimates and not explicit measures. The obligation on companies was to make certain carbon emission cuts, not a specified financial investment. The financial investment in making these cuts was the company’s responsibility however Ofgem was empowered to impose financial penalties on those that missed their targets. The Warm Home Discount scheme that came into operation in 2011 also affected gas and electricity suppliers by obliging them to give £1.13 billion worth of support to fuel poor customers over a four year period. This scheme is overseen by the government’s Department of Energy and Climate Change (DECC) and Ofgem.

The CRC Energy Efficiency Scheme, formerly known as the Carbon Reduction Commitment (CRC), applies to all organisations that consume over 6,000 MWh of electricity per year and has been active since 2010. The organisations subject to the CRC Energy Efficiency Scheme account for approximately 10% of UK carbon dioxide emissions and are required to measure and report their carbon emissions. At the end of each year, beginning in 2012, companies must purchase an allowance to cover the carbon they have emitted. In the 2011 budget, the UK government set the 2012 price of carbon dioxide to £12 per tonne (UK Government, 2011). In the future a public league table will be published for participating companies, making more transparent a company’s climate change mitigation performance. The CRC is presently under review, with the aim of simplifying the scheme (DECC, 2012a).

3.1.3 Domestic customer incentives

The Green Deal and Energy Company Obligation (DECC, 2010b) are intended to better incentivise the making of sustainable energy improvements in homes. The Government’s “golden rule” of the Green Deal is that the consumer will save more money on their energy bills than the cost of the loan required for installation of the energy saving measure. Also, instead of paying capital upfront for the improvements, the costs will be attached to the cost of home energy bills. The costs of improvements are associated with the property, not the current owner. This aligns the cost of improvements with the benefactor. If ownership of the property should change the on-going cost of improvements fall to the new owner. There remains considerable uncertainty around the Green Deal (Mallaburn and Eyre, 2013), which is targeted at domestic buildings but has been delayed for business premises. A number of criticisms have been raised with regard to the policy. These criticisms include: that there is a significant gap between the present cost of installing energy saving measures and the cost of borrowing, even at government interest rate levels (Holmes, 2012); locking future occupiers into contracts to which they were not party without any opportunity to renegotiate, whilst taking on full liability for loans and repairs and; given that the Green Deal will be the only policy and mechanism in place to meet the binding government target of eliminating fuel poverty by 2016, there is concern that the allocation of 75% of solid wall insulation funding to anyone and only 25% to the fuel poor will not be sufficient in targeting the fuel poor (Citizens Advice Bureau, 2012).

The Warm Front scheme offered grants of up to £3,500 to home owners or private tenants who are on income-related benefits to improve their heating system or home insulation. Between the start of the scheme in 2000 and 2013 Warm Front has assisted 2.3 million households. The scheme ended at the beginning of 2013, with the start of ECO.[4]

The Energy Company Obligation (ECO)[5] refocuses major energy electricity and gas suppliers' efforts to support energy efficiency under three schemes. The Carbon Emissions Reduction Obligation requires major suppliers to target 'hard-to-treat' homes with expensive energy efficiency measures that would not be funded under the Green Deal. The Carbon Saving Community Obligation requires major suppliers to support community energy efficiency schemes in low income areas, such as via district heating. The Home Heating Cost Reduction Obligation requires major suppliers to target heat energy efficiency measures (e.g. boiler replacement) on low income and vulnerable customers.

3.1.4 Feed-in-Tariffs

The UK has a Feed-In-Tariff (FIT) in place for the micro generation of Renewable Energy (RE); this policy was introduced in the Government's Energy Act 2008 (UK Government, 2008) and is administrated by Ofgem. The FIT offers payment to users of the tariff by two different means: a fixed regular payment is given, which differs depending on the type of RE technology in question; in addition, the electricity exported into the grid is also paid for. The maximum sized generator entitled to benefit from the scheme is 5 MW.

Preceding the FIT scheme and still active is a similar policy, the Renewables Obligation (RO). This was established in 2002 (2005 in Northern Ireland) following its legislative introduction in the Utilities Act 2000 (UK Government, 2000). The obligation requires electricity suppliers to purchase a specified fraction of their electricity from certified renewable sources; failure to meet their obligation results in the supplier paying a penalty per MWh that they are short. The fund generated from these penalty payments is then paid back to the Renewable Obligation certified generators, proportional to the amount of electricity they can generate. RE generators may not benefit both from the Renewable Obligation and the FIT schemes. As part of the government's Electricity Market Reform (see Pollitt, 2012), the RO will be phased out pending the introduction of Contracts for Differences

[4] See https://www.gov.uk/government/news/written-ministerial-statement-by-greg-barker-on-warm-front-and-energy-company-obligation, Accessed 1 October 2013.

[5] See https://www.ofgem.gov.uk/environmental-programmes/energy-companies-obligation-eco, Accessed 1 October 2013.

(CfDs). CfDs will involve a government backed contract for a strike price and customer funded payments to generators based on the difference between the market electricity price and the fixed strike price.

The Renewable Heat Incentive (RHI) will provide similar support for heat as the FIT does for electricity. The RHI documentation was finalised in March 2011 (DECC, 2011a) and will operate in two phases. In the first phase the RHI focussed on the non-domestic sector, but the domestic sector benefited from £15 million of “Renewable Heat Premium Payments” (RHPPs) which provides partial support for homeowners who install renewable heating systems. In the second phase, which started in 2012, a wider range of technologies is eligible for the scheme and RHPP payments continued to be made. The scheme is administered by Ofgem with non-domestic sector, payments are made quarterly for twenty years to owners of renewable heat sources. The tariff received for renewable heat varies as a function of the size of the installation and of the source of heat (DECC, 2011a) and is retail price index linked. Combined Heat and Power (CHP) generators are, at least initially, eligible to benefit both from the Renewables Obligation and also from the RHI. For the UK financial year 2012/2013 the RHI budget was capped at £70 million but is expected to be £251 million in the year 2013/2014 (DECC, 2012b). The second phase of RHPPs continues into 2014 (DECC, 2013.

3.2 National energy data

In recent years the UK Government has increased the availability of statistics relating to numerous aspects of energy usage including annual consumption data at the local level. Analysis of this data can provide a quantitative insight regarding whether the potential for climate change is successfully being mitigated and whether per capita energy consumption is falling. In the UK energy statistics at a regional level are reported in two ways with regions defined by both the UK and the EU’s Eurostat.

For both the UK’s Super Output Area (SOA) (see Subsection 3.2.1) and the EU’s Nomenclature of Territorial Units for Statistics (NUTS) (see Subsection 3.2.2) regionally-disaggregated UK energy data has been analysed and presented in Subsection 3.3 following a description of the energy data n Subsection 3.2.3. Some of the analysis in Subsection 3.3 also considers the degree of deprivation experienced by residents in each region (applies to the UK SOA definition of regions only). The data from which the deprivation data derives is described in Subsection 3.2.4.

3.2.1 Super output areas

Since the 2001 National Census the UK Government has made a strategic decision to change its method of reporting local-level statistics for the UK with the Office for National Statistics (ONS) ceasing to report on regions based on grouping houses and industry by electoral wards. The reasons cited for this are the population variations between wards and changes in ward boundaries which have lead to difficulties in direct comparison between wards and problems with time-series analysis (Bristol City Council, 2005).

Under the new system the UK is separated into three levels of geographical Super Output Areas (upper, middle and lower SOA) and each is defined by census data. Each Lower Level SOA (LLSOA) has approximately 1,500 residents citizens are resident with no less than 1,000 habitants or 400 houses. There are a total of 34,482 LLSOAs in England, 1,896 in Wales and 187 LLSOAs from the City of Leicester. There are 7,193 Middle Layer SOAs (MLSOA) in England and Wales, each with approximately 7,200 residents and a minimum number of 5,000 people or 2,000 households. Typically several LLSOAs nest within a single MLSOA although boundary modifications in response to feedback from local authorities has led to fine tuning and, in some cases, groups of LLSOAs do not align with a single MLSOA. The Upper Level SOAs (ULSOAs) encompass several MLSOAs within their boundaries; however, no data has yet been published for them. Because super output areas are defined by population and not geography it means that some areas are physically larger than others.

3.2.2 The EU's Nomenclature of Territorial Units for Statistics (NUTS) regions

In addition to the internally defined super output areas the UK reports similar statistics for the EU statistics office, Eurostat, which allows for comparison of regional performances across the EU. Its reporting framework divides geographical regions within EU countries through its NUTS methodology (Eurostat, 2003). As with the UK SOAs, NUTS are published for a range of granularities of geographical division. There are five different layers, each for regional divisions of decreasing size: NUTS1, NUTS2, NUTS3, LAU1 (formerly NUTS4) and LAU2. The NUTS1 layer regions are the largest with 3-7 million people although it is the LAU1 division that is of interest for the present work. There are 410 LAU1 areas in the UK, 356 of which are in England and Leicester city constitutes one.

3.2.3 Energy data sources

Detailed explanatory notes for how regional electricity and gas data is reported is available from the DECC (DECC, 2010c) and key points are summarised as follows. In 2003 and 2004 the DECC released experimental electricity statistics for LAU1 NUTS regions. These statistics have been classified as National Statistics since 2005. In 2004 provisional electricity statistics were also reported for MLSOAs and subsequently also awarded National Statistics status in 2005. LLSOA electricity data was first released in 2007, although only for 45 local authorities, in 2008 and 2009 the reporting scheme remained experimental, but data is now released for the whole of England and Wales. The majority of the electricity data is taken from non-half-hourly meters with meter readings made at least six months apart being used to estimate annual consumption. In cases where recent meter readings have not been taken, usage estimates are made using historical data and any other information associated with that meter point. A minority of data (approximately 0.1% of meters) comes from half hourly metering providing measured readings rather than estimations. Two types of domestic electricity tariffs (Ordinary or unrestricted and Economy 7) are reported separately, however, in this analysis these data have been combined with related implications for accurate representation of behavioural variation.

Annual gas consumption is also based on two meter readings that are at least 6 months apart, if this data is not available estimates are made. For approximately 18 % of meters recent readings are not available and an alternative, probably less accurate, estimate must be made. A drawback in the gas data, as reported by the DECC (2010c) is that any user consuming more than 73,200 kWh is crudely termed an industrial user and any user that consumes less is deemed domestic, regardless of whether this is the case in reality. As a result only about half a million connections are allocated to the business category, this leaves approximately two million UK businesses categorised as domestic users (DECC, 2010c). Gas statistics were first made available for the NUTS LAU1 framework in 2001. For 2001 to 2004 this data was reported by National Grid, which at the time was the monopoly operator of gas distribution in the UK. Following the partial divestiture of UK gas distribution responsibility for reporting gas statistics moved to the Department for Trade and Industry (DTI), now

DECC. The 2004 data was revised and reported for a second time and treated as experimental by the DECC. For 2005 and onwards gas statistics have been awarded National Statistics status. All of the gas consumption data is regionally corrected for variations in weather conditions for the year in which the data derives compared to the average weather conditions for either the previous 35 or 17 years. The correction applied to the original National Grid 2001-2004 data is based on a 35 year average, which is different to that of the 2004 (revised) to 2009 data; this is based on a 17 year average. The shorter time period is being used to better account for affects due to climate change on weather conditions. The DECC strongly advise that the original National Grid data, and the revised 2004 data onwards, are not compatible with one another and should not be directly compared (DECC, 2010c). MLSOA electricity data for 2005 onwards is available, as is LLSOA data for 2007 (45 local authorities only) and 2008-2009. The electricity statistics are also weather corrected. The quality of MLSOA data reporting significantly improved from 2006 onwards; that for 2005 suffers from a significant number of inaccuracies in its recording and has therefore not been used for the present work. The data presented is not controlled for the variation from average weather conditions that each region experienced in the years that data is reported for. When drawing comparison between regions in the gas and electricity data presented in this work it is not possible, for example, to explicitly determine why a region might have greater/less energy consumption than another. It could be because households in the region have poorer energy efficiency or it could be because a regions climate was unusually cool compared to how much cooler (or warmer) other regions were to their average.

