Department of Energy and Climate Change

Potential of Smart Technologies in SMEs

Final Report

Issue | 14 April 2016

Job number 248143-00

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

Contents

Page

1	**Introduction**		**1**
	1.1	Background and Objectives	1
	1.2	Research Approach	1
	1.3	Organisation of this Report	2
2	**The UK SME Market**		**3**
	2.1	Economic Impact of SMEs	3
	2.2	SME Sectors	4
3	**Spending on Energy by UK SMEs**		**8**
	3.1	Key Assumptions	8
	3.2	Energy Sources	9
	3.3	Energy Expenditure	9
	3.4	Energy Expenditure by Sector	9
	3.5	Expenditure by Business Size	12
4	**Smart Technologies**		**12**
	4.1	Definitions of Smart Technology	12
	4.2	Applicable Smart Technologies for SMEs	13
5	**Results – Estimated Energy Savings**		**22**
	5.1	Methodology	22
	5.2	Results	23
6	**Barriers to Adoption and Proposed Solutions**		**27**
7	**Quality of Data**		**30**
	7.1	Data Quality of SME Energy Expenditure	30
	7.2	Data Quality of Technology Energy Savings	31
	7.3	Summary of Data Quality	31
	7.4	Key Data Gaps	35
	7.5	Further Research	35
8	**Conclusion and Next Steps**		**36**

Tables

Table 1 – 2015 UK SME distribution by size.
Table 2 – SMEs by sector, 2015

Table 3 – Sector mapping
Table 4 – Annual SME energy expenditure by energy source and sector, 2014
Table 5 - SME energy expenditures by business size
Table 6 – Smart technologies and energy saving potential by fuel type.
Table 7 – The relevance of smart technologies to SMEs within different industries and of different sizes.
Table 8 - The shortlisted smart technologies and estimated energy saving benchmarks by energy source
Table 9 – Annual energy savings by sector
Table 10 – Annual energy savings by energy source (£ mil)
Table 11 – Annual energy savings by business size (£mil)
Table 12 – Possible solutions to SME energy savings barriers
Table 13 – Summary of Research Studies and Quality Ratings
Table 14 – Largest energy saving potential smart technologies and sectors

Figures

Figure 1 - Research approach and report layout.
Figure 2 - Percentage of SMEs operated from home. Source: Department for Business Innovation & Skills - Small Business Survey 2014: SME employers
Figure 3 - SME sectors, by employment size (expressed in percentage). Source: Department for Business Innovation & Skills - Small Business Survey 2014: SME employers.
Figure 4 - Overview on the overlapping among the shortlisted smart technologies for energy
Figure 5 – Illustrative example of the methodology.
Figure 6 – UK SME typical business costs 2014 Source: Aldermore SME Monitor – March 2014

1 Introduction

1.1 Background and Objectives

Arup has been commissioned by the Department of Energy and Climate Change (DECC) to deliver consultancy services in regards to the potential for smart technologies in Small and Medium sized Enterprises (SMEs) in the UK. This is a short, high level top down study for which the main objectives include:

- to estimate the potential savings for UK SMEs by better understanding the technical potential of smart technologies currently available to them;
- to comment on the availability and quality of data available on SME energy use and energy savings from different smart technologies; and
- to suggest various strategies to remove observed barriers to adopt smart technologies by SMEs.

1.2 Research Approach

This report summarises the findings and recommendations from our study. Our research included desk-top research on information and data published by other organisations such as governmental agencies, research institutions, and manufacturers. In addition to published data, we consulted with other Arup technical experts to review our findings and provided estimated parameters (based on their engineering judgement and experience) when published information was not available. Throughout the document and within the appendix, we provide references to the published data upon which our analysis was based, and highlight key information that is unavailable from public sources.

Our analysis included estimates of the energy expenditure by different SME sectors, broken down across five energy sources:

- Coal and solid fuel
- Natural gas
- Electricity
- Petroleum products
- Heat and other fuels.

We have identified seven currently smart technologies that are available to various SMEs in different sectors. Since one of the goals of the study is to help SMEs overcome various barriers to adopt smart technologies that are currently available to them, we have only included products or services that are readily available to, and targeted towards SMEs. Technologies such as smart grids, in spite of their enormous savings potential, are excluded from this study as the implementation decision for such technologies fall outside of SMEs themselves (in the case of smart grids, the decision lies with the utility companies). It is also important to highlight that the technologies we identified are active digital systems that actively control energy consumption based on data transmitted to the device. As such, passive devices that improve energy efficiencies but are neither digital nor handle data (such as insulated windows or energy efficient light bulbs) are not considered in this study.

An important factor on the applicability of different smart technologies on an SME is the size of the business. Hence, we have segmented the SME market into three, size-based categories in line with current government definitions[1]:

- Micro: 1 to 10 employees[2]
- Small: 11 to 50 employees
- Medium: 51 to 250 employees

Based on our research and technical knowledge, we have generated a matrix that assesses the applicability of different smart technologies to different sectors of different sizes. A copy of the model (in excel format) has been submitted to DECC as a supplement to this report.

1.3 Organisation of this Report

The content of this report generally follows our research approach:

- In Section 2 – we provide the context of the study by profiling the SME market in the UK and its significance to the UK economy and energy market. In addition, the industry sectors are discussed.
- In Section 3 – we discuss the current SME energy expenditures, broken down by sector, energy source, and business size.
- In Section 4 – we introduce the current smart technologies available to SMEs and their energy savings potential. We present a matrix which summarises the applicability of these smart technologies to different SMEs of different sectors and different sizes.
- In Section 5 – we present our findings on the potential energy saving if SMEs adopt currently available smart technologies. The results are broken down by sector, energy source, and business size.
- In Section 6 – we discuss the barriers for SMEs to adopting smart technologies based on previous studies and how DECC may strategically help SMEs and other stakeholders (such as energy suppliers and building owners) overcome them so the potential energy savings can be realised.
- In Section 7 – we discuss the quality of the data and identify significant gaps in the current body of literature. Our recommendations for future studies are offered.
- In Section 8 – we summarise our findings and recommend next steps.

Figure 1 below illustrates the research approach and the layout of the report.

[1] House of Commons, Business Statistics Briefing Paper No 06152, 7 December 2015.
[2] Sole proprietorships are classified as having no employees and hence the number of employees listed throughout this report is always the number in addition to the business owner. A sole proprietor is a person who owns the business and is personally responsible for its debts.

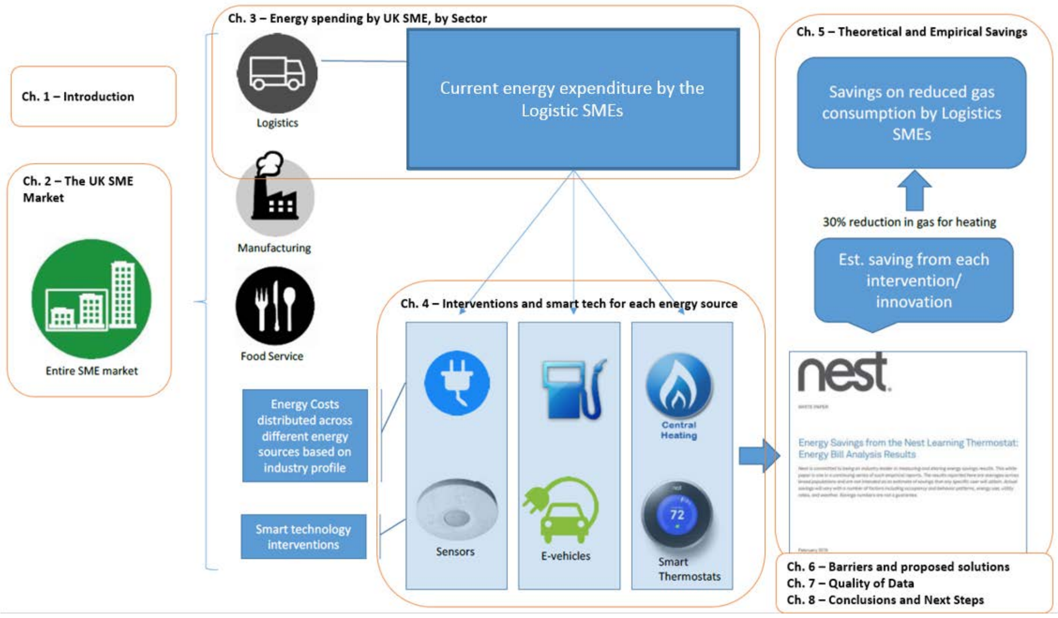

Figure 1 - Research approach and report layout.

2 The UK SME Market

2.1 Economic Impact of SMEs

SMEs play an integral role in the UK economy, accounting for 99% of all businesses by number, 60% of employment in the UK private sector, and 47% of UK Private sector turnover in 2015[3]. Furthermore, it has been SMEs which have been the driving force for the overall increase of the UK business population since 2000[4].

According to the Business Population Estimates from the Department for Business Innovation & Skills (BIS)[5], there were 5,389,450 private business in the UK at the start of 2015. Of that number, just over three quarters were listed as sole proprietorships, having no employees other than the business owner (this equates to 4,077,453 private businesses, or 76 percent of all businesses registered in the UK). Sole proprietorships accounted for 17 percent of all employment in the UK private sector in 2015 and generated six percent of all private business turnover.

The table below shows the size distribution of SMEs based on employee count.

[3] House of Commons, Business Statistics Briefing Paper No 06152, 7 December 2015.
[4] DECC – Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium Sized Enterprises, November 2014.
[5] Business Population Estimates (BIS) as referenced in: House of Commons, Business Statistics Briefing Paper No 06152, 7 December 2015

Table 1 – 2015 UK SME distribution by size.

BIS SME classification	No. private businesses (000s)	Percentage of SMEs	No. Employees (000s)	Percentage of employment among SMEs
Micro (0 to 9 employees)	5,146	95%	8,461	54%
Small (10 to 49 employees)	204	4%	3,967	26%
Medium (50 to 249 employees)	33	1%	3,183	20%
Total SMEs	5,382	100%	15,611	100%

Source: House of Commons, Business Statistics Briefing Paper No 06152, 7 December 2015

It is interesting to point out that 32 percent of SMEs were operated from the home of one of the business owners[6]. As expected, the percentage of such work-at-home arrangements is highest amongst micro SMEs. The table below from the BIS 2014 Small Business Survey[7] shows the number of SMEs having the same home/work address broken down by business size.

	All SME employers	Micro (1-9)	Small (10-49)	Medium (50-249)
SBS 2014 (n=)	4355	1653	1714	988
	%	%	%	%
Work/home at same address	32	**37**	**9**	**4**

Figure 2 - Percentage of SMEs operated from home. Source: Department for Business Innovation & Skills - Small Business Survey 2014: SME employers

We have integrated the above insight into our assessment of which smart technologies are applicable to which SMEs based on size and sector (Table 6). In particular, technologies that are targeted towards individual residential customers will also be more likely to be applicable to micro SMEs as many of them operate in a home/residential setting.

2.2 SME Sectors

In the BIS Business Survey, Standard Industrial Classifications (SIC) were used to classify the SME businesses into different sectors. The chart below from the said

[6] Department for Business Innovation & Skills - Small Business Survey 2014: SME employers

[7] Ibid.

report illustrates the estimated SME distribution across different sectors based on a survey of 4,355 SME employers.

	All SME employers	Micro (1-9)	Small (10-49)	Medium (50-249)
(n =)	4355	1653	1714	988
	%	%	%	%
AB Agriculture/mining	4	5	2	1
DE Utilities & waste	1	1	*	1
C Manufacturing	7	6	11	19
F Construction	12	13	8	6
G Retail & wholesale	19	19	18	15
H Transport & storage	3	3	4	4
I Food & accommodation	10	9	13	8
J Information/ comms.	5	6	4	5
K Finance	2	2	2	2
L Real estate	2	2	2	2
M Professional & scientific	14	14	10	9
N Administrative services	8	8	7	12
P Education	1	1	2	2
Q Health	5	4	11	11
R Arts & recreation	2	2	2	2
S Other services	5	6	3	1

Figure 3 - SME sectors, by employment size (expressed in percentage). Source: Department for Business Innovation & Skills - Small Business Survey 2014: SME employers.

Note that in this report, we deviate from the above SIC system[8] and adhere to the DECC sector classification. This allows for the findings and data presented in this report to be more readily consumed and analysed by DECC. Moreover, in order to assess energy expenditures by SMEs in different sectors (further discussed in Section 3), it was necessary to gather raw data from a number of sources about the number and make-up of businesses in the UK, as well as their energy expenditure and energy consumption. This meant that we were required to align sector definitions provided by DECC to those defined by BIS. The DECC sector classifications comprise:

- Agriculture, Forestry and Fishing
- Mining, Quarrying and Utilities
- Manufacturing
- Construction
- Wholesale, Retail, Transport, and Storage
- Accommodation and Food Services
- Commercial Offices (such as information & communication, financial & insurance)[9]

[8] Readers who are interested in examples of different sectors according to the SIC definitions can consult Companies house - Standard Industrial Classification of Economic Activities report (2007).
[9] The Commercial Offices sector corresponds to the following sectors from the BIS Definitions: Information & communication (J), Financial & insurance (K), Property (L), Professional, scientific & technical (M), and Business administration & support services (N).

- Education
- Human Health and Social Work Activities
- Arts and Other Services

These sectors are utilised in the remainder of this report. For future studies, researchers may consider segmenting some of the DECC sectors into sub-categories. For instance, one may consider breaking the wholesale, retail, transport, and storage sector into several subsectors as they may have different energy consumption profiles due to different transport and space requirements. For this report, we will adhere to the DECC sector classification for the reasons mentioned in the previous paragraph.

The table below shows the number of SMEs within each sector, and the share of total businesses.

Table 2 – SMEs by sector, 2015

Sector	Number of SMEs	Share of total businesses (%)
Agriculture, Forestry and Fishing	153,207	3%
Mining, Quarrying and Utilities	29,302	1%
Manufacturing	274,463	5%
Construction	956,105	18%
Wholesale, Retail, Transport and Storage	795,935	15%
Accommodation and Food Services	182,447	3%
Commercial Offices	1,761,471	33%
Education	267,550	5%
Human Health and Social Work Activities	370,632	7%
Arts and Other Services	591,020	11%
Total	5,382,132	100%

Source: BIS, Business Population Estimates, 2015[10]

It should be noted here that the UK Education sector is defined as all public and private pre-primary, primary, secondary, and higher education institutions, as well as other institutions such as cultural activities and support organisations[11].

The sectors considered within this study are mapped to the BIS industry sectors and DECC Digest of UK Energy Statistics (DUKES) business areas as illustrated below.

[10] BIS, Business Population Estimates, 2015
[11] UK Commission for Employment and Skills, Sector Skills Insights: Education, 2012

Table 3 – Sector mapping

Sectors used in this study	BIS Sectors	DECC DUKES Category
Agriculture, Forestry, and Fishing	Agriculture, Forestry, and Fishing	Industry
Mining, Quarrying and Utilities	Mining, Quarrying and Utilities	Industry
Manufacturing	Manufacturing	Industry
Construction	Construction	Industry
Wholesale, Retail, Transport and Storage	Wholesale	Other Final Users
	Retail	Other Final Users
	Transportation and Storage	Other Final Users
Accommodation and Food Services	Accommodation and Food Services	Other Final Users
Education	Education	Other Final Users
Human Health and Social Work Activities	Health	Other Final Users
Commercial Offices	Information and Communication	Other Final Users
	Financial and Insurance Activities	Other Final Users
	Property	Other Final Users
	Professional, scientific & technical	Other Final Users
	Business administration & support services	Other Final Users
Arts and other Services	Arts and other services	Other Final Users

3 Spending on Energy by UK SMEs

3.1 Key Assumptions

In our analysis of energy expenditure by SMEs we have made a number of assumptions. These are outlined below.

Item	Assumption
Energy Consumption	SME turnover data from BIS[12] was used as a proxy indicator for SME energy consumption in the UK. Within each sector, the proportion of turnover generated by SMEs was applied to the sector's total energy consumption figure[13] to approximate sectoral SME energy consumption.
Sector and Business Area Mapping	The DECC DUKES 2015 provides data on energy expenditure from 2014 according to three business areas. We have made assumptions about which sectors fall within each business category as per below: • Industry (Mining, Quarry and Utilities; Manufacturing; and Construction); • Domestic – not relevant to this study; and • Other Final Users (Agriculture, Forestry, and Fishing; Wholesale, Retail, Transport and Storage; Accommodation and Food Service Activities; Commercial Offices; Education; Human Health and Social Work Activities; and Arts and Other Services).[14]
SME Business Area Share	We made assumptions about the SME share of total energy expenditure across the sectors using energy consumption as a proxy. Based on the sector and business area mapping indicated above, the cumulative SME consumption for all the sectors within each business was calculated. This was then compared to the total consumption in that business area to determine the ratio of SME consumption to total consumption for each sector. These assumptions are listed below; • Industry (0.3% for Mining, Quarrying, and Utilities; 29% for Manufacturing; and 2% for Construction); and • Other Final Users (5% for Agriculture, Forestry and Fishing; 19% for Wholesale, Retail, Transport and Storage; 9% for Accommodation and Food Service Activities; 6% for Commercial Offices; 11% for

[12] BIS Business Population Estimates 2015, 14 Oct 2015
[13] DECC, Energy Consumption in the United Kingdom (EC UK), 30 July 2015
[14] Limitations on the use of these business areas is highlighted in Section 7.

Item	Assumption
	Education; 6% for Human Health and Social Work Activities; and 2% for Arts and Other Services)
Energy Source SME Expenditure	Using the breakdowns by energy source type from the DUKES data[15], we then made assumptions about the levels of energy expenditure by UK SMEs in each sector and on each energy source type.

These different items are further elaborated in Section 3.3, 3.4, and 3.5 of this report. A model including detailed calculations of the above was submitted to DECC with this report.

3.2 Energy Sources

The energy sources used by SMEs, as commonly identified in DECC documents[16], are as follows;

- Coal and solid fuels
- Natural gas
- Electricity
- Petroleum products
- Heat and other fuels, including biofuels

We have adhered to the above energy sources throughout the remainder of our analysis.

3.3 Energy Expenditure

In the UK, expenditure on energy across all sectors totalled £126 billion in 2014[17]. This information was reported in the 2014 DUKES from DECC, which breaks this spending down according to three categories: Industry, Domestic and Other Final Users. Excluding the domestic sector, businesses in the UK spent around £92.6 billion on energy in 2014. SMEs accounted for around £49.6 billion of this, representing approximately 54% of industry spending despite accounting for over 99% of all private businesses in terms of business number.

3.4 Energy Expenditure by Sector

Table 4 below outlines 2014 spending by SMEs on energy, broken down by energy source and by sector. It has been calculated based on the assumptions outlined in Section 3.1.

The sector that spends the most on energy is the Wholesale, Retail, Transport and Storage sector with expenditure of around £15.4 billion. This is primarily driven

[15] DECC, Digest of UK Energy Statistics, 2014
[16] Ibid.
[17] Ibid.

by high spending of around £12.4 billion on petroleum[18]. Other high spending sectors include the Education and the Accommodation and Food Services Activities sector which spend around £8.6 billion and £6.9 billion on energy respectively. Again, this is driven by high spending on petroleum, with electricity being the second biggest expenditure on energy for SMEs. SMEs generally spend a small amount on coal and solid fuels.