3.2.4 Deprivation data

The Department for Communities and Local Government (DCLG) has developed a methodology for quantitatively determining the degree of deprivation experienced by UK residents. Data is collected for the whole country using this methodology and is reported for each LLSOA layer in England, Wales, Scotland and Northern Ireland separately and combined. Each LLSOA is ranked relative to the others based on this quantitative score with Rank 1 corresponding to the most deprived (DCLG, 2010b). Deprivation data is not reported for MLSOAs and it is not possible to accurately calculate MLSOA deprivation based on the LLSOA data due to LLSOA boundaries not always residing entirely within a single MLSOA. These boundary issues have been assumed to be a small correction factor, therefore when considering MLSOA deprivation in this analysis an approximation has been determined from the mean rank of the LLSOAs encompassed by each MLSOA (in cases where boundaries do not match precisely, the LLSOA has been grouped under the MLSOA that the majority of the LLSOA resides within).

The measure of deprivation is determined by an Index of Multiple Deprivation (IMD), which is based on seven categories with an individual weighting according to their influence on the overall IMD. The categories are (their percentage weight is given in brackets): income (22.5%); employment (22.5%); health and disability (13.5%); education, skills and training (13.5%); barriers to housing (9.3%); crime (9.3%) and; living environment (9.3%). Each SOA's deprivation rank is determined based on its score compared to all other SOAs, the areas with the highest IMD score are considered to be the most deprived and are ranked the lowest numerically.

According to the DCLG's IMD measurements (DCLG, 2010b), Leicester's 187 LLSOAs are more deprived than average for England. Their mean rank of deprivation is 8,966, out of 32,482 LLSOAs for the country as a whole. 25% of Leicester's LLSOA's are among England's 10% most deprived areas and England's most deprived LLSOA is situated in the city.

3.3 Energy demand data

To obtain a clearer understanding of how Leicester is performing in terms of its energy consumption two other English cities (Nottingham and Coventry) that are geographically close and demographically similar have been selected for comparative examination. The MLSOA and LLSOA consumption data are taken from the DECC (2012c), the NUTS LAU1 consumption data from the DECC (2012d, 2012e) and the deprivation data from the DCLG (2010b). Only data defined to be for domestic consumption is considered in the present analysis (Figures 1, 2 and 3).

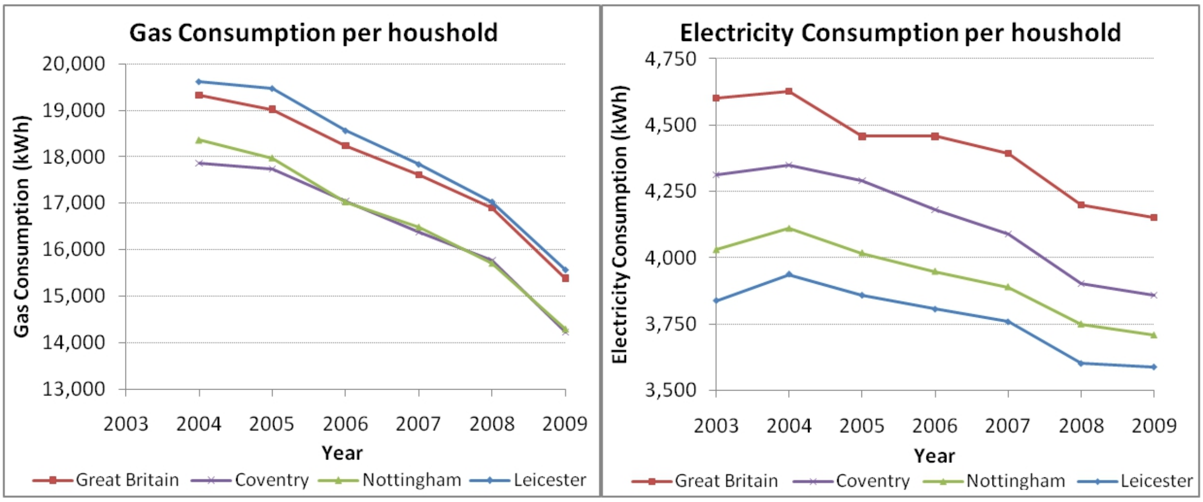

Figure 1: Annual gas and electricity consumption per household for Leicester, Coventry, Nottingham and Great Britain using data for LAU1 NUTS regional boundaries.

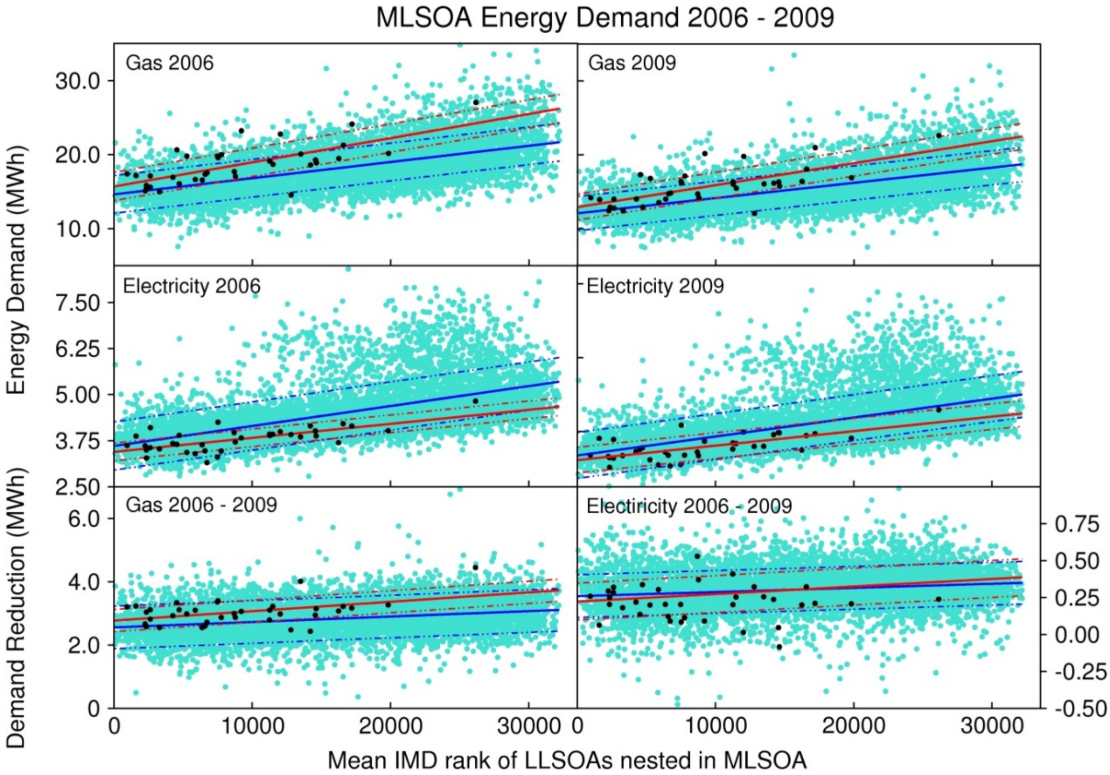

Figure 2: Comparison of IMD with gas and electricity data for MLSOAs in England. In turquoise are MLSOAs in England and in black those in Leicester. The blue and red lines are mean for England and Leicester, respectively. Dashed lines represent one standard deviation from the mean.

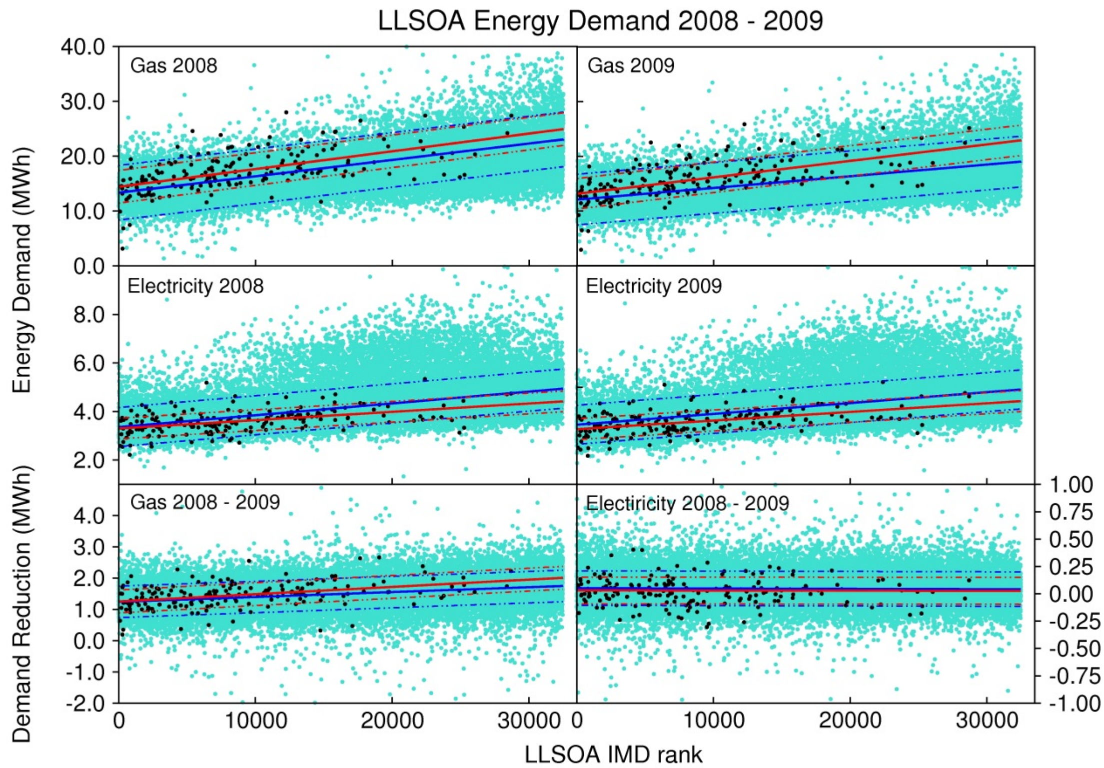

Figure 3: Comparison of IMD with gas and electricity data for LLSOAs in England. In turquoise are LLSOAs in England and in black those in Leicester. The blue and red lines are mean for England and Leicester, respectively. Dashed lines represent one standard deviation from the mean.

3.3.1 Gas Data with Deprivation

Figure 2 shows demand data for MLSOAs between 2006-2009. In 2006 Leicester MLSOA's average household gas consumption was above the English average, only 3 of 36 areas used less gas than average for similarly deprived areas in England. In 2009 the city's consumption of gas had reduced by 16.3% of the 2006 demand and the country as a whole had reduced by 15.6%. At this time Leicester's gas demand was an average of 1.7 MWh per year greater than other English MLSOA's, compared to 1.9 MWh in 2006 however during this period total gas demand in the city has been reducing at a slightly higher rate than the UK average, by approximately 110 MWh/year more.

Analysis of the LLSOA data in, Figure 3, between 2008 and 2009 brings similar conclusions. This data does highlight the areas that are connected to the district heating network. Three LLSOAs have particularly low gas demand compared to other areas. These areas include the houses connected to the existing district heating, it is therefore expected that their gas demand is not included in the domestic data that is reported by the local gas distribution company, National Grid because the gas demand of the district heating network is likely to be classed as being for industrial consumption. Between 2008 and 2009 Leicester LLSOA's decreased their gas demand by 83 MWh more than the national average.