In terms of average spend per business, the Wholesale, Retail, Transport and Storage, Accommodation and Food Services Activities and the Education sectors spend the most, with expenditure of £84,400, £37,500, and £47,300 per business respectively. The total average spend per business is around £9,227.

[18] Note: please refer to Section 7 on data limitations in relation to DUKES data – in particular in relation to Petroleum use estimates.

Table 4 – Annual SME energy expenditure by energy source and sector, 2014

	Energy Sources							
Sectors	Number of SMEs	Coal and solid fuels (£ mil)	Natural gas (£ mil)	Electricity (£ mil)	Petroleum products (£ mil)	Heat and other fuels (£ mil)	Total (£ mil)	Average spend per business (£)*
Accommodation and Food Service Activities	182,447	0.9	238.2	904.5	5,489.8	211.7	**6,845**	**37,518**
Agriculture, Forestry and Fishing	153,207	0.5	135.8	515.7	3,129.7	120.7	**3,902**	**25,471**
Arts and Other Services	591,020	0.2	48.9	185.7	1,127.3	43.5	**1,406**	**2,378**
Construction	956,105	22.9	48.2	152.9	53.5	8.4	**286**	**299**
Education	267,550	1.1	300.6	1,141.4	6,927.5	267.1	**8,638**	**32,284**
Human Health and Social Work Activities	370,632	0.6	174.6	663.0	4,024.1	155.2	**5,018**	**13,538**
Manufacturing	274,463	293.8	617.8	1,958.6	685.5	108.0	**3,664**	**13,349**
Mining, Quarrying, and Utilities	29,302	3.0	6.3	20.1	7.0	1.1	**38**	**1,282**
Commercial Offices	1,761,471	0.6	155.3	589.6	3,578.2	138.0	**4,462**	**2,533**
Wholesale, Retail, Transport and Storage	795,935	1.9	536.1	2,035.6	12,354.4	476.4	**15,404**	**19,354**
Total	**5,382,132**	**325.5**	**2,262.1**	**8,167.2**	**37,377.0**	**1,530.0**	**49,662**	**9,227**

* Note: Average spend per business is in pounds, and not millions of pounds.

Arup analysis based on data from DECC, Energy Consumption in the United Kingdom (EC UK), 30 July 2015 and BIS Business Population Estimates 2015, 14 Oct 2015

3.5 Energy Expenditure by Business Size

Table 5 below outlines the estimated 2014 spending by SMEs on energy based on our analysis, broken down by business size. It has been calculated based on the assumptions outlined in Section 3.1.

Table 5 - SME energy expenditures by business size

SME Business Size	Sum of Energy Expenditure (£ billion)	Percentage of all SME energy expenditure
Micro	19.981	40%
Small	16.121	32%
Medium	13.558	27%

The distribution of the energy expenditure is relatively even across the three business sizes. With the highest number of SME business count – micro SMEs – representing 40% of the current SME energy expenditure. Note that the above estimate is based on our approach of using turnover as a proxy for energy expenditure.

4 Smart Technologies

There are numerous smart technologies available in the market today, both hardware and software, that can help reduce energy consumption, improve energy efficiency, or facilitate energy usage behaviour change. This section identifies and describes seven shortlisted key smart energy technologies for SMEs included as part of the analysis in this project.

The development of technology and information services is creating new solutions for energy challenges. New technology interventions, such as big data and the Internet of Things (IoT), are increasingly seen as smarter methods to help people manage energy demand and supply. Differing from other technologies such as LED lighting and electric vehicles, smart technology interventions are usually solution packages that consist of both hardware and software enabled by communication capabilities (often wireless), and can handle energy data in real time.

4.1 Definitions of Smart Technology

Drawing on our professional knowledge and experience, for the purposes of this project, we have defined smart technology as a solution which has one or more of the following features:

- It uses communication technology to collect and feed real time or close to real time energy data back to energy service suppliers or end users;

- It allows end users to monitor or manage energy usage remotely; and/or
- It connects or communicates with other devices or systems to realise service automation.

This definition aligns with the DECC definition of smart energy technologies as being ‘those that use digital and communications technologies based on signals’.

Based on this definition, we researched smart technologies which are available in the market for SMEs. This includes two main types of smart technologies:

- **Active –** Smart technologies which can optimise energy usage based on data insights or evidence automatically, such as smart lighting systems and building management systems (BMS).
- **Passive –** Smart technologies, such as smart meters, which can collect or monitor real time energy usage data and/or relevant data (e.g. environmental and occupancy data), and transmit that data back to a central hub. It can enable end users or energy service suppliers to predict energy usage patterns, take proactive action and make informed decisions to better manage energy demand and supply.

4.2 Applicable Smart Technologies for SMEs

This section describes the smart energy technologies that are considered applicable for SMEs in line with the definitions presented in Section 4.1. It explains the approach and rationale behind the smart technologies selected for consideration, and presents a matrix summarising the energy sources, relevant industry sectors and business sizes (by the number of employees) for which various smart technologies are applicable to SMEs.

4.2.1 Approach and Rationale

Based on the above smart technology definition, we reviewed a variety of smart technologies and selected seven applicable options that could help SMEs save energy. This selection process was based on the approach below:

Smart Technology for Energy Research – We researched the available technologies for energy saving in the market today through following activities:

- **Desk-Top Research:** We researched and developed a list of available technology for energy by reviewing relevant researches, reports and case studies developed by UK Government (including Department of Energy & Climate Change, Office of Energy Efficiency & Renewable Energy), research institutes, universities and technology suppliers.
- **Smart Technology Definition:** With an initial list of technology for energy, we applied our experience and knowledge in smart city, digital technology to define smart technology for this study. This allows us to determine which available technology could be considered as “Smart”. See section 4.1 for the definition details.

Shortlisting and Describing Smart Technology for Energy

- **Shortlisting:** Drawing on the outcomes from the desk-top research, we eliminated items that did not fit our definition of smart technology. We had a meeting with Arup specialists in smart building, wireless communication technology and IoT areas to review and guide the technology shortlisting process.

  For example, technologies, such as hybrid / electric vehicles, HVAC systems (Heating, Ventilation and Air Conditioning) and LED lighting, are not considered as smart technologies in this study. Those technologies could help energy consumption reduction by improving fuel or electricity efficiency with better use of materials or product design, but are not necessarily able to collect energy data or require data communication to function. Through this project activity, we have shortlisted seven smart technologies for Energy which are applicable for SMEs.

- **Describe Smart Technology for Energy:** We provided a description for each shortlisted smart technology based on our knowledge in digital technology, input from Arup's specialists and the product descriptions provided by technology vendors. We kept the description for each shortlisted smart technology general and at a high level, supported by further explanation where appropriate.

Assessing the High Level Feasibility of Smart Technologies for SMEs – The project further refined the selection outcomes to assess the smart technology feasibility for SMEs and mitigate any overlap between shortlisted smart technologies through:

- **High Level Feasibility Assessment:** We used the UK SMEs data, including industry type, business size by number of employee and average energy spent by energy source, and our knowledge in digital technology to assess how likely a shortlisted smart technology could be adopted by SMEs.

  For example, compared to small or medium SMEs with up to 250 employees, it's less likely that a micro SME with less than 10 employees will be willing to install an integrated building management systems, due to the size, operation needs and priority of its business.

- **Business Judgement and Assumptions:** We used general business judgement, including the nature of the SME business by industry, daily business operation needs and technology implementation requirements, together with assumptions on SME business priority, level of interest in energy saving and affordability of smart technologies, to avoid smart technologies with similar functions overlapping across different business sizes in the same industry.

  For example, smart lightings are more likely to be important for SMEs which occupy larger workspace with higher electricity cost. In contrast, micro businesses with less than 10 employees or based in home may not need or be interested in smart lighting solution.

4.2.2 Seven Smart Technologies for Energy for SMEs

Based on the selection criteria discussed in Section 4.2.1, the seven smart technologies selected for this study are:

- **Smart Heating Controls**: Smart heating controls are used to control heating and cooling systems remotely or automatically. The solution usually consists of automation devices, such as Smart Thermostats, sensors, and software services such as end user service applications and data analytics. It also requires wireless communication to enable real time energy usage monitoring and control, either automatically or manually by end users.
- **Smart Lighting Systems**: Intelligent lighting systems use sensors and wireless communication technology to realise automated lighting control and adjustments based on the environment, e.g. daylight availability, locations etc.
- **Smart Meters:** Smart meters are new gas and electricity meters that can digitalise meter readings and provide near real-time readings back to energy suppliers. This enables energy suppliers to feed meter readings back to customers with near real-time energy cost information. With knowledge on level of consumption and energy costs, consumers can then change their behaviour and reduce energy costs and cut emissions[19]. It should be noted that smart meters are applicable but may not always be available to SMEs, due to the fact that smart meters implementation is usually controlled by energy suppliers in the UK. There is currently an ongoing effort by the UK government to roll out smart meters in the non-domestic market.[20]
- **Integrated Building Management Systems:** Integrated building management systems are computer-based control systems installed in buildings that integrate the controlling and monitoring functions of the mechanical and electrical equipment, such as ventilation, lighting, power systems, heating systems, fire systems, lighting and security systems etc. This technology is applicable to SMEs that occupy large workspaces. The decision to install integrated building management systems normally lies with the landlord, but SMEs may have power to request the technology especially if it is an anchor tenant.
- **Demand Responsive Energy Management:** This is a remote energy management service usually provided by private demand response aggregators. It uses smart meters or similar products provided by private aggregators to balance energy supply and demand in real time and reduces the need for inefficient backup power stations during peak hours by

[19] DECC, Smart Meters, Great Britain, Quarterly report to end December 2015, March 2016

[20] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/276656/smart_meter_roll_out_for_the_domestic_and_small_and_medium_and_non_domestic_sectors.pdf

providing real time energy (mainly electricity) balancing requirements to system operators and end user sites.

There are a numbers of service packages with different options provided by private demand response aggregators, so the total energy consumption saving may vary depending on service types, service agreements and implementation scale.

- **Big Data for Logistics and Transportation:** This involves using data analytics to improve business operations, including logistics, service provision, transport, etc. Through these big data analyses, the technology enables businesses optimise travel routes, full utilise cargo capacity, reduce utility and fuel costs, and cut carbon emissions.
- **Fleet Management:** This is a software-based solution that uses mainly fleet / vehicle data (such as vehicle types, driving routes, speed, number of stops, vehicle locations and even driver's driving behaviours etc.) to optimise fleet usage and service routes, improve safety and reduce fuel consumption. Some fleet management service suppliers also provide a built-in-telematics option for car manufacturers to allow fleet owners to manage their new fleets when they are delivered, without any installation downtime.

Shortlisted Smart Technologies Functions / Capabilities Overlapping

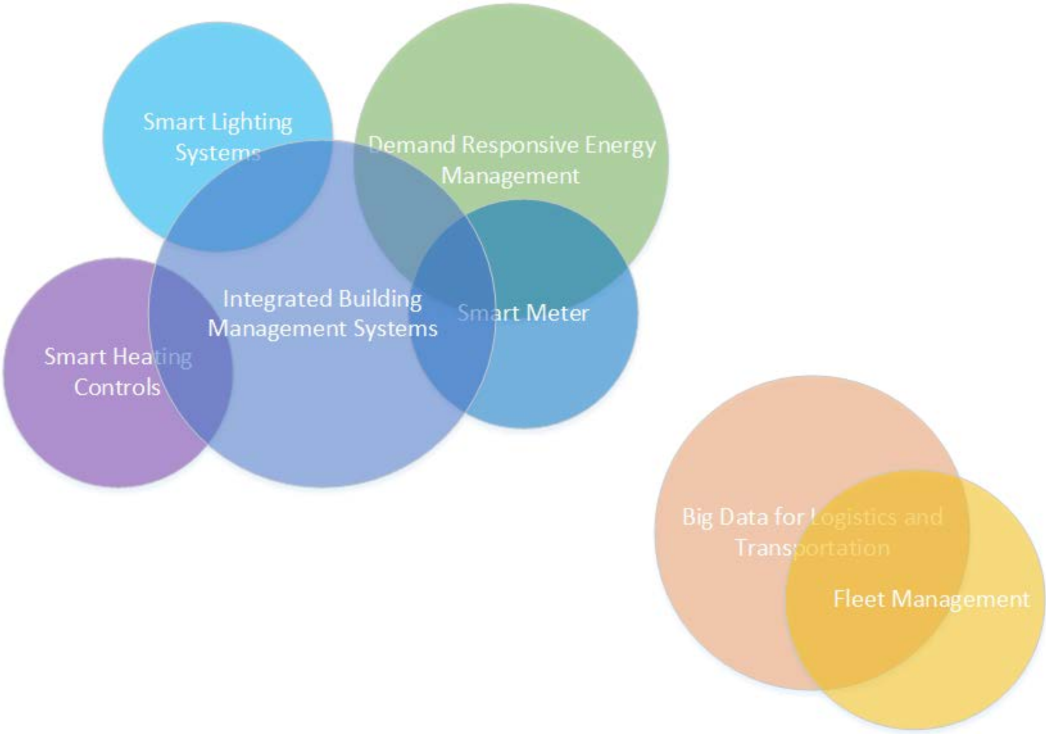

Figure 4 - Overview on the overlapping among the shortlisted smart technologies for energy

The seven shortlisted smart technology for energy have some overlapping function and capabilities (see Figure 4). The following describes the different levels of functional overlap among the seven smart technologies, and segments the overlapping functions into three types:

- **Serve Different Service Functions**
    - Smart meter and smart lighting systems can both offer energy savings but deliver results in different ways. The former supports electricity reduction through usage of real time electricity consumption data to facilitate changes to energy consumption behaviour; whereas the latter reduces electricity usage and improves energy efficiency by optimising lighting operation automatically.
    - Some smart heating controls can work with other technologies such as smart lighting systems, smart meters and sensors to achieve larger energy savings, but do not have major system function overlap with other smart technologies.
- **Serve as Part of Smart Technology Package**
    - Smart meters, smart lightings and smart heating controls can act as building services that are controlled by integrated building management systems.

- Smart meters are key components of demand responsive energy management. They collect and send real time electricity data via wireless networks back to the supplier service operation centres for real time data analytics.

- **Serve Similar Functions with Different Focuses**
  - Fleet management and big data for logistics and transportation are both software-based services and use data analytics techniques, but they each use a different range or type of data for analysis.
  - Fleet management technologies focus on asset management and on saving fleet operation costs, including fuel consumption. It mainly uses vehicle data (e.g. engine performance, speed, location, vehicle fuel efficiency etc.) to conduct data analytics and enable better usage and maintenance of vehicles.
  - Big data for logistics and transportation looks beyond managing fleet. It can use any relevant data, such as crowd sourcing data and customer data, to help businesses not only reduce fuel consumption and improve service efficiency, but also to predict service trend and needs, e.g. service capacity and customer service usage pattern.

Table 6 below identifies the fuel sources which are likely to be affected by appropriate use of the seven smart technologies identified. An "X" represents an applicability whilst a "–" represents no energy saving potential.

Table 6 – Smart technologies and energy saving potential by fuel type.

Energy Sources	Integrated building management systems	Smart lighting systems	Demand responsive energy management	Smart Heating Controls	Big data in logistics and transportation	Fleet management	Smart Meters
Coal and solid fuels	-	-	-	-	-	-	-
Natural Gas	x	-	-	x	-	-	x
Electricity	x	x	x	-	-	-	x
Petroleum products	-	-	-	-	x	x	-
Heat and other fuels	-	-	-	-	-	-	-

Arup analysis

As illustrated in Table 6, none of the seven smart technologies have significant energy savings implication to two types of energy sources - coal and solid fuels, and heat and other fuels. This suggests that no energy savings will be listed for those two energy sources in our analysis. Note that from the figures in Table 4, the two said energy sources represent only 3.7% of the energy consumed by

SMEs based on our calculation. As such, our exclusion of savings toward the two energy sources from our analysis will have little effect on the overall findings of our study.

Table 7 summarises the applicability of smart technologies by business size and industry type based on the following assumptions:

- Most smart technologies focus on energy supply, but are not limited to workspace, such as office space, retail space and factories or warehouses.
- Medium size businesses (51-250 employees) occupy larger workspaces and have larger scales of business operation. They will be more likely to adopt smart technologies that can be used to manage higher energy demand or usage, e.g. integrated building management systems and demand responsive energy management, instead of smart technologies like smart heating controls which are usually more suitable for smaller workspace with lower energy usage.
- Smart technologies for fuel consumption reduction, including big data for logistics and transportation and fleet management, are more likely applicable to SMEs that own multiple corporate vehicles. As such, micro-businesses of different industries will not take advantage of the energy saving potential offered by fleet management, which is a technology more applicable to small- and medium- sized businesses.
- Smart technologies that are unlikely to be controlled by SMEs, such as smart meters and integrated building management, are only be available for SMEs with the support from energy suppliers or landlords.

An “X” within Table 7 indicates that a specific smart technology is relevant and applicable to the identified business type and that it can have energy savings potential within that sector and scale of SME.

Table 7 – The relevance of smart technologies to SMEs within different industries and of different sizes.

	Industry Segment	Scale	Integrated building mgt. systems	Smart lighting systems	Demand responsive energy management	Smart Heating Controls	Big data in logistics and transportation	Fleet management	Smart Meters
1	Agriculture, Forestry and Fishing	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x
2	Mining and Quarrying; Electricity, Gas and Air Conditioning Supply; Water Supply; Sewerage,	Micro				x			x
		Small		x		x			x

	Industry Segment	Scale	Integrated building mgt. systems	Smart lighting systems	Demand responsive energy management	Smart Heating Controls	Big data in logistics and transportation	Fleet management	Smart Meters
	Waste Management and Remediation Activities	Medium	x	x	x				x
3	Manufacturing	Micro				x			x
		Small		x		x	x	x	x
		Medium	x	x	x		x	x	x
4	Construction	Micro				x			x
		Small		x		x	x	x	x
		Medium	x	x	x		x	x	x
5	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles + Transportation & Storage	Micro				x			x
		Small		x		x	x	x	x
		Medium	x	x	x		x	x	x
6	Accommodation and Food Service Activities	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x
7	Commercial Offices	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x
8	Education	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x
9	Human Health and Social Work Activities	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x
10	Arts and Other Services	Micro				x			x
		Small		x		x		x	x
		Medium	x	x	x			x	x

Arup analysis

Table 8 summarizes the estimated energy saving potential of different smart technologies, based on publicly available sources. The values from Table 7 and Table 8 have been utilised to help determine energy savings potential available to SMEs. More information on the methodology regarding how those savings have been calculated across different industry types and different sizes of SMEs is presented in Section 5.1 below.