3.3.2 Electricity Data with Deprivation

Figure 2 shows that on the whole Leicester's MLSOA's 2006 electricity demand was lower than the English average for equivalently deprived areas, by a mean of 0.30 MWh per household. In 2009 the mean household demand for electricity had reduced with Leicester's demand being only 0.23 MWh lower than the English average. The MLSOA data shows that over the 2006-2009 period Leicester's mean household electricity demand reduced by 5.6%, while the mean English reduction was 6.8%. In the LLSOA data it is interesting to note that for all of England the demand for electricity increased by 0.6% between 2008 and 2009, while in Leicester it decreased by 0.5%.

3.3.3 European Gas and Electricity Data

The LAU1 data (Figure 1) shows that in 2004 Leicester's gas demand per household was greater than the average of Britain, Nottingham and Coventry; however, its electricity demand was lower than all of them. This remains the case in 2009. A breakdown of the actual and percentage changes in demand for these four localities is given in Table 2 and shows that, while Leicester has reduced demand at a slightly higher rate than Britain as a whole (which is consistent with its performance compared to England in the super output area data), compared to Coventry and Nottingham its gas demand is greater and is reducing at a slower rate. The city's electricity demand is also reducing at a slower rate; however, the demand for electricity per household is already lower than for Coventry and Nottingham. The higher general fall in gas demand relative to electricity demand is due to a combination of the higher price rises for gas (over the period gas prices rose 87% in real terms against a rise of 54% in real terms for electricity[6]) and the higher price elasticity demand for heating relative to power (due to the generally lower level of electricity relative to gas expenditure for dual fuel households).

[6] See DECC (2013b).

Table 2: Gas and Electricity demand per household for 2004-2009, as reported for the EU NUTS LAU1 layer (DECC 2012d, 2012e).

Location	Demand per household (MWh)					
	2004 Gas	**2009 Gas**	**2004 -2009 Gas demand reduction**	**2004 Electricity**	**2009 Electricity**	**2004 -2009 Electricity demand reduction**
Great Britain	19.3	15.4	3.9 (20.2%)	4.63	4.15	0.48 (10.4%)
Coventry	17.9	14.2	3.7 (20.7%)	4.35	3.86	0.49 (11.3%)
Nottingham	18.4	14.3	4.1 (22.3%)	4.11	3.71	0.40 (9.7%)
Leicester	19.6	15.6	4.0 (20.4%)	3.94	3.59	0.35 (8.9%)

Leicester's demand for electricity is consistently lower when compared to the country as a whole, to similar cities and to similarly deprived regions. While not conclusive, appropriate electricity data for the years prior to 2004 is not available, however the overall trend is consistent with the city council's longstanding efforts to improve energy efficiency. Leicester's actual and percentage rate of improvement in electricity efficiency is now less than the areas it has been compared to, however this might be expected as the easier and more cost effective improvements may already have been made in the city.

The picture for Leicester's gas demand is less positive. When compared to Great Britain, Coventry and Nottingham, Leicester is found to have the highest demand and one of the lowest percentage rates of reduction in demand. Comparison with similarly deprived areas again shows the city to have higher gas demand, but does show a slightly better rate of demand reduction.

3.4 Carbon Emissions Data

Carbon dioxide emissions per capita are published annually by DECC for the European NUTS LAU1 layer (DECC, 2010e) and the requirement for local areas to report this information, called National Indicator (NI) 186, has been in place since 2005. The emissions for Great Britain, Leicester, Coventry and Nottingham are given in Figure 4 and show that while Leicester is performing better than the national average, its emissions per capita have been consistently higher than Nottingham and Coventry for the period 2005-2008.

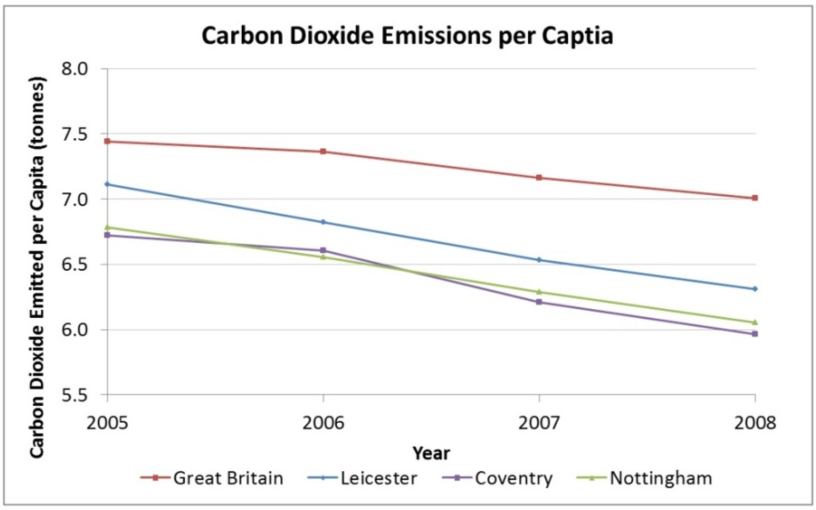

Figure 4: NI186 data for carbon emissions per capita given for the NUTS LAU1 layer.

Since the 2008-2009 financial year local authorities are also required to publish the carbon emissions of council properties under the DECC's NI185 (DECC, 2010d). The DECC note that when compiling the information they observed inconsistencies in methods of reporting carbon emission data between local authorities; this suggested that the data should be treated cautiously. The 2008/09 council emissions for Great Britain, Leicester, Coventry and Nottingham are given in Table 3, along with estimated mid-2008 populations for each area (taken from the DECC (2010e)).

Table 3: 2008-2009 carbon emissions from local authority owned property (including transport) for all of Great Britain and three local authorities.

Location	Mid-2008 population estimate (million)	Total emissions (thousands of tonnes of CO2)	Emissions per capita (tonnes of CO2)
Great Britain	61.0	8,339	0.137
Leicester	0.301	66.2	0.220
Coventry	0.307	56.8	0.185
Nottingham	0.292	62.4	0.214

3.5 Central Leicester's major energy consumers

Across Leicester in 2009 4,258 GWh of gas and 1,454 GWh of electricity were consumed (DECC 2012d, 2012e). The major users of this energy (table 4) are: LCC, which includes administrative buildings and public facilities such as leisure centres; Leicester City's three hospitals and its two universities. Some assumptions have been made in order to arrive at the numbers given in Table 4. For LCC, only costs for gas and electricity usage combined have been made available; to disentangle these it has been assumed that the council's ratio of gas and electricity consumption is the same as for Leicester overall (2.9 kWh of gas per kWh of electricity). It has also been assumed that in 2009 LCC paid the mean gas price charged to "Large" (2.015 p/kWh) and "Very Large" UK commercial firms for electricity (8.23 p/kWh), as reported by the DECC (DECC, 2011b). The combined 2009 electricity and gas bill for the LCC was £8.87 million. The same method has been employed for the hospitals where only the combined electricity and gas bills were available for the year 2007, this was £6.3 million (University Hospitals of Leicester, 2007). De Montfort University have made available an explicit month-by-month breakdown of their 2009/10 utility demand and cost (De Montfort University, 2011) and for the same time period the University of Leicester has made available its total utility demand (University of Leicester, 2011a). The latter university includes only the energy consumed on campus.

Table 4: Approximate energy demand of Leicester's major energy users (DECC, 2011b; University Hospitals of Leicester, 2007; De Montfort University, 2011; University of Leicester, 2011a).

Energy User	Period that the data is taken from	Gas (MWh) (% of city 2009 Total)	Electricity (MWh) (% of city 2009 Total)
Leicester City Council	2009	158,000 (3.7%)	69,000 (4.7%)
University Hospitals of Leicester – NHS Trust	2007	112,000 (2.6%)	49,000 (3.4%)
University of Leicester (campus only)	August 2009 – July 2010	63,435 (1.5%)	37,698 (2.6%)
De Montfort University	August 2009 – July 2010	16,728 (0.4%)	14,782 (1.0%)
All of Leicester	2009	4,258,000	1,454,000

4 Local Level Coordination of Energy Policies

Local government authorities are uniquely placed to influence local energy policies. They can play an important role in maximising the benefit realised from national energy policies and are also very well positioned to innovate, test and implement additional policies that may suit their local area and potentially others too. Public administration accounts for approximately 5% of UK energy demand and socially rented houses a further 5%. Local authorities manage a wide range of public services; a responsibility that brings them into contact with local communities and businesses (Kelly and Pollitt, 2011). As a result they can exert influence over a significant proportion of total energy demand both directly in their management of their managed buildings and also through interaction with local communities and businesses in the energy market.

Groups in Leicester joined together to form the One Leicester partnership, which has recently (April 2012) been replaced by the City Mayor's Partnership[7]. This is a community driven partnership dedicated to improving Leicester through a collaborative strategic vision. Fundamentally this vision is a non-legally binding statement of intent by its members with seven core objectives:

> "investing in our children, planning for people not cars, reducing our carbon footprint, creating thriving, safe communities, improving wellbeing and health, talking up Leicester, investing in skills and enterprise" (Leicester Partnership, 2008).

Two of these aims closely match the current energy policy investigation: primarily "reducing our carbon footprint" and secondarily "planning for people not cars". A theme-group responsible for delivering these two aims is the Environment Partnership Board.

The One Leicester Partnership produced an annual State of the City report detailing their progress towards meeting One Leicester's goals. With respect to "reducing our carbon footprint" the 2009/10 State of the City report (Leicester Partnership, 2010) claims carbon emissions have reduced by 7.5% between 2005 and 2008, with improvements made across all sectors. It also claims that 79% of schools have travel plans in place, with fewer children travelling to school, and that 39% of the labour market is now included in workplace travel plans. With respect to "planning for people not

[7] See http://citymayor.leicester.gov.uk/welcome/city-partnership/ (accessed 1st November 2012)

cars" cycle ways have been extended, 9,000 trees have been planted, 298 affordable homes are being constructed, public bus transport and access to the city centre have been improved, as have the facilities within it.

The State of the City report was released with an accompanying technical report (Leicester Partnership, 2010). Regarding deprivation, the technical report acknowledges that the city lies 20th out of 354 local authorities (using the DCLG IMD ranking methodology) and as such is deprived compared to most other regions in the UK. The report also points to further activities that aim to improve energy usage, these include: ensuring that every new building constructed after 2013 is zero carbon, installing insulation in homes, upgrading and expanding the city's district heating networks and implementing energy management schemes for Small and Medium Enterprises (SMEs).

Owing to wide-ranging environmental, social economic and historical factors the considerable differences can be apparent in the makeup of networks of players involved with energy efficiency issues in any given local area. Furthermore, local 'players' and their priorities are changing all the time. This combination of factors means there can be no single model for how energy policy is best enacted at the local level and it is precisely because of this that it is difficult determine whether any single area is taking the best course of action available to it when tackling energy policy issues. It is, however, informative to examine and evaluate specific local communities that are viewed as being successful. As discussed in Section 2, Leicester is thought of as being such a community. To initiate analysis of the way this local community is tackling energy issues, a systematic identification and examination of energy-related local players and activities has been performed and from that a diagram that attempts to characterise and map the local energy "landscape" has been created (Figure 5).

Surveys of local authorities in England and Wales suggest that local councils are able to have more comprehensive climate policies if they get more support from other local actors (see Allman et al., 2004). This suggests the importance of local interaction between the relevant players. Figure 5 is intended to indicate the key interactions between Leicester's players or features and the significant initiatives, schemes and programmes in the city. It includes presently active players and also those that have been active over recent years. The figure does not include a comprehensive list of every group/feature that plays a role in Leicester's local energy policy, but is instead a selective balance between including the most pertinent and interesting players and also ensuring that the figure is clear and comprehensible to the reader. The core ways in which these different groups and features interact and affect one another are indicated by black arrows and brief accompanying descriptions. Bullet point descriptions of each group/feature are given under their name to summarise their nature. The groups are described in more detail in Appendix A and the features in Appendix B. Where possible, web links to the groups and features have been given.