Table 8 - The shortlisted smart technologies and estimated energy saving benchmarks by energy source

Smart Technologies for Energy	Estimated Energy Saving Benchmark					Example Smart Technology Vendor	Source
	Coal and solid fuels	Natural Gas	Electricity	Petroleum products	Heat and other fuels		
Smart Heating Controls	n/a	1. 10-12% [1] 2. 26-29% [12]	n/a	n/a	n/a	Nest Tado Vivint Hive	[1] Nest - Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results [12] Hive Energy Saving Report, British Gas, 2014
Smart meters	n/a	7% [3]	1. 3% [2][13] 2. Up to 6% [3]	n/a	n/a	n/a	[2] 2013 EPRG Public Opinion Survey: Smart Energy—Attitudes and Behaviours, University of Cambridge, 2013 [3] Smart meters and consumer engagement, The Concerted Action for Energy Efficiency Directive, May 2015 [13] Energy Demand Research Project Final Analysis, AECOM, ofgem, 2011
Integrated building management systems	n/a	10% - 30% [4]	Electricity & Gas combined - as much as 50% vs. traditional buildings [5][6][7]	n/a	n/a	Honeywell Siemens Schneider Electrics	[4] Building Management System Procurement Guide, Natural Scotland 2014 [5] Bright Green Building, CABA [6] Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential, K.W Roth et al, July 2002 [7] Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways, Prepared for the U.S. Department of Energy, April 2005
Smart lighting systems	n/a	n/a	About 32% energy saving comparing to conventional lighting systems [8]	n/a	n/a	Philips Belkin GE	[8] Energy savings due to occupancy sensors and personal controls: a pilot field study, Lux Europa 2009, 11th European Lighting Conference, Istanbul, Galasiu, A.D.; Newsham, G.R., Turkey, September 9–11, 2009
Demand responsive energy management	n/a	n/a	6.5% - 10% [9]	n/a	n/a	KiWi Power Open Energi	[9] KiWi power Case study - Time Inc. UK
Big data for logistics and transportation	n/a	n/a	n/a	1.5 million gallons of fuel / Year [10]	n/a	ORION SAP IBM	[10] UPS - Big Data = Big Wins for the Environment, 2013
Fleet management	n/a	n/a	n/a	1. Average fuel saving of 25% [11] 2. 30% in average fuel saving [14]	n/a	Telogis Fleet Teletrac	[11] Benefits of Fleet Management Systems, FROST & SULLIVAN, 2012 [14] 2013 Teletrac Customer Survey

Arup analysis

The appropriateness and reliability of these sources is further discussed in Section 7.

5 Results – Estimated Energy Savings

5.1 Methodology

The approach used to estimate the potential for energy savings within UK SMEs involves combining the expenditure data analysis in Section 3 and the benchmarks established in Section 4 to determine potential energy savings for SMEs in each sector and for each energy source.

Figure 5 below illustrates the general approach taken during this study.

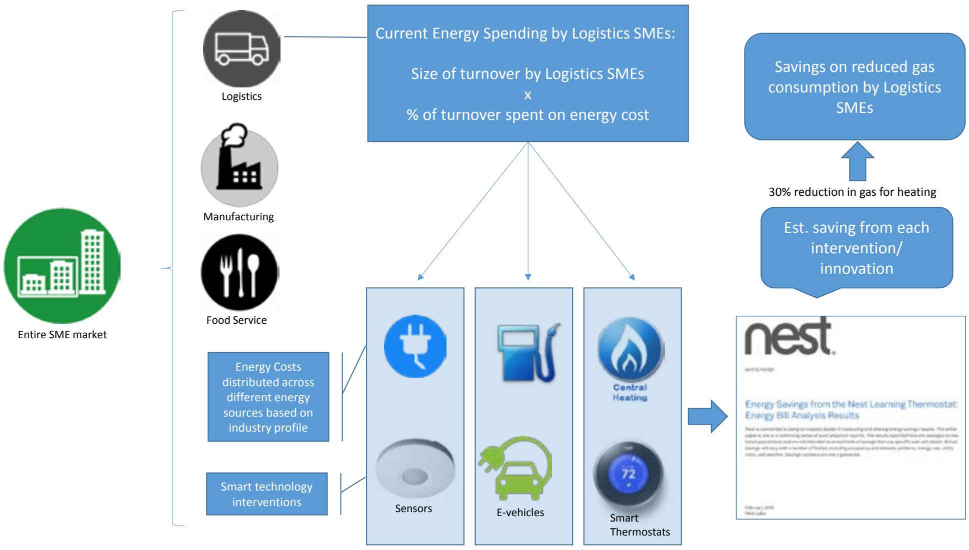

Figure 5 – Illustrative example of the methodology.

Firstly, we identified which smart technologies are applicable to which energy sources, as demonstrated in Table 6 in Section 3.5. It must be noted that not all technologies, whilst applicable to all sectors, are necessarily applicable to all energy sources. For example, the smart technologies selected for this study are not applicable to coal and solid fuels, and to heat and other fuels, and therefore the analysis determines that there are no savings to be made for SMEs for these energy sources. This is can be seen later within the results tables, as a series of £0 values for potential savings.

For each sector's energy expenditure by energy source type, we have found energy savings benchmark data (see Table 8). We have gathered multiple benchmarks in some cases and therefore the analysis provides an average savings estimate for each sector and for each energy source.

To calculate energy saving by energy source type we have used DUKES data to determine each source's share within each business area. For example, coal and solid fuels account for 8 percent of energy spending in the Industry business area, 1 percent in the Domestic business area and zero percent in the Other Final Users business area. This was described in Section 3, alongside other assumptions made. Section 7 outlines the limitations with making use of DUKES data on energy expenditure for the purposes of this study and results should be interpreted with these limitations in mind.

It should be noted that our analysis determine the collective saving potential by adding the potential savings from each technology operating in isolation (to the extent the technologies are applicability to an SME sector, business size, and fuel type). This is a simplified assumption as SMEs in any one sector would likely use a variety of different smart technologies and the saving from one technology may be offset by another technology in the same system. This suggests that our cumulative results may overestimate the likely savings across the entire SME market.

In Section 4.2.2, we have qualitatively identified and described likely overlaps for the seven technologies selected as part of this study. Quantifying the extent of overlap in energy savings for different technologies is beyond the scope of this study. Such research attempt will require analysis of the level of uptake and behavioural elements. We have identified a research on the collective effects of multiple smart technologies in the same system as a future study as findings from such research will help smart technology providers and users understand the empirical performance of an equipment in a wider system with other smart technologies.

Following the calculation of energy savings, four [4] Arup experts from the engineering and change management fields were consulted in relation to the barriers facing SMEs and potential solutions to overcome such barriers. Those consulted are listed below and the commentary related to their feedback is included within Section 6 and 8.

- Barry Austen, Associate Director, Building Performance and Systems
- Deborah Barleggs, Associate Director, Operational Performance
- Rob Goode, Senior Consultant, Operational Performance
- Graham Aldwinckle, Associate, Building Engineering.

5.2 Results

The results are presented as SME energy savings by sector, by energy source, and by business size. More detailed combinations of these results, such as savings by sector, energy source, and business size, are available in our analysis within the model being submitted to accompany this report. To keep this section concise and manageable, we offer a high-level overview of the potential savings in this section.

It should be noted that the source of data for the energy savings benchmarks in Section 4.2.2 comes largely from technology manufacturers, universities, external industry associations and consulting firms. They are not all backed by large scale, controlled experiments or empirical data. The contribution of these benchmark figures on energy savings calculated within this report is significant, so it’s important to understand that there may be a large confidence interval associated with the results presented below. More information on data limitations and data quality is presented in section 7.

5.2.1 SME Energy Savings by Sector

Table 9 summarizes our findings on the energy savings potential available to SMEs. Our findings suggests the energy saving potential from smart technologies within the SME sector is roughly £8.6 billion annually. The top three SME sectors set to save the most from using smart technologies are: (1) the Wholesale, Retail, Transport and Storage; (2) Education and (3) Accommodation and Food Services sectors, with estimated annual savings of £3.0 billion, £1.3 billion and £1.1 billion respectively. This is in part due to large savings expected for Fleet Management and Integrated Building Management Systems.

Other sectors expected to make moderate savings include the Human Health and Social Work Activities sector which is expected to save roughly £808 million per year, the Manufacturing sector and the Commercial Offices sectors, with annual savings save up to £912 million and £728 million, respectively. The Agriculture Forestry and Fishing sector is also expected to save up to £527 million per year.

In terms of savings per SME, the Accommodation and Food Services sector is expected to save the most, up to £12,369 annually per business whilst the Construction sector is only expected to save the least, around £46 annually. The Commercial Offices sector, despite being the largest by business numbers, is only expected to save around £413 per business each year.

The reliance of the data on the DUKES business area classifications should be noted here, where technologies such as Fleet Management appear as providing significant savings across most industries, despite many SMEs running only very small fleets. This is due to the lack of granularity within the DUKES dataset. Further refinement of the dataset will allow future researchers to conduct top down studies to better understand how fleet management and other smart technologies will affect SME energy expenditures.