This energy "landscape" has been developed through a systematic process with Leicester City Council selected as the starting point. The underlying assumption made during the process was that local authorities play a significant role in the execution of energy policy at the local level and that any other significant player/feature of the local energy landscape will have either a direct or indirect connection to the local authority, i.e. that there is a single web of energy concerned players in a local area and that there does not exist more than one autonomous collection of active energy players making a significant contribution to tackling energy issues.

Information was firstly gathered on the local authority through reading its own published documents and through direct interviews with members of staff. Two types of information were gathered from this: players and features of the energy landscape in Leicester were identified and more detailed information regarding the council, and other players was gathered. In a second stage of information gathering, the newly identified players and features were similarly subjected to an information gathering exercise. From this, further players were identified, and additional information on known players ascertained. Some players were studied on multiple occasions following additional information on them being brought to light from subsequent stages of the investigation.

One player (the Carbon Action Rationing Group (CRAG)) is included in Figure 5 but does not have a link that can be drawn back to the local authority. This group was identified as a part of Leicester's energy landscape through direct discussion with employees at the council; however, although the group could be identified by the council, there were no significant interactions identified during this research between them and the other players in the area.

Figure 5: Key groups (blue) and features (orange) involved in Leicester's local energy initiatives. The three shades of blue/orange indicate presence/activities: local to Leicester (darkest, white text); national (mid-shade) and; international (lightest). Groups/feautures inset within another are subsidiaries. Black arrows indicate how one group or feature interacts with another.

The information gathered on Leicester's energy landscape and presented in Figure 5 has highlighted a wide range of organisations and activities that are involved with tackling energy issues. These include a mix of UK wide activities, such as the Neighbourhood Renewal Fund (NRF) and the Home Energy Saving programme (HESP) alongside more innovative undertakings that groups in Leicester have embarked upon under local initiative, such as the intelligent metering scheme and the EcoHouse.

There are examples of collaboration between groups, for example loft insulation has been installed by the Mark Group but funding for it provided by British Gas (presumably prompted by their CESP obligation). The prioritisation of homes to receive the insulation is being managed by the local council, whose decisions are being aided by thermal photography provided by Blue Sky International Ltd. The intelligent metering network exemplifies policies being enacted that complement each another. By making available time-series demand data at a building level the direct measurement of energy consumption is made possible. This allows better targeting of demand reduction efforts and therefore greater efficiency savings. The provision of data is helping make easier the decision making process regarding what future action to take, and where to take it.

Two particular areas of activity identified in Figure 5 have been subject to more detailed investigation. One of these is the expanding district heating networks (Leicester City Council have recently awarded a 25 year conditional tenured ownership of the network to Cofely UK). This has been selected because district heating has a strong case for forming part of a sustainable energy system, not just in Leicester, but more widely across the UK and also other countries (Kelly and Pollitt, 2010). The creation of district heating networks can be complicated by the necessity for sustained cooperation between the participating parties and the manner in which Leicester is tackling this issue is of particular concern in our analysis. Secondly, Leicester's use of quantitative utility data (which includes energy and water) to inform other energy-related activities is examined further.

5 Combined Heat and Power (CHP) and District Heating (DH)

District Heating (DH) has only been adopted in the UK to a limited extent compared to some of its European neighbours, such as the Scandinavian countries and many former Eastern Bloc countries. Specifically the heat from UK based combined heat and power (CHP) plants is used almost exclusively for industrial applications (Radov et al., 2008). However, in recent years the propensity for DH and CHP to mitigate carbon emissions has become recognised and led to the UK Government's national heating policy to change. Kelly and Pollitt (2010) argue DH schemes are thereby gaining support and go on to discuss the multiple mechanisms that the UK government has put in place to support DH-CHP; these include: exemption from paying the climate change levy, enhanced capital allowances, the CESP, biomass grants and a requirement for government departments to source at least 15% of their electricity from CHP by the end of March 2010, a target that was not reached by most departments (see DEFRA, 2011)[8].

[8] No reasons were given.

Kelly and Pollitt (2010) also detail market challenges faced by DH-CHP, pointing out that the present electricity market and regulatory framework disadvantages small (<50 MW) power stations and that the value (in terms of economics, sustainability and security of supply) of producing the heat and electricity locally is not fairly reflected in commodity prices and market costs. Issues relating to exactly how small plants are disadvantaged are also discussed in Toke and Fragaki (2008); their research concludes that a major obstacle to DH-CHP is financing the capital costs of developing or building its network infrastructure. Further national grants and subsidies are unlikely to be effective whereas controlling for long-term risk factors and minimising future uncertainty is of pivotal importance in reassuring investors that they will see a return on their investments and that cooperation between the involved organisations is fundamental to the success of technology.

5.1 Leicester City's District Energy

Two reports led by Lord Marshall and published by the Government's then Department of Energy (DoE) are milestones in history of District Heating in the UK (Marshall, 1977; Marshall 1979). They argue that the UK would benefit from DH and CHP and that developing district heating networks would take considerable time. For the networks to be available they had to be built in advance of being needed i.e. at the time when oil and natural gas reserves begin to deplete. Investment in district heating appeared to reap long-term benefits, however, then as now, competition from alternative sources of heat weakened the short-term argument for it, often deterring investment. Marshall recommended that support for, and development of, DH-CHP networks began through designated "lead" cities. By 1981 nine such cities, including Leicester, had been identified by the firm, Atkins, and the DoE (Taki et al., 1992). In 1982 three of these cities (Belfast in Northern Ireland, Edinburgh in Scotland and Leicester in England) were selected and between them received £750,000 of investment from the DoE.

Leicester was therefore a pioneering city of DH in the UK and with the DoE investment in the 1980's attempted to install a city-wide scheme (European Academy of the Urban Environment (EAUE), 2001) and created the Leicester Energy Company (LEC) to do so. However, while localised schemes were established, the LEC did not succeed in realising a city-wide network. The reasons given for not achieving this were due to the energy industry undergoing privatisation at the time (Prof. Paul Fleming (personal communication); EAUE (2001)). Privatisation ended the existence of the UK's Central Electricity Generating Board and even though a draft contract existed between them and the LEC the change in industry structure introduced future market uncertainties for the new electricity companies. When considered alongside the long-payback times associated with District Heating these uncertainties led to the companies not agreeing long-term DH contracts with LEC.

At present Leicester's DH consists of six networks, four of which are close together and central in the city. These are named after the housing estates that they are adjacent to: St. Andrews, St. Marks, St. Mathews and St. Peters. The two other networks are named Aikman Avenue and Beatty Avenue. Between them these deliver heat (and in some cases hot water) to 2,800 council homes, nine nurseries and schools, four adult community centres, a library and a swimming pool (Publictenders.net, 2009).

LCC is making a renewed effort to extend DH and CHP to a city-wide scale beginning with the linking of existing networks. This is a two stage scheme, with a £100,000 budget allotted for stage 1 and £300,000 for stage 2 (LCC, 2009a). The funding for stage 1 was confirmed on 27th March 2008 and on

14th July 2008 LCC decided that the work should be led by the private sector (LCC, 2009b), qualifying the venture as a private finance initiative (PFI). The LCC does not expect to commit any further finance to this scheme and has several overarching goals for it (LCC, 2009a, page 3):

- To provide affordable, reliable and controllable heat to council and residential buildings and other senior users.
- To reduce carbon emissions, contributing towards the ambitions of One Leicester.
- To establish a secure and sustainable energy supply.
- To enable the option to expand the proposed energy network to include users who are not presently being considered.

In addition to these core objectives, LCC has the expectation that the scheme should reduce end user bills and that the price of heat purchased by users in the scheme will be equal to or lower than the market rate, therefore contributing to reducing fuel poverty. While initially the network is expected to be fuelled by natural gas, it is a requirement of LCC's plans for the scheme that the system is made able to switch to renewable fuel in the future, for example biofuels are being considered.

In addition to an extension of service to LCC buildings (most significantly this includes a leisure centre) the DH network is hoped to expand to include the University of Leicester, HM Prison Leicester (subject to change owing to ongoing reforms of the UK's prison service), a college, a primary school and two workshops. Additional users are hoped to be included during future expansions of the network, the largest among these are De Montfort University and the Leicester Royal Infirmary.

Leicester City Council (LCC) project that the scheme (while still using natural gas as fuel) will reduce Leicester's carbon emissions by 13,100 tonnes per annum. This is 0.7% of the city's total 2008 emissions and 1.2% of the way towards meeting the One Leicester annual emissions target of 0.8 million tonnes of carbon dioxide by 2025 (using 2008 as the baseline).

Before it tendered a contract the LCC gave consideration to key issues involved in the implementation of the scheme (LCC, 2009a; LCC, 2009b); a summary of these are as follows:

- Although LCC could have borrowed finance relatively cheaply to undertake the scheme on its own it was unwilling to hold a financial share in the ESCO that performs the work. This is because the council does not expect the investment to increase its influence over decision making but ownership will subject it to financial and political risk.

- Whether or not the DH scheme should include the installation of meters in the served homes proved a difficult issue; in large part this was due to the positive feedback of increased capital outlay for the ESCO (estimated by the LCC at £6 million for installation alone) while the meters will serve to reduce user consumption (predicted to be by 12%). This in turn reduces the financial viability of the project and could lead to increased energy prices. The LCC invited ESCOs tenders through two bids, one including meter installation and the other not.

- The LCC wishes consumers to be billed directly by the supplier; this means that the smart meters installed will not need to be as sophisticated and less costly models can be installed.

- The four central boiler houses are included in the proposed single network with the two outlying boiler houses being too distant for viable inclusion (in Figure 6 the two outlying networks are included in the discontiguous areas of the map, labeled Aikman Avenue and Beatty Avenue. The central four networks are all located in the main area of the map in the figure). While the LCC expected these boilers to be included in bids, the option was open as to whether they would form part of the same network, or remain isolated.
- It was expected that as an ESCO takes control of the network there may be costs associated with the termination of contracts for supply/maintenance. The council already owns all of the land and initial assets for this scheme.
- There will be a requirement to include Right to Buy leaseholders in the DH scheme and their lease agreements will be changed to include this.
- The Housing Act (1985 S.105) requires that the council consults tenants and leaseholders about how they may be affected, the introduction of meters and any charges that may be levied on the leaseholders.
- Issuing bonds as a means of financing the scheme was deemed not to be prudent. Retail bonds have a minimum size of around £1 million, however, the one-off administration costs costly are complex and expensive.

Recently the tendering process for the scheme came to a conclusion with Cofely District Energy, a GDF SUEZ subsidiary company, winning the bid (University of Leicester, 2011b) and construction work has now begun (Cofely, 2012). The network will be operated by a new subsidiary company that is being set up by Cofely, the Leicester District Energy Company. Cofely has a 25 year long lease, with a possible extension clause of a further five years. The company will be investing £14 million to perform its upgrade and expansion (this is exclusive of the £6 million for meters, which are not in the agreement). Part of the reason that the scheme is economically viable is because GDF Suez is using the carbon savings that will be made to meet a part of its CESP obligations. Figure 6 shows the present networks and Cofely's planned extended network; it is significant that the pipe works will bypass many potential small users en-route between the larger users that are intending to connect to the network. The new network will have a total capacity of 50 MW, featuring 5MWe of gas fired CHP (3.2 MWe of which will be from within the University of Leicester campus) and 100 kW from a biomass boiler (Cofely, 2011).

Although the mass installation of meters is not a part of the existing agreement between Cofely and LCC, the council is trialling the use of metering in fifty volunteer households for one year to see if their energy bills reduce to below the flat rate that residents presently pay (Martin, 2010). This trial will gather data on the costs and benefits of meters and will better inform the council on the best course of action to proceed with regarding the entire 2,800 houses supplied by the DH network.

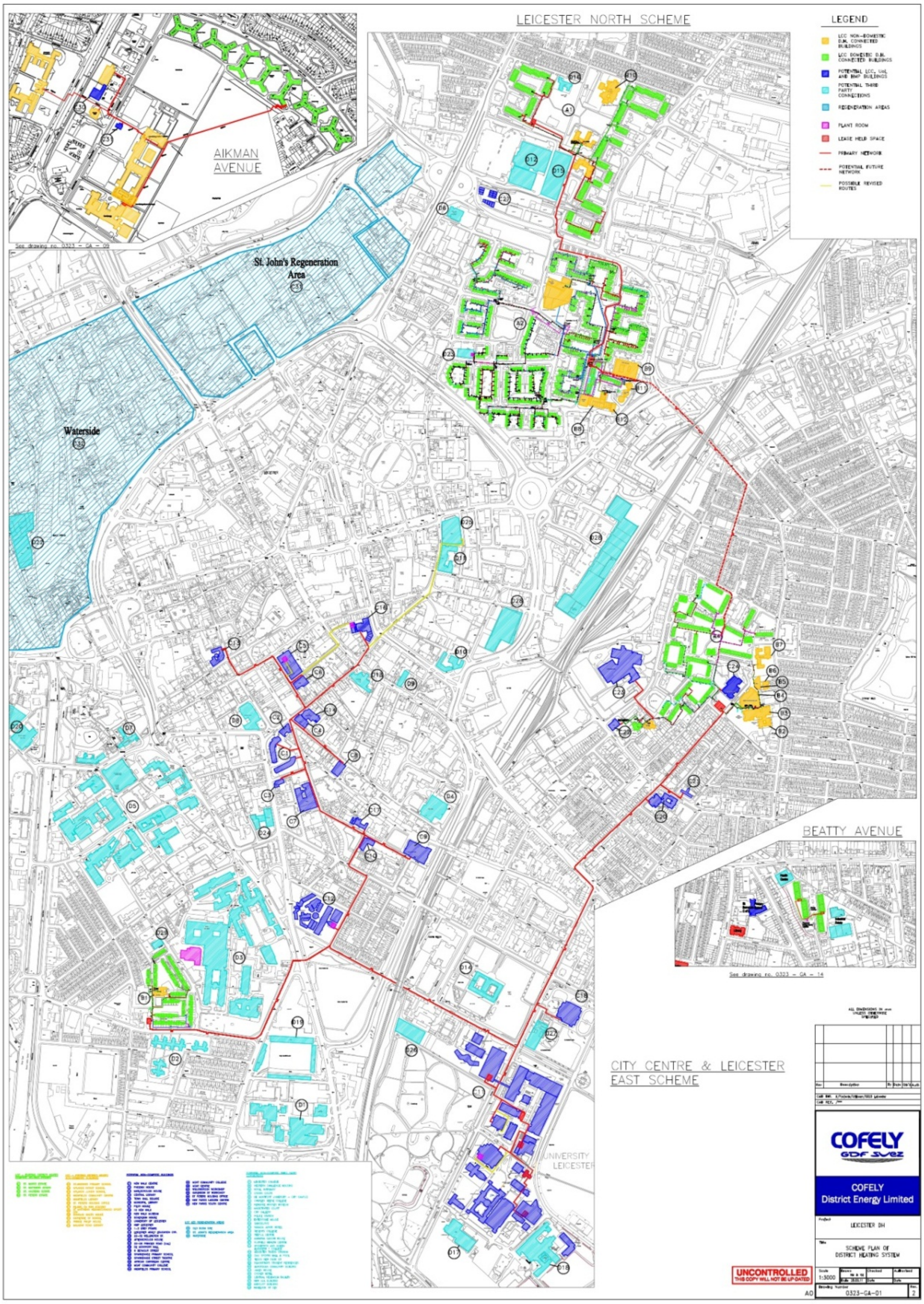

Figure 6: Leicester's existing DH networks and Cofely's plans for upgrade and expansion. Green and yellow marked buildings are domestic and non-domestic premises served by the existing networks, respectively. Dark blue premises are planned to be in the expanded network and light blue buildings are being considered for future inclusion. The red line indicates where the pipes will link the premises in the network (Map included by kind permission of Cofely District Energy Limited).

5.2 Evaluation

Coordination between all involved parties has been critical to the success of the DH network. The willingness of major users to commit to joining the network (for example LCC, the University of Leicester and HM Prison) is important to provide assurance to that the investing ESCO, Cofely, will realise a return on their investment. The timing of the upgrade is also important; the economics of a proposal are considerably stronger if the existing boilers of potential customers are due for replacement anyway, as is the case for the DH boiler houses and the University of Leicester. Due to the long lifespan of boilers, these opportunities do not come along frequently or together. The integration of small users (e.g. individual houses) into the network is not an option given the prohibitive cost of the infrastructural investment that would be required. Even given Leicester's favourable situation for a city-wide DH network (existing scheme, community cooperation and support, boilers due for replacement, support through the CESP) the economic viability of the scheme appears challenging. In the short-term it is potentially cheaper to simply fit individual highly efficient new boilers; however the future price of electricity and carbon will be an important deciding factor in this (Halsey, 2012). The CESP scheme has arguably been a significant economic driver behind the expansion of Leicester's DH network and provides an excellent example of national policy having the intended impact on actions taken at the local level.

6 Energy and Water Data: Gathering, Monitoring and Management

6.1 Intelligent Meter (IM) Network

As a part of its efforts to improve energy and water usage efficiency in 2001 LCC began an Intelligent Meter (IM) network (i.e. smart meters with an IT infrastructure) in its premises. The aim was to enable the identification and reduction of waste energy and water and to obtain disaggregated data on the consumption patterns of building types. By 2005 a network of nearly 600 meters had been installed in between 270 premises (Brown and Wright, 2007) with half-hourly data from each of the meters sent via radio wave transmission to one of seven radio stations throughout the city. This data is then centrally recorded and monitored by the Leicester Energy Agency (LEA). IM is presently a fast evolving technology and as such the meters installed by LCC can now be considered out of date, with internet-based systems having taken over from this radio wave transmission style of communication. Recent research has made use of land registry data to better predict the electricity consumption patterns of Leicester's non-domestic buildings (Liddiard, 2012). The predictions made are compared to measured data and offer insights into the ways individual types of non-domestic building stock consume electricity. Being able to validate these predictions using measured data can further increases the value returned from gathering such data in the first instance. Leicester's IM experience significantly predates the national mass roll out of smart meters to domestic and small business electricity and gas users, which is due to begin in 2015.[9]

[9] See https://www.gov.uk/government/policies/helping-households-to-cut-their-energy-bills/supporting-pages/smart-meters, Accessed 1 October 2013.

6.1.1 LCC Experience with IM - Challenges

Brown and Wright (2007) have also performed a study of the LCC network and encountered the following complications with interpreting the recorded data:

- **Zero Consumption recorded:** it is not always clear whether consumption is really zero or if the reading is incorrect. For electricity it is unusual for consumption in a building to be zero, however, this is not the case for gas and water. Determining what the reading should have been requires comparison with similar historical days and the other utilities.
- **Labelling inconsistencies:** electronic labelling of buildings and premises names has been wrong or misleading, causing confusion during analysis.
- **Delayed readings:** in one half-hour period meters sometimes report zero consumption, followed in the next half-hour by a reading for the total consumption of the previous two periods combined. This causes irregular spikes and troughs in the recorded data.
- **Complex calibration:** each meter transmits its raw data, which is calibrated centrally at the energy agency (LEA). A lack of homogeneity of meters and the fact that multiple different utilities are being monitored requires users to be careful to adopt that the correct calibrations for each meter; this ensures that the raw data is correctly interpreted and can be time consuming.

If uncorrected, these data errors lead decision makers to using inaccurate information as the basis for future energy efficiency investment options. However, the processes of making corrections can be extremely time consuming and require a good working knowledge of the system. Modern intelligent meters (IMs) and their data transmission systems have overcome many of these challenges. In older systems, algorithms such as those that have been developed by Brown and Wright (2007) ought to be optimised, automated and integrated into the network's data acquisition system. Issues such as meter labelling and knowledge about calibration requirements are important for the effective installation of the network and for the planning of its future network growth..

6.1.2 LCC experience with IM – Successes

In 2005-2006 Leicester City Council benefitted from the LAEF scheme (McDonald, 2008) through which Salix (created by the Carbon Trust, which was in were created by Central Government) offered the council a £500,000 loan to match their own investment in energy efficiency measures. Investments made through LAEF are expected to have a payback period of five to seven and a half depending on the project's carbon mitigation potential (McDonald, 2008). Initially savings from the efficiency gains are used to repay the loan, after which further gains support the financing of more energy efficiency measures. The types of efficiency saving initiatives that have been supported by the scheme include:

- Insulation, such as cladding for exposed boiler pipes
- Cavity wall and loft insulation
- Installation of low-energy lighting
- Provision of covers to reduce heat losses from pools
- Replacement of motors that drive pool water flow and air conditioning

Intelligent Meters have been valuable when measuring the energy savings reaped by these initiatives. The meters give near-real-time sensitivity to compare premises consumption with expected levels for the current time, day and seasonal period. They also allow for cross-comparison between time periods. The council has identified the following savings as arising out of their being an IM network:

- Reduced water leaks or supply shutdowns;
- Heating systems being manually switched on;
- Observation of the demand impact arising from utility-consuming devices being added or removed from premises;
- The enabling of comparison to be drawn between a premises consumption rates in periods when it is occupied to when it is unoccupied;
- Tests of the synchronisation of timers that control when gas central heating is switched on and off, in particular whether the timer accounted for vacant periods (e.g. weekends);
- Comparison of demand behaviour from one year to the next;
- Determining the demand reduction realised by newly installed energy saving measures.

Specific examples of the observations made through the Intelligent Metering system are given in Appendix C; these have been provided by the Leicester City Council and in each case the energy and anticipated financial saving are calculated annually at 2010 rates.

Brown and Wright (2007) have highlighted some specific details about the capabilities of IM networks, which can provide very accurate data about a premises' energy usage. When analysed carefully, it is possible to identify when a PC cluster is switched on/off in a metered building. The accuracy of measurements is dependent on the magnitude of base load electricity consumption of the building; on the other hand, if two buildings share one meter this can lead to ambiguity and confusion e.g. over where and when the gas has been switched off or whether there has just been a net shift in the energy consumed. Resolving such issues requires either an increased number of meters or increased knowledge about the consumption patterns of the two buildings. Both of these solutions are possible but have costs and time demands associated with them. Brown and Wright's (2007) analysis recognises they were not able to identify if Leicester's metering system was sensitive to changes in consumption due to the weather, but they did not preclude the possibility that it could be used to measure these effects.

Figure 7 shows data recorded for Braunstone leisure centre, either side of the installation of variable drive pumps; one of the most significant energy savings identified in Appendix C. These drives are responsible for pumping water and controlling air conditioning fans whereas fixed speed drives, which were installed previously, provide more power than is required for the majority of the time. Their inflexibility requires that they are run at full power; this means that part of the energy they deliver may need to be deliberately wasted to align the power delivered with that required by the pool's systems. Variable speed drives can be tuned to meet the changing needs of the pool and are far more energy efficient. In addition to this direct saving, because the speed of the new drives can be controlled, and the flow rate of water in and out of the pool can be reduced compared with previously. There is a cubing relationship between drive speed and its energy demand. Reducing the speed by 20% achieves a 50% energy saving compared to what would otherwise have been consumed.