Table 9 – Annual energy savings by sector

Scenario	Number of SMEs	Smart Heating Controls	Smart Meters	Integrated Building Management Systems	Smart Lighting Systems	Demand Responsive Energy Management	Big Data in Logistics and Transportation	Fleet Management	Total Annual Energy Savings
Accommodation and Food Service Activities	182,447	£35m	£57m	£73m	£33m	£17m	£0m	£865m	**£1,081m**
Agriculture, Forestry and Fishing	153,207	£24m	£33m	£18m	£17m	£4m	£0m	£432m	**£527m**
Arts and Other Services	591,020	£8m	£12m	£8m	£6m	£2m	£0m	£160m	**£196m**
Construction	956,105	£8m	£10m	£9m	£5m	£2m	£1m	£8m	**£44m**
Education	267,550	£46m	£72m	£83m	£41m	£19m	£0m	£1,06m8	**£1,330m**
Human Health and Social Work Activities	370,632	£25m	£42m	£58m	£25m	£13m	£0m	£645m	**£808m**
Manufacturing	274,463	£54m	£131m	£386m	£94m	£88m	£18m	£141m	**£912m**
Mining, Quarrying, and Utilities	29,302	£1m	£1m	£4m	£1m	£1m	£0m	£0m	**£7m**
Commercial Offices	1,761,471	£22m	£37m	£54m	£22m	£13m	£0m	£580m	**£728m**
Wholesale, Retail, Transport and Storage	795,935	£68m	£129m	£243m	£83m	£57m	£274m	£2,153m	**£3,007m**
Total	**5,382,132**	**£292m**	**£526m**	**£935m**	**£326m**	**£216m**	**£293m**	**£6,051m**	**£8,639m**

Arup analysis based on data from DECC, Energy Consumption in the United Kingdom (EC UK), 30 July 2015 and BIS Business Population Estimates 2015, 14 Oct 2015

5.2.2 SME Energy Savings by Energy Source

From our analysis, the selected smart technologies are expected to provide savings for SMEs using natural gas, electricity, and petroleum, but not for those using coal and solid fuels, or heat and other fuels. This is because the list of smart technologies we have analysed in this study is not applicable to these energy sources. Note that coal and solid fuels and heat and other fuels represent only 3.7% of the energy currently consumed by SMEs based on our calculation (see Table 4 above).

Across all energy sources, the biggest saving is expected to be toward petroleum, with an expected saving of roughly £6 billion annually, mostly impacted by Fleet Management initiatives. This is expected as petroleum products represent most of the energy expenditures by SME (of the £50 billion annual SME energy expenditure, £37 billion is towards petroleum products, see Table 4). As noted above, the significant figure within the petroleum due to fleet management can in part be related to the top down analysis of the DUKES data, where a number of industries were identified as fitting within the Other Final Users, where petroleum represented a high proportion of energy expenditure. There are also anticipated potential annual savings of £1.7 billion for electricity. With regards to office space, it is clear that Integrated Building Management Systems provide a high potential for savings on electricity, with an estimate of around £786 million annually.

Table 10 – Annual energy savings by energy source (£ mil)

	Smart Heating Controls	Smart Meters	Integrated Building Management Systems	Smart Lighting Systems	Demand Responsive Energy Management	Big Data in Logistics and Transportation	Fleet Management	Total Annual Energy Savings
Coal and Solid Fuels	£0	£0	£0	£0	£0	£0	£0	**£0**
Natural Gas	£292	£158	£149	£0	£0	£0	£0	**£599**
Electricity	£0	£368	£786	£326	£216	£0	£0	**£1,696**
Petroleum	£0	£0	£0	£0	£0	£293	£6,051	**£6,344**
Heat and Other Fuels	£0	£0	£0	£0	£0	£0	£0	**£0**
Total	**£292**	**£526**	**£935**	**£326**	**£216**	**£293**	**£6,051**	**£8,639**

Arup analysis based on data from DECC, Energy Consumption in the United Kingdom (EC UK), 30 July 2015 and BIS Business Population Estimates 2015, 14 Oct 2015

5.2.3 SME Energy Savings by Business Size

The potential energy savings are roughly divided between micro-small and medium businesses. With micro and small-sized businesses collectively accounting for almost 70 percent of SME turnover, they account for £358 million and almost £4 billion of potential energy savings, respectively. This compares to the potential annual saving of £4.3 billion for medium-sized businesses, which account for around 30 percent of SME turnover[21]. Despite the fact that micro businesses represent most of the SME business units and consume considerable energy, they have significantly lower energy saving potential compared to small and medium enterprises. This is due to the fact that most of the energy savings from our analysis comes from the fleet management technology, and micro businesses generally do not have a large enough fleet to take advantage of the technology. Besides fleet management, large proportions of savings are expected to be made using Integrated Building Management Systems, estimated at up to £935 million annually for medium-sized businesses.

It is also important to note that these estimates are based on assumptions about SME turnover and not the number of business units.

Table 11 – Annual energy savings by business size (£mil)

	Smart Heating Controls	Smart Meters	Integrated Building Management Systems	Smart Lighting Systems	Demand Responsive Energy Management	Big Data in Logistics and Transportation	Fleet Management	Total Annual Energy Savings
Micro	£161	£197	£0	£0	£0	£0	£0	**£358**
Small	£130	£159	£0	£159	£0	£133	£3,409	**£3,990**
Medium	£0	£170	£935	£168	£216	£160	£2,642	**£4,290**
Total	**£292**	**£526**	**£935**	**£326**	**£216**	**£293**	**£6,051**	**£8,639**

Arup analysis based on data from DECC, Energy Consumption in the United Kingdom (EC UK), 30 July 2015 and BIS Business Population Estimates 2015, 14 Oct 2015

Limitations to the analysis presented here are discussed in more detail in Sections 6 and 7.

[21] BIS, Business Population Estimates, 2015

6 Barriers to Adoption and Proposed Solutions

Figure 6 highlights the typical breakdown of business costs experienced by SMEs within certain sectors and on average across all SMEs in the UK. It shows that energy and utilities represents less than 5 percent of total SME costs across all industries, including manufacturing.

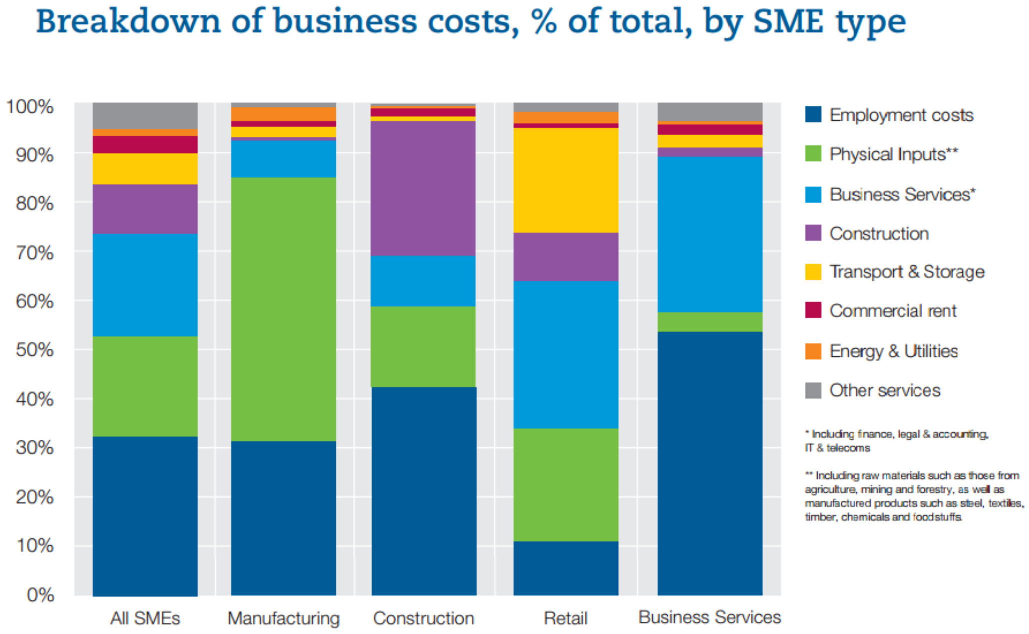

Figure 6 – UK SME typical business costs 2014 Source: Aldermore SME Monitor – March 2014[22]

This helps put energy savings in context for small business owners. Despite the tangible and quantifiable financial savings which can be made through improvements in energy efficiency, those savings are unlikely to be a key business driver for many SMEs in the context of their wider business costs. Furthermore, SMEs usually fall outside the legislative requirements for energy reporting such as the ESOS and CRC programmes, suggesting that legislative compliance is currently not a strong motivator driving SME energy efficiency either.

Despite the lack of compelling cost or legislative drivers, there is still evidence to support the fact that cost savings are one of the greatest motivators for influencing SMEs to implement energy efficiency improvements[23]. Our study has shown that there are significant cost savings available to SMEs (up to roughly £8.6 billion p.a.) through the implementation of smart technologies. The cumulative impact of this in conjunction with energy savings from passive or non-smart technology solutions is likely to be even greater.

[22] Aldermore SME Monitor – March 2014, CEBR Analysis, pg. 27 accessed at: http://www.aldermore.co.uk/media/2493/aldermore_sme_monitor_-_mar_14.pdf
[23] DECC, Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium Sized Enterprises, Nov 2014

In its November 2014 report titled Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium Sized Enterprises, DECC pointed out there were several factors why SMEs may not adopt the smart technologies solutions available to them. The reasons included:

- Challenges with quantifying and understanding financial savings
- Perceptions of high capital costs
- Reluctance to invest in building improvements in leased or rented premises (often referred to as the split incentives problem)
- Concerns over disruption of day-to-day operations
- Changes to accepted practice, both in terms of internal operations and external customer expectations.

While these factors were findings from a study concerning energy efficiency (whereas this study is primarily concerned about smart technologies that are digital and handle data), many of the barriers identified in the 2014 study can also be applied to the adaptation of smart technologies. This is because all the interventions require SME owners to actively make changes to the status quo in order to lower their energy bills.

The nature of SMEs means that they often have 'fewer technical and financial resources or less operational and management capacity'[24] than larger firms, meaning that even when financial savings are available, SMEs might not have enough staff time or availability to actualise those savings. Furthermore, for some SMEs (particularly start-ups) the business owner may have strong intentions of selling the business in the short to medium term, enhancing the need for very short payback periods. The average life of an SME is approximately five years[25], suggesting that any payback periods of greater than five years may present as only marginally attractive to SME owners and management.

Based on our engineering knowledge and findings from this study, we offer the following suggestions to remove some of these previously identified barriers. These solutions have been developed through consultation with the aforementioned four Arup experts and are high level suggestions. As identified later in this section, more research needs to be done to further investigate the cost and feasibility of each solution. However a high level score on ease of implementation has been included here to provide an initial indicator of difficulty.