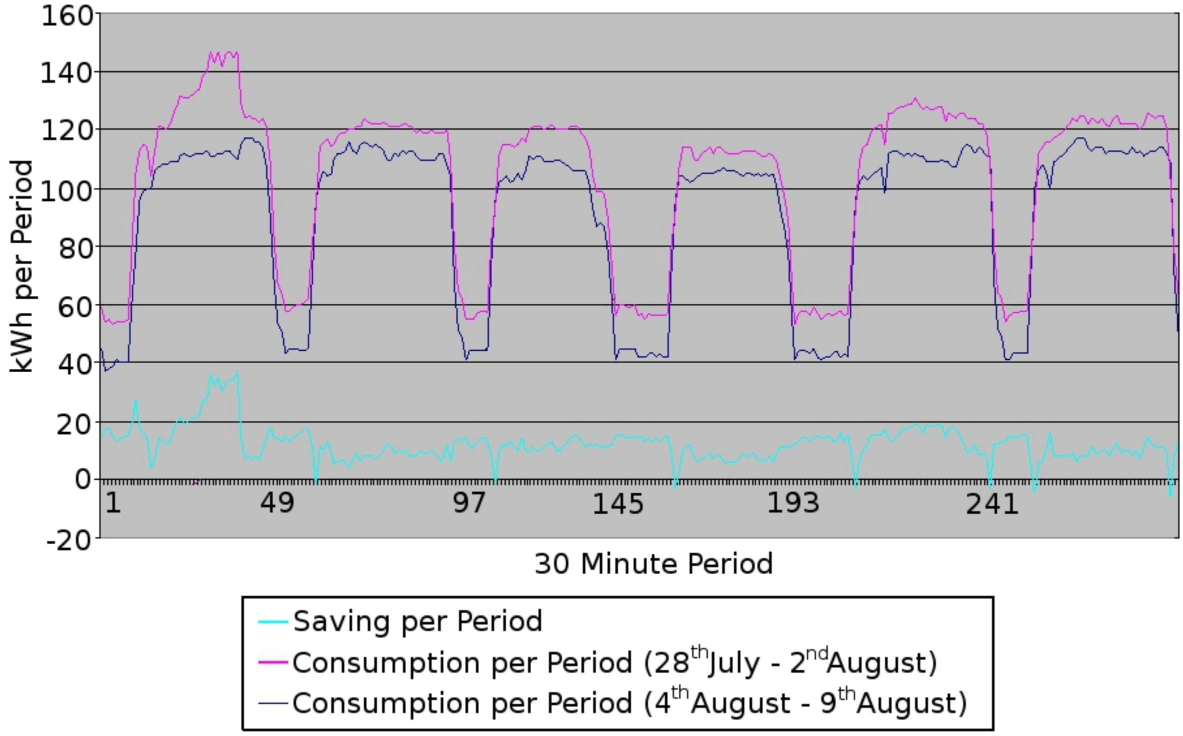

Figure 7: Electricity demand for Braunstone Leisure from 2006. The time-series ranging 28th July – 2nd August is from before the variable speed drive was installed and the 4th– 9th August is after its installation.

Aylestone and Evington leisure centres also achieved significant savings through the installation of motorised swimming pool covers making it standard practice for staff to cover the pools when they are not in use. Covered pools reduce water losses through evaporation, which results in less structural damage to the building fabric, less heat loss and corresponding reductions in gas and electricity use.

Leisure centres have also been a source for reducing LCC's energy bill through the installation of Leicester's largest rooftop photovoltaic array in 2004 at Leys Leisure Centre (LCC, 2004). Although this particular energy measure does not directly relate to IM and data acquisition, it presents a third significant type of energy efficient management innovation at the city's leisure centres. LCC claim that the solar panels generate around 23,000 kWh of electricity annually; 2.2% of the total demand for the leisure centre.

6.1.3 Savings from Intelligent Metering Data

While the total savings resulting from the examples cited by LCC, and summarised in Appendix C, with regard to their intelligent metering network are important to the managers of each premises, they are small when compared to total consumption. Appendix C does not form a comprehensive list; rather it is assumed that the city council will have chosen to highlight examples of the largest individual savings (e.g. arising from the interventions at the swimming pools). In Section 3 it was estimated from cost data and prevailing average prices that LCC used a combined gas and electricity total of 227,000 MWh in 2009. The gas and electricity savings from the three leisure centres, two schools and Phoenix Lodge (Appendix C) as measured by the IM network are a little under 925,000 kWh, or 925 MWh; 0.4% of the LCC calculated utility demand. The savings listed in the appendix are not a comprehensive list of those measured by the IM network, however, one would expect that they are do represent some of the larger savings that LCC has made. While there may be numerous small savings that are not listed, it is the leisure centres that are responsible for 90% of the energy savings. LCC itself is responsible for approximately 3.7% and 4.7% of Leicester's total gas and electricity demand, respectively (see Table 4). Based on the information in Appendix C, it is expected that the gas and electricity savings measured by the IM network amount to approximately 0.02% of Leicester City's demand for energy. Leicester has also recently become part of the EU Smart Spaces project. This project has led to new installations of advanced metering in five university buildings and four new schools in Leicester.[10]

6.2 The Hot Lofts Scheme

As discussed above, Leicester City Council has also used data from thermal aerial photography to inform its energy efficiency investments. In March 2005 photographs were taken across the entire city; Figure 8 provides an example of such a photograph overlaid with an ordinance survey map. Data from the photographs provided a relative indication about which buildings were emitting the most heat; it also supported a rank-ordering of areas of the city in terms of their priority for having additional loft and wall-cavity insulation installed. The scheme was and continues to be a collaborative effort between LCC, British Gas and the Mark Group and offers priority area residents a free loft insulation installation service, regardless of their household income. As lofts are insulated the priority list is updated and people in different parts of the city are progressively made eligible for free insulation.

[10] See http://www.smartspaces.eu/index.php?id=650. Accessed 14 September 2012.

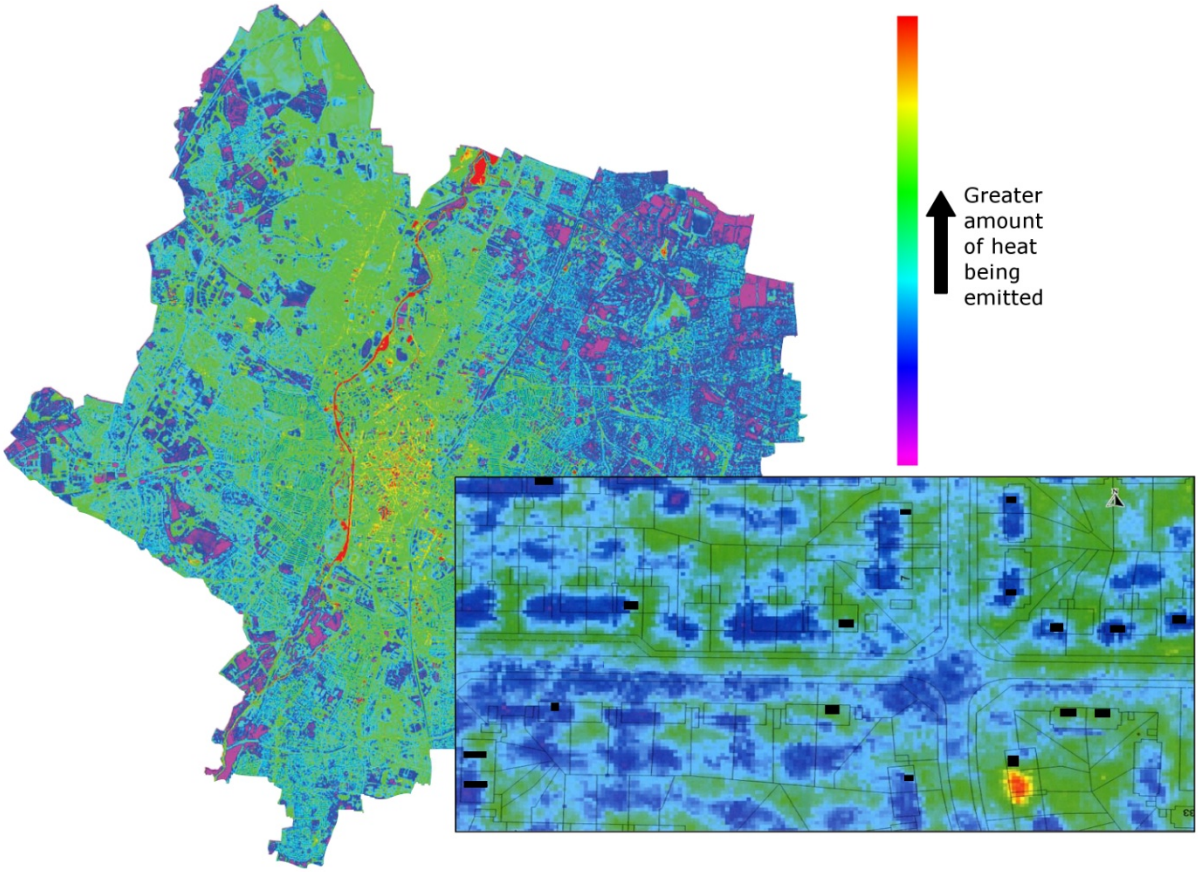

Figure8: (Left) the 2005 thermal photograph showing all of Leicester, (right) a zoom image of part of that city photograph overlaid with an ordinance survey map of the area. The black marks are hiding information from the survey map. These images have been made available by LCC. (Image with kind permission of Blue Sky Limited).

The Hot Lofts scheme has aimed to cut heating bills by up to 25% (LCC, 2005). In addition to its direct benefits, enacting the scheme has given the city council an opportunity to reach out to individual constituents through the delivery of letters to all households in priority areas. LCC have taken advantage of this and offered people the opportunity to have the council check whether they are eligible for funding from any other energy efficiency schemes. The funding for the Hot Lofts project was provided by British Gas and given to the council, who in turn have paid the Mark Group for services rendered in the homes.

The thermal photograph itself has been used for more than just data acquisition. The scheme's marketing group have utilised it as a means of branding the Hot Lofts scheme and the thermal photograph of Leicester city has been used on Mark Group vans and also on a large banner in the city centre, giving the project a unique visual identity (Improvement and Development Agency (IDeA), 2005). In 2009 the Mark Group reported that over 50,000 homes in Leicester have been consulted regarding the scheme and that 4,000 homes had had loft/wall-cavity insulation installed with energy-saving measures having been taken in 7,000 homes (Mark Group, 2009). A new aerial thermal photograph flyover took place in March 2010 with the intention to measure progress since the original flyover in 2005 and also to take advantage of improvements in thermal camera technology and thereby photographic detail and accuracy[11]. The 2010/2011 funding for the Hot Loft

[11] See http://www.leicester.gov.uk/hotlofts/, Accessed 1 October 2013.

scheme was sufficient to insulate a further 1,000 homes in the city. As of 2012 LCC state that 7,200 households have had loft insulation installed, the scheme ran until the end of 2012 (this is around 6.5% of all households in Leicester).

7 Concluding Discussion

Analysis of Leicester's local energy landscape has indicated that the city council does indeed hold a central role among the players concerned with energy related activities. This reinforces perceptions that for energy efficiency and climate change measures to be successfully brought into practice at the local level then local governments have an important role to play (Kelly and Pollitt, 2011). LCC has a facilitative role in a wide range of energy activities. It has reviewed options for the DH network and advertised a tender for its regeneration, but outsourced the construction and managerial work of that regeneration; it manages policy and regulation for new buildings, but does not construct them itself; has invested in a private firm to gather data for its Hot Lofts scheme and again outsourced the work of installing energy measures based on this data to a private firm. LCC's subsidiary, the Leicester Energy Agency (LEA), is a focal point for energy players and has been positioned to be able undertake innovative activities, like the management of a local near-real time metering scheme.

In the context of an ambitious local carbon emissions target (50% of by 2025-26 on 2008-09 levels) our analysis points to the difficulty of local energy policy having an aggregate impact on overall figures for electricity and gas consumption or for carbon emissions. While Leicester has lower per capita electricity consumption than the English average or for comparator cities, the gap is narrowing and there is no difference for gas consumption and direct council energy and emissions contributions only form a small percentage of the local total. Other public sector buildings such as hospitals, universities and the prison represent larger contributions but the energy policies of the institutions responsible for these buildings may conflict with those of the Council. Even within the council's own building stock, school level energy policies are decided by boards of governors not the Council. Local coordination, while easier than national coordination in theory, was in practice very difficult. The District Heating CHP scheme provided a good illustration of this.

Our examination of two flagship Council policies revealed how small the savings in energy and emissions currently are. Intelligent metering produced recent examples of savings equivalent to only 0.4% of total council energy consumption (0.02% of Leicester). While the extension of the district heating scheme also produces relatively small overall savings equal to around 1% of the carbon emissions of Leicester. Some of the smaller schemes however offer the prospect of high cost effectiveness; for example the Green Doctor scheme could have reduced Leicester's total energy consumption and emissions by 1% p.a. if rolled out over all of its houses at a cost of £4.675m.[12]

[12] In the context of Leicester's total emissions of 1.9 million tonnes in 2008 (Leicester Partnership, 2010) the 409 tonnes of CO_2 savings is approximately 0.02% of the total, returned on an investment of £34,000. The Green Doctor scheme visited 800 homes. By simple extrapolation, if 110,000 households were served (this is approximately the total number of households in Leicester (LCC, 2012)) then it would cost £4,675,000 and reduce emissions by 19,000 tonnes of carbon per annum (1% of the city 2008 total).

The most significant schemes are local manifestations of national policies rather than Council Initiatives. The Hot Lofts Scheme – which has reached 7,200 homes - is the local incarnation of CERT. The DH-CHP scheme is a long run local innovation, but deeply rooted in national initiatives towards community energy that date back to the early 1980s and revived recently in CESP.

Clearly much more does need to be done to marry up local and national data collection initiatives in order to ensure that national statistics are as accurate as possible. The extent to which national government was interested in collecting more detailed data that might be available to local authorities (via intelligent metering) was not obvious, indeed the reverse was also true, in that it was not clear that LCC were aware that detailed statistics which they could have been using to monitor their performance were available.

One significant tangible benefit of Leicester's commitment to a local energy policy has been the development of energy related jobs in Leicester, for example the Mark Group now has 1400 employees worldwide, many of whom are based in Leicester (see Mandis, 2012; Mark Group, 2012a, b). This clearly provides a rationale for local authority participation in national demonstration projects.

Two significant sets of implications follow from our analysis.

Firstly, it is important to understand just how difficult it is for a local authority to have a statistically meaningful energy policy. Energy policy may produce co-benefits such as a greater sense of local community, the opportunity to enhance a locality's national and international reputation and local employment in energy initiatives (as noted by Mills and Rosenfeld, 1996). However Leicester's experience illustrates that these co-benefits may be easier to achieve than demonstrable significant impact on total local energy consumption or emissions.

Second, national energy policy does not appear to foster significant local initiative in the UK. Even in a local authority which has been significantly favoured by national policy initiatives this has not translated into clear demonstrable support for the achievement of national energy policy goals. Coordination failures remain within the public sector and financially constrained local authorities find it difficult to take significant local initiatives. More careful attention needs to be given to how communities can be facilitated in their desire to take initiatives which support national targets.

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Green Doctor: Keep Warm keep Green Groundwork Leeds, http://www.yorkshire.groundwork.org.uk/leeds/who-we-are/history/25-years-of-groundwork-leeds/march.aspx [Accessed: 14th November 2012].

Appendix A: Significant players in Leicester involved in energy.

Groups in Leicester involved in energy activities	
Leicester City Council (LCC)	The unitary local authority that governs Leicester city.
http://www.leicester.gov.uk/homepage.aspx [Accessed: 1st November 2012]	
Leicester Energy Agency (LEA)	A subsidiary of LCC involved with local and international projects, prominently: near-real-time intelligent metering networks and; advising SMEs.
http://www.energyagency.co.uk/ [Accessed: 1st November 2012]	
HM Prison Leicester	May join Leicester's expanded district heating network (LCC, 2009a), it is home to approximately 400 prisoners.
De Montfort University	Numerous researchers are involved with issues relating to energy in Leicester, particularly with respect to intelligent metering (Ferreira, 2009; Snape 2012**;** Brown and Wright, 2007; Stuart, 2011).
http://www.dmu.ac.uk/ [Accessed: 1st November 2012]	
University of Leicester	Has now joined the expanded district heating network; it is having new boilers installed on site that will supply the network, with a power rating of 2 MW.
http://www2.le.ac.uk/offices/estates/environment/energy/future-projects-combined-heat-and-power?searchterm=district%20heating [Accessed: 14th September 2012]	
Schools in Leicester	There are 109 state schools in Leicester: 11 infant; 60 primary; 10 junior; 17 Secondary; 8 Special; 5 uncategorised and; 4 pupil referral units (LCC, 2010b). In addition there are 16 independent schools (Schoolsnet, 2011). Under the Building Schools for the Future programme, new school buildings in Leicester had to conform to higher energy efficiency standards. However this scheme is now under review.
http://www.leicester.gov.uk/your-council-services/education-lifelong-learning/about-schools/schools-directory/schools-directory/ [Accessed: 1st November 2012] http://www.education.gov.uk/schools/adminandfinance/schoolscapital/funding/bsf [Accessed: 14th September 2012]	
Salix	Not for profit enterprise created by the Carbon Trust; finances public sector energy efficiency measures (particularly hospitals). It financed the Local Authority Energy Financing Scheme pilot. Its budget for the 2012/2013 financial year is £20 million.
http://www.salixfinance.co.uk/home.html [Accessed: 1st November 2012]	

The Carbon Trust	Not for profit company created by Central Government active in many aspects of mitigating climate change. The carbon trust has stopped receiving core UK Government funding. It must now bid for funding government funding through a competitive tendering process. This is leading to the cancellation of some of its existing projects.
http://www.carbontrust.co.uk/Pages/Default.aspx [Accessed: 1st November 2012]	
Carbon Action Network (CAN)	Not for profit group formed from the Home Energy Conservation Association supporting local government energy officers; focus on the domestic sector. It is based in Leicester, the LEA is responsible for its administration. It is a focal point for lobbying Government.
http://www.can.uk.net/ [Accessed: 1st November 2012]	
Association of UK Energy Agencies (AUKEA)	Based in Milton Keynes (fifty miles from Leicester), the body that nationally represents the 13 currently active UK local energy agencies. It is a subsidiary of the National Energy Foundation, an independent charity.
http://www.nef.org.uk/aboutus/aukea.htm [Accessed: 1st November 2012]	
Institute of Environmental Management and Assessment (IEMA)	A professional body that promotes environmental management audits and industrial assessments. It administers the EU-wide Eco Management and Audit Scheme in the UK. It also promotes a similar UK-based scheme, Acorn.
http://www.iema.net/ [Accessed: 4th August 2011]	
Ofgem	National regulator of the gas and electricity sectors. Ofgem administers the CESP programme that has helped finance the city's district heating scheme.
http://www.ofgem.gov.uk/Pages/OfgemHome.aspx [Accessed: 1st November 2012]	
Energy Saving Trust	Central Government and privately funded organisation that helps the public save energy and reduce carbon emissions. In Leicester city centre it runs one of twenty-one high street advice centres. The LEA and the Energy Management department of LCC are based there. As per for the Carbon Trust, this organisation has recently stopped receiving core government funding. Government funding is now only available to it through a competitive tendering process.
http://www.energysavingtrust.org.uk/ [Accessed: 4th August 2011]	
Carbon Rationing Action Group (CRAG)	Grass roots voluntary organisation with no official status. Has a national network of groups including one in Leicester. Members meet, discuss and identify carbon emission saving ideas and run an informal carbon trading scheme between one another with targets and financial penalties.
http://www.carbonrationing.org.uk/ [Accessed: 1st November 2012]	
GDF Suez	A European private energy company, the parent company of Cofely, which in turn is the parent of the Leicester District Energy Company who are responsible for upgrading and managing the Leicester's district heating network.
http://www.gdfsuez.com/ [Accessed: 1st November 2012]	

Mark Group Ltd	Private energy efficiency firm. Centrally involved with the Hot Lofts scheme, installing loft and cavity wall insulation.
http://www.markgroup.co.uk/ [Accessed: 1st November 2012]	
British Gas	National private gas and electricity supplier, part of the Centrica group. Centrally involved in the Hot Lofts scheme, they finance the installation of loft and cavity wall insulation.
http://www.britishgas.co.uk/ [Accessed: 1st November 2012]	
Blue Sky International Ltd	National private firm based in Leicester. Thermal aerial photography specialists. LCC has twice used their services to monitor insulation in Leicester. Peterborough City Council has now also used their services, in Peterborough residents can look up their own home and see its insulation performance (Peterborough City Council, 2011).
http://www.bluesky-world.com/[Accessed: 1st November 2012]	
Highcross Leicester	Private local Leicester firm, its parent company is Hammerson plc, a city redevelopment company. Highcross Leicester has sponsored the Leicester EcoHouse since 2009.
http://www.highcrossleicester.com/website/home.aspx [Accessed: 4th August 2011]	
Friends of the Earth (FoE)	Grass roots international organisation. It has 200 local UK groups, including Leicester. Leicester FoE has a local energy policy manifesto and is supportive of the Green Doctor scheme.
http://www.leicesterfoe.org.uk/ [Accessed: 4th August 2011]	
Groundwork	Federation of charities working in UK (except Scotland). Strongly concerned with environmental issues. The Leicester division (previously Environ) works closely with LCC; it has managed the Green Doctor scheme, EcoHouse and the Eco Management and Audit scheme.
http://www.eastmidlands.groundwork.org.uk/leicester--leicestershire.aspx [Accessed: 1st November 2012]	

Appendix B: Significant features of Leicester concerned with energy.