[24] Ibid.
[25] Jone, Noel. "SME's life cycle-steps to failure or success?." AU-GSB e-JOURNAL 2.2 (2009).

Table 12 – Possible solutions to SME energy savings barriers

Proposed solutions	Ease of implementation
Continue to push educational information based on case studies such as the DECC SME Guide to Energy Efficiency 2015[26] so that SMEs can see real life cost saving data from businesses which they can identify with. This will help overcome the lack of understanding of the savings available and help to quantify potential savings for many SMEs. It will also partially assist to demystifying the issue of perceived high capital costs held by many SMEs	Easy
Introduce legislative compliance requirements for SME energy reporting. The nature of this could vary between incentive programmes offering tax benefits for those who comply and achieve certain benchmarks or publishing league table highlighting good performers. Alternatively an operational rating system could be implemented where businesses are rated on a scale against their competitors based on a prorated energy consumption ratio. Regardless of the incentive system introduced, it is absolutely critical that any compliance requirements are not onerous on SMEs and that they do not lead to significant disruption to day-to-day operations within these businesses.	Difficult
Targeted approaches and intensive attention for the worst energy users (taking into account the nature of the business being undertaken). This would however require detailed data collection and analysis on SME activities, building types occupied, energy ratings of those premises, processing/manufacturing energy use and hours of operation. This level of information is not available on UK SMEs at this time.	Moderate

As identified within the ORGANISER behaviour insights study[27], many solutions rely on behavioural change, which can only be achieved through securing buy-ins from and engagement with trusted players within the SME industry.

As suggested above, information and high quality data on SMEs business operations, practices, habits and costs are required in order to develop targeted and applicable strategies to overcome the complex set of barriers facing SMEs. Section 7 below identifies the key sources of data used to undertake this analysis

[26] https://www.gov.uk/government/publications/sme-guide-to-energy-efficiency
[27] HM Government, 2016, Organiser A behavioural approach for influencing organisations: https://www.gov.uk/government/publications/organiser-a-behavioural-approach-for-influencing-organisations

and highlights the main data gaps and opportunities for additional research and analysis.

7 Quality of Data

A comprehensive list of all data sources used during the course of this report has been included at the end of this report. The availability of industry data shaped the methodology used to produce the results in this report. In order to properly influence SMEs to implement energy saving measures, accurate, complete and timely information on business activities and business facilities is required. As that information was not available, energy savings within the SME market was calculated based on data that was readily available. This involved collection of data regarding:

- SME energy expenditure
- Energy savings data

The data quality or information used to inform each of these is discussed below, with particular focus on the limitations of top down analysis such as this.

7.1 Data Quality of SME Energy Expenditure

UK SME data is available from BIS and provides a comprehensive outline of the number of SMEs operating in the UK and their business size in terms of both employees and turnover. BIS provides overall UK wide figures as well as industry breakdowns according to SIC codes. This information is regularly reported and data was available for 2015 for use in this study.

DECC data provides information on energy expenditure within SMEs in the UK via the DUKES reports. The research is recent and detailed, but is broken down into different sectors than those used for the purposes of the study (three business areas of industry, domestic and other final users are presented, versus the standard DECC industry groupings highlighted in Section 2.2). This required assumptions to be made to disaggregate the data across the required sectors for this study. Furthermore, the DECC energy expenditure data did not include information on business size.

The key issue in using the DUKES data is that so many of the sectors within this study fell into the Other Final Users category. Because this is a top down study, the energy expenditure within that business area category was then applied consistently across each of the nominated sectors – meaning that technologies such as fleet management where petroleum savings existed were consistently showing significant savings – where in reality, many SMEs particularly are unlikely to have large fleets. This identifies a key weakness in the top down approach to studies such as this and highlights the need for increase granularity in reporting – especially at a sectoral level.

The BIS SME turnover data used during this study was combined with general industry turnover figures to produce a ratio which was applied to the sectoral energy consumption figures which then informed the sectoral spend on energy. As the BIS data included information on business size, this enabled the calculation of energy expenditure by business size as well as by sector. Had the DECC data provided a more detailed breakdown of SME energy expenditure by sector and business size, the process would have been simplified, and DECC should consider the possibility of incorporating these breakdowns in future DUKES publications.

Overall, we consider the data on SME energy expenditure recent and accurate and is useful for determining energy use in different sectors, but it could benefit from increased granularity of reporting. Section 7.3 provides greater detail on this.

7.2 Data Quality of Technology Energy Savings

Energy savings data across each of the seven technologies was calculated and applied to the SME energy expenditure data to estimate SME energy savings by sector, business size and fuel type.

There is a general lack of independent studies showing empirical data on how much energy savings each technology actually achieves. Energy savings data provided by manufacturers is potentially biased and sometimes can include vague assessment, such as saving up to a certain percentage. Independent studies conducted by impartial bodies such as universities and not funded by the industry can increase the objectivity and credibility of energy saving performance of different smart technologies. As the accuracy of the benchmark savings data is a key input into the calculation on SME energy savings and can significantly affect results, additional independent research is recommended to improve the robustness and accuracy of current estimates.

In addition, there is also an apparent lack of studies on the collective and interactive effects of multiple smart technologies in an integrated system It is reasonable to expect some of the energy saving performance of individual devices or packages can be offset (but unlikely to be leveraged) by the impact of other smart technologies in the same system. From our desk-top research, we find no research that offers a comprehensive review of the collective energy saving performance from an integrated, multi-facet system. Conducting such studies to assess the holistic effect of multiple devices/systems can help better understand which technologies supplement each other and which ones nullify each other, allowing for more efficient systems to be designed in the future.

7.3 Summary of Data Quality

Table 13 provides a list of the key studies used to inform our energy saving assessment in this research. We evaluated the quality of the papers based on the following three-point scale provided by DECC:

1. The document has apparently undergone the independent peer review process[28] (Yes = 1; No = 0);

[28] Academic and UK governmental publications are assumed to have undergone the peer review process; industry publications without explicit mentioning of a peer review process are assumed to be not reviewed.

2. There are no apparent conflicts of interest[29] (True = 1; False = 0); and
3. The research method(s) is/are clearly explained in the study (Yes = 1; No = 0).

Table 13 below summarises our assessments of different research studies we reviewed for this engagement. An overall high quality score means the study achieves high on all three quality dimensions (i.e. total score of 3). A medium quality score means the study achieves high marks in two quality dimensions (i.e. total score of 2). A low quality score means the study achieves low mark on two to three quality dimensions (i.e. total score of 0 or 1).

[29] We determine that studies conducted by manufacturers or technology suppliers without explicit mentioning of independent peer review of results are subject to apparent conflicts of interest.

Table 13 – Summary of Research Studies and Quality Ratings

Reference Title	Author(s)	Peer Review	No Apparent Conflicts of Interest	Cleary defined Research Method	Overall Quality Rating
Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results	Nest	No (0)	False (0)	Yes - US DOE Uniform Methods Project [DOE 2013] (1)	**Low**
Smart meters and consumer engagement	The Concerted Action for Energy Efficiency Directive (Co-funded by the Intelligent Energy Europe Programme of the European Union)	No (0)	True (1)	Yes – survey (1)	**Medium**
2013 EPRG Public Opinion Survey: Smart Energy—Attitudes and Behaviours	University of Cambridge	Yes (1)	True (1)	Yes – survey (1)	**High**
Bright Green Building – Convergence of Green and Intelligent Buildings	CABA (Continental Automated Buildings Association)	No (0)	False (0)	Yes – primary (80%) and secondary research (20%)	**Low**
Department for Business, Innovation & Skills, Business Population Estimates	BIS	Yes (1)	True (1)	Yes	**High**
Department for Business, Innovation & Skills, Small Business Survey	BIS	Yes (1)	True (1)	Yes - survey	**High**
Department for Energy and Climate Change, Digest of UK Energy Statistics	DECC	Yes (1)	True (1)	Yes	**High**
Department for Energy and Climate Change, Energy Consumption in the UK	DECC	Yes (1)	True (1)	Yes	**High**
Department for Energy and Climate Change, Research to Assess the Barriers and Driver to Energy Efficiency in SMEs	DECC	Yes (1)	True (1)	Yes - survey	**High**
Department for Energy and Climate Change, SME energy efficiency guide	DECC	Yes (1)	True (1)	No (Published as a guide to SMEs,	**N/A (guide, not research paper)**

Reference Title	Author(s)	Peer Review	No Apparent Conflicts of Interest	Cleary defined Research Method	Overall Quality Rating
				not as a research paper)	
House of Commons, Business Statistics Briefing Paper No 06152	House of Commons	Yes (1)	True (1)	Yes – governmental statistics	**High**
Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential	K.W Roth et al, July 2002	Yes (1)	True (1)	Yes	**High**
Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways	M.R. Brambley et al. U.S. Department of Energy, April 2005	Yes (1)	True (1)	Yes	**High**
Energy savings due to occupancy sensors and personal controls: a pilot field study, Lux Europa 2009, 11th European Lighting Conference, Istanbul	Galasiu, A.D.; Newsham, G.R., Turkey, September, 2009	Yes (1)	True (1)	Yes	**Medium**
Benefits After Effective Deployment of Fleet Management System	FROST & SULLIVAN	No (0)	False (0)	No (0)	**Low**
Hive Energy Saving Report	British Gas	No (0)	False (0)	Yes	**Medium**
Energy Demand Research Project Final Analysis	AECOM, ofgem	Yes (1)	True (1)	Yes	**High**

The top down approach taken based on the above research findings and reports has led to a figure of £8.6 billion of energy savings by SMEs annually. This is against an estimated SME energy spend of around £49.7 billion and represents roughly 17 percent saving on energy expenditures. This is in line with the energy savings percentage determined during past DECC research by ENWORKS, which suggested from bottom up studies that energy savings of 18 percent – 25 percent were likely within the SME market[30]. As highlighted throughout this section, caution must be exercised when making use of figures from top down studies, especially when they are based on data that lack granularity at a sector level. As such, caution should be applied when interpreting the energy savings figures identified by this study. They do however speak to the quantum of energy saving available within the sector and the potential of smart technology to drive energy savings potential.

[30] DECC, Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium-sized Enterprises, November 2014

7.4 Key Data Gaps

Energy consumption and expenditure within SMEs is generally driven by two key factors:

- Building energy use
- Processes energy use (i.e. manufacturing or high energy intensive tools or appliances).

In order to accurately calculate likely energy savings from smart technologies within the SME market, more accurate and comprehensive data on SME energy spending is required. Ideally this would involve empirical energy consumption and expenditure data broken down by SME activity, premises type and size, premises EPC rating, hours of operation and process/manufacturing appliance energy use. Unfortunately, collection or reporting of this data is not mandatory and hence top down analysis is currently the only way to estimate SME business energy consumption and possible savings.

Furthermore the availability and robustness of data related to technology interventions is a key issue in this piece of work. Additional studies looking to quantify potential smart technology energy savings based on empirical data will greatly enhance the accuracy of any future studies.

7.5 Further Research

In order to fill the data gaps identified above, a number of future studies or research could be commissioned that would greatly enhance the accuracy of SME related energy consumption and expenditure data. This would likely lead to better informed, and more impactful policy analysis. Additional research that could be undertaken includes:

- Comparing the results from this study to other new DECC-funded SMEs research projects, such as BEES (due for release soon), ESOS Tracker (due for release soon), CBER and ABS (due for release in November).
- Identifying the proportion of SMEs that work from different types of premises (e.g. building type, homes/offices, rented/privately owned). This could be done through SME surveys and should consider issues such as the age of the building stock, the location, building materials type, EPC ratings of buildings etc.
- Further stratification of the SME sector by expected life, identifying which SMEs are likely to last longer than 5 years (the average life expectancy of an SME).
- Identification of key success factors for previous schemes and initiatives that have been successful elsewhere in achieving uptake and impact within the SME sector.

8 Conclusion and Next Steps

Our findings suggest that the application of smart technologies within the SME market offers significant energy savings potential in the order of approximately £8.6 billion against an estimated energy spend of roughly £49.7 billion (representing approximately 17 percent savings potential on energy expenditures).

The detailed sector and technology results allow us to understand where some effort should be targeted to achieve maximum energy savings.

Table 14 – Largest energy saving potential smart technologies and sectors

Smart technologies with the biggest estimated savings	Estimated annual energy saving (£ million)	Biggest energy saving sectors	Estimated annual energy saving (£ million)
Fleet management	£6,100	**Wholesale, Retail, Transport and Storage**	£3,007
Integrated building management systems	£935	**Education**	£1,330
Smart meters	£526	**Accommodation and Food Services**	£1,081

Arup analysis.

Fleet management, integrated building management systems, and smart meters are the three smart technologies likely to offer the greatest energy savings to SME, providing estimated energy savings of roughly £7.5 billion annually. Meanwhile the Wholesale, Retail, Transport and Storage; Education; and Accommodation and Food Services sectors are likely to achieve the greatest energy savings (of roughly £3 billion, £1.3 billion and £1 billion respectively). Our analysis also suggests that the energy savings are likely to accrue most strongly to small and medium SMEs.

In comparison to other bottom up studies on energy efficiency within the SME sector[31], our research suggests that overall higher energy savings of roughly 17 percent is achievable on average across the industry. This is comparable to the bottom up studies which suggest savings potential of between 18 to 25 percent within the SME sector. Furthermore, our research suggests a higher SME market energy savings in the order of £8.6 billion versus an estimated £1.3 billion to £2.7 billion annually from bottom up studies. A large part of this discrepancy however, can be attributed to the limitations of top down studies, especially in relation to predicting maximum possible savings data (see Figure 4 and associated discussions). As was identified in the DECC bottom up studies, their values did not represent the maximum theoretical value of energy efficiency savings for each

[31] DECC, Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium-sized Enterprises, November 2014

company, but rather they are based on pragmatic project intervention where the focus stretches across energy and other resource use.

The availability and quality of data relating to SME energy expenditure limited and dictated the methodology and approach used in this report. SME energy expenditure data is regularly reported by DECC, however such information would benefit from presentation at a more granular level including expenditure across a broader range of sectors and business sizes. This study would also benefit from increased research into the empirical results related to specific smart technology energy savings.

Whilst energy represents only a small proportion of SME business costs, cost savings appear to be the main motivator in attracting SMEs to engage in energy efficiency measures. Ongoing engagement and education in the sector may help to involve more SMEs, however legislation or government incentive programmes are likely to be a more effective mechanism and will assist with closing the information gaps which currently exist across the industry. Regardless of the interventions devised, in order to have maximum impact, it is important that requirements are not onerous or confusing.

SMEs often make decisions based on a short window (e.g. 12 months) and many are not interested in making investments that take years to pay off when the average life of an SME is approximate five years[32]. Furthermore, SMEs have limited options in choosing smart technologies to reduce their energy expenditure as many of these technologies are implemented at a building level (rather than a tenant level).

A Glimpse into the Future

With the UK government plan to roll out smart meters as standard across the country by 2020[33], it could expect that over the next five years the adoption rate of smart meters in the UK will increase significantly. The adoption rate and choices of smart technologies, including smart heating controls, smart lighting systems, demand responsive energy management, could be increased if the interoperability between different products can be improved.

In addition, it could expect that building management systems could evolve very quickly. The development of software technologies, such as cloud computing and data analytics, and emerging technologies, especially IoT[34], could make the system integration between building services more effective. Big data would be increasingly applied to logistics and fleet management field. The emerging of new technologies, e.g. IoT, and the availability of new data source, e.g. crowd source, could provide better quality of data. It could make the outcomes from big data analytics more accurate and inform future service and business model development.

---

[32] Jone, Noel. "SME's life cycle-steps to failure or success?." AU-GSB e-JOURNAL 2.2 (2009).
[33] Transition to Smart Meters, ofgem, https://www.ofgem.gov.uk/gas/retail-market/metering/transition-smart-meters
[34] Siemens and IBM on next generation of cloud-based building energy management solutions, 2016, https://www-03.ibm.com/press/us/en/pressrelease/49159.wss

Finally, many of the drivers and barriers faced by SMEs relate to the size and capacity of their individual businesses. Understanding these differences between SME to support the development of targeted and tailored approaches to catalyse the uptake of smart technologies will be increasingly important in years to come.

References

1. Aldermore SME Monitor, CEBR Analysis, March 2014: http://www.aldermore.co.uk/media/2493/aldermore_sme_monitor_-_mar_14.pdf
2. Brambley, M. R, et al, Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways: http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/pnnl-15149_market_assessment.pdf
3. British Gas, Hive Energy Saving Report, 2014
4. Cisco, The Internet of Things: How the Next Evolution of the Internet is Changing Everything, 2011: http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
5. Continental Automated Buildings Association, Bright Green Buildings: Convergence of Green and Intelligent Buildings, 2008
6. Concerted Action Energy Efficiency Directive: Smart Meters and Consumer Engagement, May 2015
7. Department for Business, Innovation & Skills, Business Population Estimates, 14 October 2015
8. Department for Business, Innovation & Skills, Small Business Survey, 2014: SME employers
9. Department for Energy and Climate Change, Digest of UK Energy Statistics (DUKES), 2015
10. Department for Energy and Climate Change, Energy Consumption in the UK (ECUK), 30 July 2015
11. Department for Energy and Climate Change, Research to Assess the Barriers and Drivers to Energy Efficiency in Small and Medium-sized Enterprises, November 2014
12. Department for Energy and Climate Change, SME energy efficiency guide, 26 March 2015
13. Driscoll Report, Teletrac Customer Survey, 2013
14. Frost and Sullivan, Benefits of Fleet Management Systems, 2012
15. Galasiu, A. D, and Newsham, G.R, Energy savings due to occupancy sensors and personal controls: a pilot field study, 2009
16. House of Commons, Business Statistics Briefing Paper No 06152, 7 December 2015
17. Jone, Noel, SMEs life-cycle-steps to failure or success?, AU-GSB e-Journal, 2009

18. Kiwi Power, Kiwi Power and Time Inc. UK partner for demand response, 2013; http://www.kiwipowered.com/files/download/fa6e18841634151

19. Natural Scotland, Building Management System Procurement Guide, September 2014

20. Nest, Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results, February 2015: https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf

21. Ofgem, Transition to Smart Meters, https://www.ofgem.gov.uk/gas/retail-market/metering/transition-smart-meters

22. Ofgem, Energy Demand Research Project: Final Analysis, 2011

23. Roth. K, et al, Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential: http://apps1.eere.energy.gov/buildings/publications/pdfs/commercial_initiative/hvac_volume3_final_report.pdf

24. Companies House - Standard industrial classification of economic activities (SIC) 2007

25. The Brattle Group, The Five Forces Shaping the Future of Demand Response, 2015: http://www.brattle.com/system/publications/pdfs/000/005/122/original/The_Five_Forces_that_will_Shape_the_Future_of_Demand_Response_Faruqui_021815.pdf?1424451084

26. University of Cambridge, 2013 EPRG Public Opinion Survey: Smart Energy Survey – Attitudes and Behaviours, 2013: http://www.econ.cam.ac.uk/research/repec/cam/pdf/cwpe1352.pdf

27. UPS, Big Data = Big Wins for the Environment, 2013; http://sustainability.ups.com/media/UPS-Big-Data-Infographic.pdf