<table>
<tr><th colspan="2">Features of Leicester relating to energy</th></tr>
<tr><td>Local Authority Energy Financing (LAEF) Scheme</td><td>Created by Salix and first piloted in 2004, the scheme began in full in 2005-06 (McDonald, 2008). It matches local authority financial investments in energy efficiency measures with interest-free loans. In Leicester Salix matched £500,000 of investments by LCC in insulation, energy management systems, heating, ventilation and air-conditioning, lighting, CHP and swimming pool covers.</td></tr>
<tr><td colspan="2">http://www.pnec.org.pl/ruse_cd/img/ppt/Leicester_Local_Authority_Energy_Financing_Scheme.ppt [Accessed: 1st November 2012]</td></tr>
<tr><td>Home Energy Saving Programme (HESP)</td><td>A national umbrella programme for the CERT and the CESP. The CESP is running from September 2009 to December 2012, it obligates major gas and electricity suppliers to invest in low-carbon programmes in designated low-income areas.</td></tr>
<tr><td colspan="2">http://www.ofgem.gov.uk/Sustainability/Environment/EnergyEff/cesp/Pages/cesp.aspx [Accessed: 7th August 2011]</td></tr>
<tr><td>Neighbourhood Renewal Fund (NRF)</td><td>Is a national body set up by Department for Environment, Food and Rural Affairs (DEFRA) to finance improvements to England's most deprived communities. It targets 88 local authorities, selected based on their year 2000 measured IMD.</td></tr>
<tr><td colspan="2">http://www.communities.gov.uk/publications/communities/evaluationnationalareas [Accessed: 1st November 2012]</td></tr>
<tr><td>Beacon Status</td><td>An award given to local authorities for good performance on topical policy issues. The scheme was administered by DCLG and ran from 2000-10 and has been replaced by Local Innovation Awards (LIA). Leicester City Council was awarded Beacon Status in 2005-06 for its activities in sustainable energy (LIA, 2010).</td></tr>
<tr><td colspan="2">http://www.localinnovation.idea.gov.uk/idk/core/page.do?pageId=1 [Accessed: 1st November 2012]</td></tr>
<tr><td>District Heating Network</td><td>Several isolated networks exist in the city and are owned by the council. They have recently been leased to the Leicester District Energy Company for upgrading and expansion.</td></tr>
<tr><td colspan="2">http://www2.le.ac.uk/offices/estates/news/projects-under-development/district-energy-scheme [Accessed: 1st November 2012]</td></tr>
<tr><td>Intelligent Metering Network</td><td>LCC has set up an intelligent metering network, which is managed by the LEA and allows for near-real time monitor of council gas, electricity and water demand.</td></tr>
<tr><td>Thermal Aerial Photograph</td><td>LCC commissioned flyovers of the whole city in 2005 and 2010. The thermal images allow for assessing the thermal insulation performance of each individual building in the city, therefore allowing for priority targeting for the Hot Lofts Scheme.</td></tr>
</table>

Hot Lofts Scheme	LCC is insulating homes through finance provided by British Gas and with the work being carried out by the Mark Group. Houses are priority targeted using thermal imaging data taken by Blue Sky International Ltd. Targeted residents are offered the opportunity to receive insulation free of charge. Awareness of the scheme is raised through flyers and door-to-door visits.
www.leicester.gov.uk/hotlofts [Accessed: 1st November 2012]	
Planning Permission: Local Energy Policies	LCC has three key policies: UD04 (energy efficiency), BE16 (renewable energy) and BE17 (combined heat and power/ community heating). They are issued as advisory guidance, but are considered closely when making decisions. The policies are managed by Leicester City Council's Better Buildings division. The policies encourage applications to take advantage of natural conditions, e.g. solar energy, siting, landscape, layout and orientation.
http://www.leicester.gov.uk/your-council-services/ep/planning/plansandguidance/localplan/writtenstatement/contents/city-wide-policies/ [Accessed: 1st November 2012]	
Ashton Green	An area in North Leicester owned by LCC and allocated for housing development since the 1970's. In a 2009 master plan 3,000 homes a shopping centre, a new school and an energy centre (generating local renewable energy) have been planned, with the first to be finished in 2012 (LCC, 2011). These homes will be carbon neutral. Leicester is expected to need 20,000 new homes over the next 15-20 years.
www.leicester.gov.uk/ashtongreen [Accessed: 1st November 2012]	
Green Doctor	This scheme began in 2002 and was run by Environ (now Groundwork); it ran for 3 years and had a brief revival in 2007/08. It was originally funded by the NRF (£34,700), and later by LCC. In this scheme a sustainability worker (the "Green Doctor") goes door-to-door visiting city residents, with emphasis on the vulnerable. In homes £20 worth of efficiency measures are installed on the spot (e.g. efficient light bulbs, draught excluders, thermal jackets) and advice is given regarding other low-cost opportunities for making efficiency improvements. An assessment of the scheme (Local Government Improvement and Design, 2008) found that it was very popular with residents; however, the Green Doctor made an average of 2 visits per day. Only 800 out of a planned 900 homes were visited in 3 years. The lifetime impact of the efficiency measures has been calculated to have saved £59,000 and over a three year period 409 tonnes of carbon. The report notes that the Green Doctor and the Hot Lofts schemes interfered with one another through both making home visits and efficiency gains are expected to be achievable by combining these initiatives. The Green Doctor scheme was also adopted by Leeds City Council in 2008.
http://www.idea.gov.uk/idk/core/page.do?pageId=8411664 [Accessed: 7th August 2011]	

EcoHouse	This is an environmental show home first opened in 1989; it was the first of its kind in Britain and was intended to demonstrate realistic sustainable living. There is a visitor centre for advice and organised visits, such as by schools or businesses. In 2000 EcoHouse benefitted from an extension that was funded by LCC and the UK National Lottery. The building is on long-term lease from LCC to Groundwork. Being over 20 years old EcoHouse no longer excels in comparison to modern low-carbon and sustainability standards. Recently Highcross Ltd has provided finance to help make a major renovation to EcoHouse and in 2010 a tender was issued for an architect to draw up a master plan (Groundwork, 2010).
http://www.eastmidlands.groundwork.org.uk/leicester--leicestershire/our-services/communities/eco-house.aspx [Accessed: 1st November 2012]	
Eco Management and Audit Scheme (EMAS)	This is a voluntary structured framework devised by the EU (EC, 2009) for firms to enact environmental measures. EMAS status is awarded to organisations that go "beyond minimum legal compliance and continuously improve their environmental performance" (IEMA, 2011).. EMAS is promoted by Groundwork and in particular they have collaborated with LCC, which achieved EMAS status in 1999,to implement EMAS in Leicester's schools. Groundwork have educated children about environmental issues highlighted by EMAS and have ensured that the topics discussed relate to the school curriculum. They have also organised school trips to EcoHouse.
http://ec.europa.eu/environment/emas/index_en.htm [Accessed: 1st November 2012]	
Automatic Intelligent Metering for Small and Medium Enterprises (AIM4SMEs)	A collaborative project funded by the European Commission. The LEA is the project secretariat. There are 9 partners from 5 European countries. The project closed in March 2010. Its aim was to demonstrate the energy saving potential of metering and monitoring of energy consumption.
http://www.energyagency.co.uk/projects/aim4smes.php [Accessed: 1st November 2012]	

Appendix C: Examples of utility consumption inefficiencies observed using Intelligent Metering - IM (data derived from the Leicester Energy Agency).

Premises	Utility	The Observation	Energy/Water Consumed(a)	Costs(b)	Comment
Rowlatts Hill Primary School	Gas	The IM data showed that the school heating system was being left on constantly in winter, including school holidays.	The heating system uses a mean of 8.3 kWh/hour. If it were used 8 hours a day 5 days a week (subtracting 7 weeks for school holidays) it would consume 8,700 kWh in 6 months, but instead it was using 36,000 kWh.	Annual cost of the extra 27,300 kWh was £440, while the required 8,700 kWh cost only £145.	Only part of the IM time-series data was made available. It was therefore assumed that the heating was switched off in summer holidays.
Beaumont Lodge Primary School	Gas	The times of day that the school was being heated were poorly matched with the times it was used. The boilers were running from 11pm to 3pm each week day.	The boiler uses approximately 70 kWh/hour. Wasted hours are assumed to be 11pm to 7am, 8 hours (560 kWh) per weekday in winter. Over 6 months of winter, subtracting 7 weeks for school holidays and excluding weekends, 53,200 kWh was being wasted.	Double the required energy was being used to heat the school. Before the heating system was synchronised with the times the school was actually in use it was costing £1,760, after it had been corrected it came down to approximately £880.	
Phoenix House Housing Options Advice Centre	Gas	IM detected when users manually switch the central heating on and forgot to switch it off afterwards.	The heater was run at 35 kWh per hour at the weekend. The normal average for this period is about 5 kWh/hour, a total of 1,800 kWh was wasted over a weekend.	It costs £30 to leave the heating on over the weekend, £0.5 /hour. It should be less than £5 per weekend.	In the worst case event of this happening every weekend of the year 3,640 kWh are wasted.
Aylestone Leisure Centre Installed in 2005	Gas	Motorised pool covers were installed, IM measured the reduction in energy demand.	Before their installation the pool used approximately 1,150,000 kWh of gas per year. After that demand dropped to approximately 900,000 kWh/year.	The saving of 250,000 kWh translates to a cost saving of £4,150. The bill before the motorised pool covers were installed was £19,000.	The benefits from having reduced damage to the building material are not captured here.

Evington Pool Installed June-July 2005	Gas	As for Aylestone Leisure Centre, motorised pool covers were installed.	Before installation gas demand was approximately 1,200,000 kWh/year. Since it has reduced to 850,000 kWh/year.	The 350,000 kWh efficiency saving reduced the £20,000 gas bill to £14,200, saving of £5,800.	The benefits from having reduced damage to the building material are not captured here.
Braunstone Leisure Centre Installation complete 3rd Aug 2005	Electricity	Fixed speed drives (for pool water and Heating, Ventilation and Air Conditioning (HVAC)) were replaced with variable speed drives.	An annual saving of 240,000 kWh is reported following the installation of the variable speed drives.	LCC have stated that the 240,000 kWh saving gives a saving of £18,000 annually, implying an electricity price of £0.075 /kWh. Using the "very large" consumer 2010 price of electricity, that saving would be £15,700.	It is interesting to note that Braunstone Leisure Centre was newly built and that these changes to the drives took place just one year after it opened.
Barnes Heath House, Home for Disabled Children	Electricity	In 2008 the Jacuzzi was fixed. Notably increasing electricity usage. Also in the same year builders started working on site, their demand also measurably increased overall usage.	On average the Jacuzzi requires 30 kWh/day. The builder's demand was highly variable, mean demand was 50 kWh/day. Comparing 11 month periods in 2007 and 2008 demand increased 13,000 kWh in 2008. The Jacuzzi had been repaired for 6 months of 2008 (demanding 5,475 kWh). The builders were on site for 2 months. The total 2007 demand for that period was 100,000 kWh.	For the period 1st January to 23rd November 2007 compared to the same period in 2008, the electricity bill is reported by the LEA to have increased by £1,500 as a result of the extra 13,000 kWh demand (implying a price of 11.4 pence/kWh). Using the 2010 "very large" electricity consumer rates, the cost is only £850.	The energy costs associated with the Jacuzzi and building work are not an efficiency issue. The information, however, is of benefit for guiding policy decisions for what works/facilities are necessary and which should be considered a luxury.

Granby Primary School	Water	IM data identified a major leak. Water usage was at peak levels over the weekend.	0.7 m^3/hour of water was being wasted by the leak. From Friday 4pm to Monday 6 am (65 hours) 45 m^3 of water was wasted.	Assuming leaks happen at any random time of the year and using the average price of water across a year this leak costs £27 per weekend.	
Cooper House Residential Care Home	Water	A laundry building was installed on the premises, IM detected the increase in water consumption.	The average rate of water consumption rose from 2 to 4.5 m^3/day. A 900 m^3 per year increase.	The water cost for the laundry building is £530 per year.	This is not an efficiency issue. Only the location of where laundry is done had changed.
Ash Field School (Boarding special school)	Water	A leak was identified through observing base load consumption, even when no water was supposed to be being used.	An additional demand of 0.3 m^3/hour was being consumed. Over the course of a year this would be an additional 2,600 m^3, on top of the normal demand, 550 m^3	LEA state that eliminating the 2,600 m^3/year leak translates to a saving of £4,204 annually. This implies a water price of £1.62 /m^3. Using the Severn Trent average Large user price (£0.59 /m^3) the money saved is £1,550 annually.	Leaks are irregular and vary in their severity. This case study highlights potential savings, but does not provide sufficient data to measure the overall savings that can be achieved through identifying leaks.

[a] All calculations are approximate; they have been made based on graphical figures displaying time-series data made available by the LEA and the LCC, not the raw data.

[b] Gas and Electricity cost calculations performed using nominal 2010 prices assuming all of LCC's buildings are treated by suppliers as an average "Very Large" electricity consumer and a "Large" gas consumer; therefore they pay 6.54 p/kWh and 1.66 p/kWh, respectively, as according to prices in DECC (2011b). Water cost calculations performed using 2008-09 data submitted to Ofwat by Severn Trent for "Large users". That is 81.47 pence/m^3 (May-September) and 43.65 pence/m^3 (October-April) (Ofwat, 2009), this is an average of 59.40 pence/m^3 across a year